China and the New Moon Race

A Collection of Papers by Dean Cheng

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Preface

Dean Cheng is a distinguished scholar and commentator on China, with a particular focus on China's space program, Chinese military doctrine, and "dual-use" issues associated with China's scientific and technical enterprises. He has testified before Congress numerous times, served on government advisory boards, and called upon for public commentary on policies toward China.

In addition to his many other affiliations with think tanks and non-profit research institutions, the Space Policy Institute is proud to include Dean among its small number of non-resident scholars. These persons have long-standing collaborative relationships with our research and teaching programs, have a history of significant scholarly contributions, and who share our recognition of the importance of space technology, exploration, and development to international security, economic growth, and scientific discovery.

This monograph is a collection of papers on "China and the New Moon Race" with a focus on China's plans for robotic and human missions to the Moon. These are not engineering or technical papers on China's plans, but rather an examination of China's possible motivations and political priorities for undertaking ambitious space efforts. Rivalry between great powers that extends into space may seem familiar in some respects, but geopolitical conditions today are very different from the Apollo era. This work is intended to contribute to a better understanding of the competitive challenge the United States and its allies are facing and will face in the years ahead.

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Introduction

Sixty-seven years after Sputnik sparked the beginning of the Space Age, and fifty-five years since Neil Armstrong set foot on the Moon, the world now finds itself in a renewed space race. While there are more players, including commercial companies, forging new paths, the biggest competitors are again the two foremost powers: the United States and the People's Republic of China (PRC).

As with the US and the Soviet Union in Space Race 1.0 (1957-1989), the competition between the US and PRC in Space Race 2.0 is only partly about space itself. Instead, space is the arena for terrestrial competition, ambitions, and rivalry. Both sides view space as a forum for demonstrating technological prowess, economic robustness, and ideological appeal. Moreover, as space has become a demonstrated part of modern military operations, a clear lead in space capabilities affects calculations of national power and strategic deterrence, but now extending beyond the nuclear realm into conventional warfare capabilities.

Even more than in the 1960s, though, today's audience for space achievements is global. More states are fielding their own space capabilities, and even states with no space industries of their own can buy satellites and access space services. Consequently, international interest in space is much more integral, extending beyond observing others' space achievements. Indeed, unlike in Space Race 1.0, both the US and PRC are actively forging international coalitions as they strive to land their countrymen on the Moon.

In this familiar but different environment, the PRC is a familiar but different competitor.

China's space program is considered to have been founded in 1958, soon after US-trained scientist Qian Xuesen forwarded "A Proposal to Establish China's Defense Aviation Industry" to the senior Chinese leadership. This document called for the creation of an aerospace industry, which would not only design and build aircraft, but also rockets and missiles. His proposal was incorporated into the "National Long-Term Plan for the Development of Science and Technology, 1956-1967," a broad blueprint for PRC efforts at developing their scientific and technical capabilities.[1]

China's paramount leader Mao Zedong subsequently called for an indigenous Chinese space program, stating at the Second Plenum of the Eighth Party Congress, in May 1958, that "we should also manufacture satellites (*women yie yaogao renzhao weixing*; 我们也要搞人造卫星)."[2] As a result, the PRC established the Fifth Research Academy of the Ministry of National Defense, responsible for missile development, with Qian at its head. Chinese histories of their space, missile, and strategic weapons programs generally date their start to the founding of the Fifth Academy. The initial space program, Project 581, reflects this 1958 start date.

This vision of a Chinese space program following literally on the heels of Sputnik was extraordinarily ambitious, for a nation that was still largely peasant, often illiterate, and recovering from nearly

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[1] Yanping Chen, "China's Space Activities, Policy and Organization, 1956-1986," 1999, unpublished dissertation, p. 72, and Deng Liqun, ed., *China Today: Defense Science and Technology*, Vol. I (Beijing, PRC: National Defence Industry Press, 1993), p. 32.

[2] Deng Liqun, ed., *China Today: Defense Science and Technology*, Vol. I (Beijing, PRC: National Defence Industry Press, 1993), p. 356.

twenty years of continuous war. Indeed, it was excessively ambitious, as China's limited human, financial, and industrial resources proved insufficient to sustain any kind of space development effort.

Nonetheless, every Chinese leader since Mao has supported the development of Chinese space capabilities. In the ensuing sixty-six years, this constant support and attention from the highest levels of Chinese leadership have resulted in a PRC that was the third nation to field a position, navigation, and timing (PNT) constellation, the third nation to deploy human-rated launch vehicles, and the first nation to land at the lunar south pole as well as to deploy a lunar sample retrieval mission to the lunar far side.

Today, a far wealthier China is poised to become the second nation to land people on the Moon, and may even be able to do so before the United States can return to the Moon.

The PRC has succeeded the Soviet Union as the second foremost space power (with an eye towards becoming the foremost) due to a number of considerations.

More resources. As China's economy has grown, the resources available for various projects, including those in space, have correspondingly risen. Today, the PRC has the second-largest economy in the world. More to the point, it is a global trading power. Where the Soviet Union strove for autarky, to its own detriment, China is a part of global supply chains, not only for the United States but almost every nation. Its relative economic power, compared to the United States, is substantially higher than the Soviets ever achieved.

Greater ability to mobilize resources. China's ability to grow is only partly rooted in its large population and openness to trade.

Although the PRC does not have a free market economy, the economic system of "socialism with Chinese characteristics" has allowed the PRC to mobilize its various assets.[3] Although restricted and carefully overseen, the PRC has nonetheless allowed market mechanisms to eclipse most elements of centralized planning in the allocation of resources. Chinese entrepreneurs have been able to develop new markets, and as an important benefit from them, encouraging technological and production innovation and allowing China to make better use of its human, natural, and industrial resources than its Soviet-era counterpart, or even modern-day Russia.

Greater programmatic stability. One area where the PRC continues to exercise centralized control is in the development of five-year economic plans. These plans establish both overall targets and specific goals within various industrial and scientific sectors. As important, they provide programmatic stability, as funding resources and political support are largely set for the duration of the five-year plan. This provides researchers, designers, and production engineers with greater predictability, facilitates long-term planning and acquisition of long-lead items, and allows for better staffing decisions. As important, it has also meant that Chinese goals have remained the same over extended periods, rather than changing upon the rise of new leaders.

These elements have combined to provide Chinese space planners with long-term goals, predictable bureaucratic and financial support for the "crawl-walk-run" Chinese approach to achieve those goals, and a growing pool of financial and human resources to sustain these efforts over the long haul.

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[3]https://www.bipc.com/2023-report-to-congress-on-china%E2%80%99s-w to-compliance

At the same time, the Chinese approach has been very different from the American or Russian one. Chinese deep space activities, like their terrestrial ones, are driven by multiple motivations. Chinese interest in developing the "Earth-Moon economic zone," i.e., cis-lunar space, is driven by not only scientific and technological advances, but also a desire to set standards that will apply to PNT, space traffic management, and resource development. Chinese leaders integrate strategic messaging, political warfare, and perception management in a comprehensive manner, and employ not only governmental space experts, but Chinese academics, media, and industry in a "whole of society" approach little different from the Belt and Road Initiative or general PRC trade.

Understanding the Chinese as a competitor for the development of cis-lunar space is essential, as the PRC and the United States will be encountering each other more and more in that volume of space over the coming decades. Just as the PRC constitutes a very different economic and political rival terrestrially, it will pose a different challenge in outer space.

This monograph will hopefully help shed some light on how the PRC thinks about the Moon and cis-lunar space and highlight some of the different ways they may approach the challenges of deep space.

China's Use of International Engagements in its Human Spaceflight Efforts

The People's Republic of China (PRC) has long expressed interest in international space cooperation and engagement. Every space white paper issued by the PRC has included a chapter on international space cooperation efforts.

For most of the early days of PRC space efforts, there was little actual interaction with foreign space programs. The Sino-Soviet split and the ensuing self-imposed strategic isolation of the PRC meant that China had little opportunity to work with other countries while it was developing its first satellite (the DongFangHong-1, or DFH-1, launched in 1970). Even after the PRC's opening to the West in 1972, and official recognition by most states in 1979, China's limited resources and minimal space capabilities meant the PRC was not an attractive or even interesting partner for space cooperation. Thus, while China offered to launch satellites for foreign customers in 1985, it did not actually undertake such a launch until 1990, and that was for a Hong Kong-based firm.

It should be noted that the lack of international interaction has not limited China's ability to field a substantial space capability. Indeed, in the intervening half-century since the launch of DFH-1, the PRC has achieved major space milestones. These have included:

- Deploying a variety of satellite constellations including earth observation; position, navigation, and timing; meteorology; and communications;

- Establishing a space station, facilitating a long-term human presence in space;
- Landing spacecraft on the Moon, including the lunar far side, as well as undertaking a sample retrieval mission from the Moon;
- Deploying satellites to the Lagrange points;
- Landing spacecraft on the Martian surface and in Martian orbit.

These achievements have been largely through an indigenously developed space industrial complex. That complex has developed the Long March family of launch vehicles, a variety of satellite buses, and the vast bulk of the ground equipment at China's various launch, mission control, and telemetry and tracking sites. China has not needed to cooperate with foreign countries to access space.

For the PRC, this indigenous development and innovation is a matter of pride. The concept of "two bombs, one satellite" (referring to the atomic bomb, the hydrogen bomb, and a rocket capable of lifting a satellite or a nuclear warhead) not only embodied the primary strategic research and development projects of the 1960s but also became synonymous with domestic development of key, strategically vital capabilities and technologies.

Given the indigenous achievements, as well as the strategic importance accorded space, especially over the last quarter century, the PRC is arguably interested more in international space *engagement*, as opposed to international space *cooperation*. That is, while the PRC wants to engage with other states and be seen doing so, it is unlikely to become so intertwined as to be *dependent* on foreign partners for key technologies, capabilities, or operations. Thus, the PRC undertakes a variety of international exchanges, shares data, and even engages in cooperative scientific projects, but

has chosen to develop its own position, navigation, and timing (PNT), communications, and meteorological constellations. In the area of human spaceflight and lunar missions, the PRC has arranged for access to some foreign tracking, telemetry, and control (TT&C) sites, or to build such sites in some countries, but largely developed its own technology, procedures, etc.

Moreover, unlike many Western nations, there is little evidence that international cooperation is seen as a means of obtaining additional funding. Both the International Space Station (ISS) and the European Galileo PNT network sought to use international participation as a form of burden-sharing. There is little evidence, at this time, that Beijing is seeking international partners to reduce its own space expenditures.

Importance of Space Engagement

Since the passing of Mao Zedong, the PRC has sought, to varying degrees, international engagement across a variety of endeavors. Most notably, the PRC has become an integral part of the global trading system and is among the top 5 trading partners of every major economy.

In the space domain, the PRC has undertaken international engagement at a variety of levels under a variety of guises. These have included:

- *Multilateral engagement*s. China has been part of the United Nations Office of Outer Space Affairs and helped establish the Asia-Pacific Space Cooperation Organization (APSCO). This latter organization includes Bangladesh, Iran, Mongolia, Pakistan, Peru, and Thailand. Turkey subsequently also joined. Indonesia is currently applying to

join APSCO as a full member, while Mexico is an observer and Egypt is an associate member.

- *Bilateral engagements*. The PRC has engaged in a range of bilateral space relationships. One of the most longstanding has been with Brazil, which has marked 45 years. Beijing signed agreements with Brasilia in 1988, which led to the China-Brazil Earth Resource Satellite (CBERS) program. This program has produced both shared CBERS satellites and Chinese Ziyuan satellites (some for purely Chinese customers).[4] More recent bilateral projects include the China-France Ocean Satellite (CFOSAT) and the Space-based Multiband Astronomical Variable Objects Monitor (SVOM).
- *Commercial engagements*. The PRC has engaged in an array of commercial space activities, including satellite launch services and the provision of space services. It has also been one of the leaders in turnkey satellite sales arrangements, providing everything from satellite design and construction to launch to insurance to ground station construction in a single package. The growing Chinese commercial space sector has further expanded the range of Chinese commercial interactions, such as between China's Emposat and Argentina's Ascentio Technologies SA.[5]

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[4] "CBERS-1 and -2 (China-Brazil Earth Resources Satellite) EO Portal (May 28, 2012)
https://www.eoportal.org/satellite-missions/cbers-1-2#foot2%29

[5] Samantha Lu, Brianna Boland, and Lily McElwee, *CCP Inc. in Argentina: China's International Space Industry Engagement* (Washington, DC: CSIS, January 2023)
https://csis-website-prod.s3.amazonaws.com/s3fs-public/2023-01/230124_Lu_CCPInc_Argentina.pdf?VersionId=m.swG4THoU1KpRxximJoSrSujgRdqwpx

- *Scientific engagements*. The PRC has undertaken a number of joint scientific missions, such as the "Double Star" satellite effort, where China deployed two Tan Ce satellites into orbits that complemented two previously deployed "Cluster" satellites deployed by the European Space Agency (ESA).[6] Some of the instruments that were supposed to fly aboard "Cluster" spacecraft were also installed aboard the two Chinese satellites.[7]
- *Ground segment engagements*. The PRC has forged ties with various nations based on the ground segment. Indeed, one of the earliest such engagements was the construction of tracking stations in Namibia and Kiribati to support China's manned space missions in the late 1990s. China has worked extensively with Argentina as well, as reflected in the China-Argentina Radio Telescope (CART) and the deep space ground station in Neuquen, which allows China to maintain more complete coverage and tracking of its satellites.

There is, at this time, little public evidence of Chinese military space cooperation with other states. The Aerospace Support Force (ASF), like its predecessors, the PLA Strategic Support Force and the General Armaments Department (GAD), manages significant portions of the Chinese space infrastructure. None of these organizations have typically been portrayed by the PRC media as engaging in international space exchanges or joint space exercises.

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[6] "A History of Collaboration," https://www.cosmos.esa.int/web/double-star/history-of-collaboration

[7] Sally Goodman, "Europe Hooks Up with China for Space First," *Nature* (July 12, 2001) https://www.nature.com/articles/35084340

Chinese international space engagement activities are consistent with regular Chinese messaging. In each of the five space white papers issued by the Chinese government (2000, 2006, 2011, 2016, 2021), there is a chapter dedicated to outlining the Chinese space cooperation efforts of the previous five years.[8*] Each such chapter includes a statement of the key principles for Chinese international space cooperation. Some of those principles have changed from edition to edition, but there are certain commonalities across the two decades.

- *A central role is accorded to the United Nations*. Reference is made in every white paper to the importance of conducting space activities within the "framework of the United Nations." The UN is seen as a key part of managing space affairs at the international level.
- *Support is expressed for both inter-governmental and non-government space organizations*. This reflects the reality that many space activities (e.g., the setting of standards and norms) are not necessarily undertaken by governments but include industrial and scientific organizations as well as universities and NGOs. As several of the earlier editions of the white paper noted, this support touches on "space technology, space application, and space science."
- *China is especially interested in regional space cooperation*. Chinese space white papers consistently note the importance of working with other Asia Pacific states. More recent editions specifically reference the Asia-Pacific Space Cooperation Organization (APSCO), as well as the BRICS

[8*] China's space white papers are keyed to their five-year economic plans. Each space white paper includes a review of the key developments of the previous five years and provides an outline of key programmatic goals for the coming five years.

coalition (Brazil, Russia, India, China, and South Africa) and the Shanghai Cooperation Organization (SCO).

- *China seeks to ensure that space activities benefit developing countries*. More recent editions of the space white paper specify the goal of supporting the PRC's Belt and Road Initiative.

Beyond these broad principles, Chinese efforts at international space engagement are likely driven by a number of more concrete motivations. Just as China's Belt and Road Initiative (BRI) is the product of domestic economic, international economic, diplomatic, financial, and strategic considerations, Chinese efforts to expand their international space outreach will have many different motivational strands. This would include:

- *"Learn from the West."* Ever since the "Century of Humiliation," this has been a constant motivation for China's leadership, whether imperial, Republican, or Communist. The goal has been to emulate highly industrialized, more advanced economies and national systems to elevate China's level of science and technology, improve Chinese industry, and make China more competitive politically, economically, and militarily. At the same time, however, Chinese leaders of all stripes have sought to retain "Chinese characteristics," i.e., not to simply adopt Western ways. Thus, "learning from the West" has long been associated with the motto "Chinese essence, Western application (*zhong ti, xi yong*; 中体西用)," dating back to the Qing dynasty.[9]

[9] Andrea Braun Strelcova, Stephanie Christmann-Budian, Anna Lisa Ahlers, et. Al., "The End of 'Learning from the West'?" *Observations #6* (Berlin, Germany: Max Planck Institute for the History of Science,

- *Enhance Chinese prestige*. Cooperating with foreign countries reflects the reality that the PRC has something to offer, and marks the evolution of the PRC from a consumer of intellectual property to a generator of it. This enhances Chinese prestige abroad.

  As important, though, this evolution also demonstrates *to the Chinese people* that the PRC, under the leadership of the CCP, now fields technology comparable to that of more advanced Western nations. As important, it also signals to the domestic audience that the PRC itself is now seen and treated as an equal by foreign powers. To both audiences, international engagement demonstrates the passing of the "Century of Humiliation" and China's status as a weak, exploited state.

- *Supporting other Chinese policy efforts*. Both the act of engagement and the enhancement of Chinese prestige can leverage and support other Chinese policy efforts. For example, Chinese efforts at creating a "Space Silk Road," with the Chinese offering aerospace-related projects as part of their broader BRI efforts, not only help recipient states develop a nascent space capability, generating diplomatic goodwill but also tie those states to Chinese space and telecommunications standards. For the PRC, embedding Chinese-backed standards into major technologies, including telecommunications and space systems is a major policy goal. "China Standards 2035" is an ongoing Chinese

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September 16, 2022)
https://www.mpiwg-berlin.mpg.de/observations/end-learning-west-trends-chinas-contemporary-science-policy

program to help Beijing set global industrial standards—which would in turn benefit Chinese manufacturers and companies.

Similarly, cooperative space ventures in Latin America have provided the PRC with the ability to monitor both its own and other nations' space activities on the other side of the planet, enhancing Chinese space domain awareness, with military and intelligence benefits. It has also helped strengthen or expand ties with states with important natural resources (e.g., food, lithium).

The history of Chinese engagement with foreign partners on space projects is a mixed one, however. Chinese Long March rockets had a poor track record in the 1990s. When Long March rockets carrying Loral Space & Communications Ltd. and Hughes Electronics Corporation satellites failed, Chinese officials repeatedly blamed the Western satellites. This led to demands from insurers for a joint investigation after the failure of the Intelsat-7A launch. A Loral official faxed a copy of the investigation and associated analysis to the Chinese, in violation of US export controls, and this eventually led to the Cox Commission report, whose findings in turn influenced Congress to effectively restrict all US exports of aerospace systems and components to China.

With Europe, the PRC partnered with the European space effort in the early phases of the Galileo position, navigation, and timing (PNT) constellation. Eventually, however, the Chinese found themselves excluded from many of the most sensitive parts of the Galileo PNT system, including software development and satellite manufacturing. Beijing was also informed that the new governance structure for the Galileo program was restricted to European states.

Far from an equal partnership, Beijing was clearly relegated to a minor player despite its significant financial stake.

Engagement with Russia has also experienced difficulties. China worked with Russia to deploy China's first Mars probe, the Yinghuo-1 orbiter, on the Phobos-Grunt mission. When the Zenit rocket did not fire on schedule, the entire payload, including the Chinese probe, was stranded in Earth orbit. Despite intermittent contact, Roscosmos was never able to reestablish control over the spacecraft, and it reentered Earth's atmosphere in January 2012.

Despite these frustrations, however, the PRC has continued to employ its space program as an instrument of foreign policy. A major focus has been on selling satellites and satellite services or gaining rights to either construct facilities or access existing ones on foreign territory. China has exported a number of satellites, primarily to less developed countries.

It has also continued to try and develop space ties to more advanced countries. In 2015, the PRC and the European Space Agency agreed to cooperate in a joint effort to study Earth's magnetic environment. This has been described as a successor to the Sino-European DoubleStar project of the 2000s. The resulting satellite dubbed the Solar Wind Magnetosphere Ionosphere Link Explorer, or SMILE is being jointly designed and developed by ESA with the Chinese Academy of Sciences (CAS). ESA will provide the payload module, launcher, and assembly, integration, and testing facilities. The CAS Innovation Academy for Microsatellites (IAMCAS) will provide the satellite bus and the propulsion and service modules.[10] CAS will

[10] "ESA Gives Go-Ahead for SMILE Mission with China," ESA (March 5, 2019) https://sci.esa.int/web/smile/-/61191-esa-gives-go-ahead-for-smile-mission-with-china, and Andrew Jones, "ESA, China Conduct Spacecraft-Rocket

also be responsible for mission operations after it is launched in 2025.

There have thus far been no efforts at international cooperation in human spaceflight. No Chinese astronauts have been part of either Soviet, Russian, or American spaceflights, nor has the PRC invited foreign astronauts onto any of the crewed missions conducted thus far by the Chinese space program. The PRC *has* included foreign instrument packages on its lunar missions. On the Chang'e-4 lunar lander, Dutch, Swedish, and Saudi instrument packages were included, and PRC authorities have already announced that French, Italian, and ESA instrument packages were incorporated into the Chang'e-6 mission.[11] With the announcement of a Chinese crewed mission to the Moon by 2030, it is likely that, in the longer term, the Chinese will undertake international cooperative efforts in their human lunar missions.

The Role of Human Spaceflight

For the PRC, human spaceflight has long been a core part of China's broader space program. Plan 863, the National High Technology

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Integration Tests, But Joint Science Mission Delayed to 2025," Space News (February 20, 2023)
https://spacenews.com/esa-china-conduct-spacecraft-rocket-integration-tests-but-joint-science-mission-delayed-to-2025/

[11] Leonard David, "With First Ever Landing on Moon's Far Side, China Enters 'Luna Incognita," *Scientific American* (December 21, 2018) https://www.scientificamerican.com/article/with-first-ever-landing-on-moons-farside-china-enters-luna-incognita/, and PRC State Council Information Office, "China Offers Int'l Cooperation Opportunity Via Chang'e Lunar Missions," Xinhua (November 25, 2022)
http://english.scio.gov.cn/internationalexchanges/2022-11/25/content_78537226.htm

Research and Development Plan (*guojia gao jishu yanjiu fazhan jihua*; 国家高技术研究发展计划), promulgated in 1986, has long served as a blueprint for major Chinese R&D efforts into key areas of technology, including aerospace. Aerospace projects were apparently grouped as "863-2," and include "863-204," a large-scale launch vehicle and space transportation system, and "863-205," a manned space station.[12]

Human spaceflight has also long been a focus of the top echelons of the Chinese leadership. The decision in 1991-1992 to commit the enormous sums (some 3 billion renminbi, or approximately $550 million at the time) necessary to place a Chinese astronaut in orbit involved the most senior political figures and reflected a high-level consensus that such a program would reflect the aspirations and capabilities of the Chinese nation and people.[13] Indeed, then-Premier Li Peng observed:

> Money is a difficulty. However, for a major nation such as ourselves, it is a resolvable issue. If we are to engage in "manned aerospace," then let us begin with a space capsule. Strive to achieve manned flight by the 50th anniversary of the founding of the nation! The 'Gulf War' warns us that, in order to maintain great power status, one must have a certain level of real power. Although we cannot

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[12] SHI Lei, ZHOU Wu, FENG Chunping, et. al., *Launching the Shenzhou* (Beijing, PRC: China Machine Press, 2003), p. 6, ZUO Saichun, *Chinese Astronaut Flight Documentary* (Beijing, PRC: People's Publishing House, 2003), p. 31, and SHU Wen, *"Shenzhou-VI" Background and Story* (Beijing, PRC: Chinese Language Press, 2005), p. 209.

[13] $1 = 5.514 RMB in 1992. ZUO Saichun, *Chinese Astronaut Flight Documentary* (Beijing, PRC: People's Publishing House, 2003), p. 37.

> engage in an arms race with the United States, in some areas, we must engage. If our nation is to engage in space capsules, we should start from our own roots![14]

Consequently, the decision to proceed with an indigenous space program reflected a true consensus. In 1992, meetings of the Central Special Committee (*zhongyang zhuanwei*; 中央专委), which was focused on the Chinese manned spaceflight program and included members of the Politburo and the Central Military Commission, formally authorized the effort to proceed. The minutes of the final meeting note that, because of the importance of a manned space program, and its impact on the Party, the nation, and the people, all of the members of the Central Special Committee, as well as the aerospace leading small group, would have to sign the minutes.[15]

Despite the enormous costs, the PRC persevered in developing its human spaceflight program through its own efforts. While it benefited from the "fire sale" of Soviet technology after the collapse of the USSR, the Shenzhou space capsule and Tiangong space

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[14] ZUO Saichun, *Chinese Astronaut Flight Documentary* (Beijing, PRC: People's Publishing House, 2003), p. 37.

[15] One source suggests that the minutes of the meeting where Li Peng demanded signatures were for the Fifth meeting of the Central Special Committee, held on January 8, 1992. ZUO Saichun, *Chinese Astronaut Flight Documentary* (Beijing, PRC: People's Publishing House, 2003), p. 43. Two of the other sources used here state that this occurred at the Seventh meeting of the Central Special Committee, which was held on August 1, 1992. SHU Wen, *"Shenzhou-VI" Background and Story* (Beijing, PRC: Chinese Language Press, 2005), p. 220 and SHI Lei, ZHOU Wu, FENG Chunping, et. al., *Launching the Shenzhou* (Beijing, PRC: China Machine Press, 2003), p. 11. Given the Chinese method of project nomenclature, it would seem more likely that the January 1992 meeting was seen as more significant.

station (and earlier Tiangong-1 and Tiangong-2 space labs) were indigenous programs. The PRC space establishment, and especially its human spaceflight efforts, is one of the main advertisements for Chinese policies promoting "indigenous innovation."

The symbolism attached to the Chinese human spaceflight program has been explicitly remarked upon by various Chinese leaders. In a December 2016 speech, Xi Jinping noted the "manned aerospace spirit (*zairen hangtian jingshen*; 载人航天精神)," one that would be emblematic of socialism with Chinese characteristics. This "manned aerospace spirit" reflects confidence in China's path, China's theory, China's administration, and Chinese culture.[16]

Given this prominence of the human spaceflight program, including the presence of General Secretaries Jiang Zemin, Hu Jintao, and Xi Jinping at various launches, every crewed launch is likely to be carefully scrutinized. The political impact of a failed launch, or of casualties, would likely be significant.

Involving foreign astronauts on a mission, then, would first and foremost be a *political* decision, and one that would likely involve the highest echelons of CCP leadership. The attendant risks would arguably be doubled, especially should there be an accident or failure. Nonetheless, Chinese officials have indicated that they are interested in including foreign astronauts in future missions. This has been expressed through both multilateral and bilateral engagements.

In 2016, Chinese and United Nations officials signed a Memorandum of Understanding, whereby the PRC committed to

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[16] Ministry of Education, China Association for Science and Technology, "The Manned Aerospace Spirit,"
http://www.kexueying.org.cn/cms/Partystudy/view?id=310

helping other UN member states develop their space capabilities through opportunities aboard the Chinese space station (which had not yet been placed in orbit).[17] Subsequently, Chinese space officials emphasized their interest in expanding engagement in human spaceflight. At the 2016 International Astronautical Conference, for example, Chinese officials gave a presentation on the "China Manned Space Programme and Opportunity for Cooperation."[18]

This was followed in 2018 by a joint ceremony between the UN Office of Outer Space Affairs (UNOOSA) and the China Manned Space Agency formally announcing opportunities and providing application instructions. At that meeting, it was stated that the Sino-UN effort was intended to

- Promote international cooperation in human space flight and activities related to space exploration;
- Provide flight experiment and space application opportunities on-board the CSS for United Nations Member States;
- Promote capacity-building activities by making use of human space flight technologies, including facilities and resources from China's human spaceflight program; and

[17] "United Nations and China Agree to Increased Space Cooperation," https://spacewatch.global/2016/06/united-nations-china-agree-increased-space-cooperation/

[18] "China Manned Space Programme and Opportunity for Cooperation," 67th International Astronautical Congress program (September 30, 2016), https://www.iafastro.org/events/iac/iac-2016/global-networking-forum/china-manned-space-programme-and-opportunity-for-cooperation.html

- Promote increased awareness among United Nations Member States of the benefits of utilizing human space technology and its applications.[19]

The reference to promoting human space flight technologies has often been interpreted as suggesting that China would help train other countries' astronauts at its own facilities. Since then, Beijing has repeatedly noted its interest and intent on expanding international participation in its human spaceflight program. In 2020, in a Xinhua news report, the China Manned Space Agency reportedly indicated that the Chinese space station would help "foster international exchanges and cooperation in the areas of equipment development, space applications, astronaut training, joint flights and aerospace medicine."[20] In 2023, senior Chinese manned space program officials again stated their intention to host foreign astronauts, and stated that "we will soon begin to select candidates from those nations for joint flights to our space station."[21]

Besides broad general commitments to the UN, China has also raised the prospect of cooperation in human spaceflight with

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[19] United Nations Office for Outer Space Affairs, "United Nations and China Invite Applications to Conduct Experiments Onboard China's Space Station," (May 28, 2018) https://www.unoosa.org/oosa/en/informationfor/media/2018-unis-os-496.html

[20] "China Focus: China Advances International Space Cooperation," Xinhua (July 13, 2020) http://www.xinhuanet.com/english/2020-07/13/c_139209385.htm

[21] "China Will Soon Train Foreign Astronauts for New Space Station," AP (February 28, 2023) https://www.pbs.org/newshour/science/china-will-soon-train-foreign-astronauts-for-new-space-station

potential partners. Such discussions have perhaps been most extensive with European space agencies and officials.

In 2012, Thomas Reiter, head of the European Space Agency's human spaceflight division, stated that his agency was looking into joint missions with the PRC, and said he would welcome a European astronaut flying aboard China's future space station.[22] Soon after those remarks were reported, China Manned Space Agency director general Wang Zhaoyao and China's first female astronaut, Liu Yang, met with then-ESA Director Jean-Jacques Dordain to discuss potential joint opportunities.[23] Notably, Dordain had expressed interest in ESA-Chinese manned spaceflight cooperation in 2007, a week after the PRC conducted its anti-satellite test.[24] Soon thereafter, a delegation of Chinese space officials from the Chinese astronaut training center visited the European Astronaut Center in Cologne, Germany, and was briefed on the European astronaut training program.[25]

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[22] Frank Jordans, "Europe Space Agency Explored Manned Missions with China," NBC News (September 11, 2012)
https://www.nbcnews.com/id/wbna48992819

[23] Rob Coppinger, "Europe May Work with China on Space Station," Space.com (February 26, 2013)
https://www.space.com/19960-china-space-station-europe-cooperation.html

[24] "European Space Agency Ready for Cooperation with China," Xinhua News Agency (January 19, 2007)
https://www.spacedaily.com/reports/European_Space_Agency_Ready_For_Cooperation_With_China_999.html

[25] Rob Coppinger, "Europe May Work with China on Space Station," Space.com (February 26, 2013)
https://www.space.com/19960-china-space-station-europe-cooperation.html

In 2013, ESA and Chinese officials formed three joint working groups, to discuss rendezvous and docking, crew training, and the exchange of payload facilities and experiments.[26] That effort apparently led to the sharing of details on the ESA's International Berthing and Docking Mechanism (IBDM) with their Chinese counterparts.

In 2014, Chinese and ESA officials signed an agreement concerning human spaceflight missions. Then-ESA Director Jean-Jacques Dordain noted that his agency would "always actively support the cooperation with China in the field of manned spaceflight, and is willing to continue to promote China into participating in the multilateral cooperation on the International Space Station."[27]

Dordain's successor, Johann-Dietrich Woerner, maintained close ties with the Chinese manned space effort. In 2017, ESA publicly disclosed that European astronauts were engaging in joint training with their Chinese counterparts, and had hosted at least one Chinese astronaut in 2016. As the press release noted, "The ultimate goal is for ESA to establish a long term cooperation with China and ESA astronauts to fly on China's space station."[28] Some European

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[26] Rob Coppinger, "Europe May Work with China on Space Station," Space.com (February 26, 2013) https://www.space.com/19960-china-space-station-europe-cooperation.html

[27] ZHANG Titi, "China Manned Space Agency Signed Cooperation Agreement with European Space Agency," (December 16, 2014) http://en.cmse.gov.cn/cooperationexchange/201412/t20141216_44773.html

[28] "ESA and Chinese Astronauts Train Together," (August 24, 2017) https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Astronauts/ESA_and_Chinese_astronauts_train_together

astronauts were even reportedly learning Chinese, to better function aboard the Chinese space station.[29]

In addition to European partners, China has also courted Middle East countries. In remarks at the China-GCC summit in 2022, Xi Jinping expressed his hope for "new breakthroughs in aerospace cooperation." This would include a joint effort to "select and train astronauts together, and China welcomes GCC astronauts to its space station for joint missions and space science experiments with their Chinese colleagues."[30]

Prospects for Foreign Crew on the Chinese Space Station

It should be noted that as of mid-2024, it is not clear whether any foreign candidates have, in fact, been selected for training in the PRC, or that any actual missions or crews involving foreign astronauts have been announced. This does not mean that the PRC will not, in fact, host one or more foreign personnel on their space station. Indeed, the inclusion in the Shenzhou-16 mission of Gui Haichao, a civilian mission specialist (i.e., not a trained astronaut), widens the range of potential candidates. China could choose a civilian, rather than an astronaut, as its first foreign crew member aboard the Tiangong.

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[29] Frank Sieren, "Sieren's China: Speaking Mandarin on Mars," Deutsche Welle (October 19, 2018)
https://www.dw.com/en/sierens-china-speaking-mandarin-on-mars/a-45964091

[30] "Full Text of Xi Jinping's Keynote Speech at China-GCC Summit," *China Daily* (December 10, 2022)
https://www.chinadaily.com.cn/a/202212/10/WS6393e690a31057c47eba3b6c.html

Meanwhile, Beijing's various announcements suggest that China's principles regarding international space cooperation apply to its human spaceflight program. The agreements and MoUs with the UNOOSA are consistent with the emphasis placed on the United Nations as the framework for international space endeavors. Meanwhile, its discussion of training of foreign astronauts, and its approach to the GCC, would appear to support the principle that space activities should support developing countries. This adherence to stated principles would suggest that the Chinese are likely to draw from members of regional groupings such as APSCO or the SCO for its first international partner. As BRICS has been specifically mentioned, that would be another likely source of candidate astronauts.

Chinese discussion partners similarly suggest that underlying motivations for human spaceflight engagement parallel those for broader space engagement. The various discussions with European partners, for example, have apparently already provided the CMSA with insight into how Europe selects and trains astronauts, and may have also provided information on the IBDM. This would appear to be an excellent return on a minimal investment, in terms of "learning from the West." As important, being courted by ESA, and even having European astronauts ostensibly learn Chinese, would certainly enhance Chinese prestige, for both international and domestic audiences.

China has also exploited the opportunities afforded by its current human presence to reinforce ties with various partner countries. The Shenzhou-14 mission in 2022 included a number of seeds provided by the Pakistan Science Foundation (PSF) to study the effects of cosmic radiation. The PSF invited students to write a letter to Chinese astronauts to discuss the experiment, space effects, and

their interest in science. The Chinese crew responded, and the overall exchange was reported in Pakistan. A Xinhua article suggested that the interplay "would motivate other students to study deeply about science and about Pak-China friendship."[31]A similar exchange occurred several months later, with Pakistani students invited to talk directly with members of the Shenzhou-15 crew. This exchange was under the auspices of the Shanghai Cooperation Organization and was again reported in local press.[32]

Finally, Beijing is almost certain to consider other national objectives (e.g., securing long-term access to resources, strategic terrestrial positions, and key partners) in selecting foreign candidates for the space station, much as this appears to be a consideration in China's international sales of satellites and other space services and capabilities. Given China's need for energy imports, for example, this is likely to be a factor in its active courting of the GCC states as a space partner. Its wooing of European space partners likely included complicating US-European relations as part of its motivation.

There is also likely to be the desire to demonstrate that China is able to both garner partners and make significant aerospace strides despite the imposition of sanctions by the United States and the West. As noted earlier, China's space program initially developed largely through indigenous innovation, during a period of

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[31] Xinhua, "Pakistani Girl's Letter to Chinese Astronaut Sparks Conversation on Space," *Pakistan Today* (February 18, 2023) https://www.pakistantoday.com.pk/2023/02/18/pakistani-girls-letter-to-chinese-astronaut-sparks-conversation-on-space/

[32] "Pakistani Students Chat with Chinese Astronauts," *The Express* (Pakistan) (April 21, 2023) https://tribune.com.pk/story/2413074/pakistani-students-chat-with-chinese-astronauts

self-imposed strategic isolation, but it nonetheless achieved world-class levels of capabilities. Demonstrating that today's Chinese space efforts can and will overcome such constraints would emphasize the parallels between past and present efforts. An article discussing the launch of the Shenzhou-12 mission prominently noted that the CMSA director, General Li Shangfu (formerly China's defense minister until he was removed on corruption charges in 2023) had been sanctioned by the United States.[33]

There may be added impetus for the Chinese to include a foreign partner, given the growing skepticism aimed at Beijing. In particular, the announcement in January 2023 by ESA Director-General Josef Aschbacher that Europe had neither the monetary nor political capacity to engage the PRC has deprived Beijing of a key potential partner, at least in the short term.[34] Any foreign astronaut on a mission to the Tiangong will clearly be acting under Chinese authority. A prominent Chinese space role, such as commanding a European or Russian astronaut, would underscore Xi Jinping's abandonment of the Deng Xiaoping dictum to "Observe calmly; secure our position; cope with affairs calmly; hide our capacities and bide our time; be good at maintaining a low profile; and never claim leadership," but in a way that would enhance Chinese prestige without necessarily raising alarms among China's neighbors or trading partners.

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[33] SHANG Guanghe, "63 Year Old General Issues Order to Three Astronauts: Launch!" *Shanghai Observer* (June 17, 2021) https://export.shobserver.com/baijiahao/html/377642.html

[34] Andrew Jones, "ESA No Longer Planning to Send Astronauts to China's Tiangong Space Station," *Space News* (January 25, 2023) https://spacenews.com/esa-is-no-longer-planning-to-send-astronauts-to-chinas-tiangong-space-station/

Given these considerations, one of the most likely candidate nations to provide China's first foreign astronaut would be ***Pakistan***. Pakistan is both a member of APSCO and the SCO. It is also a key strategic partner of the PRC, having been one of the first nations to have recognized the PRC, doing so in January 1950, and serving as a bridge between Beijing and many members of the Islamic world. A Pakistani astronaut aboard the Chinese space station would also send a signal to Delhi, reinforcing the message of close strategic ties between Beijing and Islamabad. In 2019, Pakistan and China initialed an agreement establishing a framework for Chinese training of Pakistani astronauts, with the expectation of a Pakistani mission to the Tiangong by 2022. Interestingly, the agreement was signed on the sidelines of the 2019 Belt and Road Summit.[35]

The status of Pakistan's astronaut program, however, is uncertain. Clearly, they did not succeed in training astronauts in time to meet the 2022 deadline. One news report of uncertain accuracy stated that, due to COVID, Pakistani Prime Minister Imran Khan was reportedly forced to suspend Pakistan's astronaut training program in 2020.[36]

Russia would seem to be a prime candidate for providing an astronaut to the Tiangong space station. Sino-Russian space cooperation would require relatively little effort by Beijing since Russia can train and even launch its own astronauts. A Russian

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[35] "Pakistan Signs Space Cooperation Agreement with China to Enable First Pakistani Astronaut," Space Watch Asia Pacific, https://spacewatch.global/2019/05/pakistan-signs-space-cooperation-agreement-with-china-to-enable-first-pakistani-astronaut/

[36] Juan Pons, "Pakistan Abandons Its Space Race with India to Put an Astronaut in Orbit in 2022," *Atalayar* (Madrid, Spain) (June 14, 2020) https://www.atalayar.com/en/articulo/society/pakistan-abandons-its-space-race-india-put-astronaut-orbit-2022/20200613085908146188.html

serving aboard the Chinese space station would be a significant political achievement for the PRC.

At the same time, however, such a move would also be seen as a de facto endorsement of the Putin regime, which in light of the Ukraine war, would potentially antagonize much of the West, and potentially push Europe further towards not only the United States, but also Taiwan. Given Beijing's relatively tepid support for Moscow (including, as of June 2023, no open provision of weapons systems or munitions to Russia), such a move would also appear to be somewhat out of phase with Beijing's broader Russia policy. As important, it is not clear whether *Russia* (or, more precisely, Vladimir Putin) would be willing to accept a secondary status, either in terms of mission operations or more generally as a reduced space power. The optics of such a mission would only reinforce the idea that Russia is increasingly the junior partner in the Sino-Russian relationship.

Brazil could be a logical choice for the PRC. The Sino-Brazilian space relationship is one of the oldest that the PRC has, and it has borne actual fruit. The BRICS relationship is being invigorated by Brazilian president Lula, who has openly called for the creation of a BRICS currency (which would heavily rely on the Chinese renminbi for credibility.) Although Brazil has a space launch capacity, it does not have a major astronaut program.

Much would likely depend on Brazil's leadership. While current President Lula da Silva would appear to be fairly pro-PRC, his predecessor Jair Bolsonaro was more disposed towards the United States. Under the latter's leadership, Brazil joined the Artemis Accords. This does not mean that Brazil could not work with the PRC, but it does reflect the relative uncertainty of Brazil's political stance. The option of sending a non-astronaut mission specialist,

however, suggests that Brazil (or other potential partners) is not necessarily constrained by the time it would take to train a cadre of astronauts in order to send a person to the Tiangong.

Iran would be an interesting possible partner. Given the recent China-brokered deal reconciling Iran and Saudi Arabia, the choice of an Iranian astronaut would not necessarily be as antagonizing towards Riyadh as it would have been even a year or two ago. China does not depend on Iran for oil as much as it depends on Saudi Arabia, however. Although China is one of the main purchasers of Iranian oil, importing about half a million barrels per day between November 2020 and March 2021, Iran was not even among the top 5 sources of Chinese oil imports in 2021.[37] It is therefore unclear what the strategic benefit of incorporating an Iranian, as opposed to Saudi or even UAE crew member, would be.

At the same time, although an Iranian astronaut would be less antagonizing to European space powers, it would almost certainly be seen as a negative signal in a number of European capitals, and certainly in Washington. The likelihood of such a choice is therefore likely to be heavily dependent on the broader state of China's relations with the West. If relations deteriorate further, such as one or more European countries elevating ties with Taiwan or a major

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[37] Shu Zhang, Chen Aizhu, and Sabrina Valle, "China's Iranian Oil Buying Spree Crushes Demand for Brazil, Angola Crude," Reuters (April 13, 2021) https://www.reuters.com/world/middle-east/chinas-iranian-oil-buying-spree-crushes-demand-brazil-angola-crude-2021-04-14/#:~:text=Middle%20EastChina's%20Iranian%20oil,demand%20for%20Brazil%2C%20Angola%20crude&text=China's%20record%20imports%20of%20Iranian,shipments%20to%20India%20and%20Europe, and Daniel Workman, "Top 15 Crude Suppliers to China," World's Top Exports (June 2023) https://www.worldstopexports.com/top-15-crude-oil-suppliers-to-china/

US arms sale, Beijing may well want to signal its unhappiness by making such a choice. Conversely, if US-PRC relations are improving, Beijing would almost certainly choose a different nation's astronaut, in order to avoid antagonizing Washington.

Similar considerations likely govern the prospect of a Chinese invitation to *Venezuela*.

It is almost inconceivable that the PRC would invite the *United States* to visit the Chinese space station. However, from a political maneuvering perspective, such an invitation is not entirely without merit. Should the PRC extend such an invitation, American decision-makers would have a difficult choice.

- Rejecting the Chinese overture would provide Beijing with an excellent opportunity to portray the United States as uninterested in the peaceful use of outer space and intensifying tensions.
- Accepting the Chinese offer would place Americans in a subordinate position to China, and provide Beijing with the opportunity to argue that in space terms, the PRC is clearly the equal of the United States.

It would behoove American policy-makers to have a ready response to any such invitation, however unlikely it may be.

International Engagement on Manned Lunar Missions

With Beijing's announcement that it intends to land a crew on the Moon by 2030, there is the longer-term question of foreign astronauts on a Chinese-led lunar mission.

China has already incorporated foreign payloads on a number of the Chang'e probes. The Chang'e-4, for example, carried German, Dutch, and Swedish instruments.[38] The Chang'e-6, scheduled for launch sometime between 2024 and 2025, will be carrying instruments from France, Italy, and the ESA.[39] It will also launch a Pakistani cubesat.[40] It is therefore clear that Beijing intends to exploit its lunar exploration program to build ties with foreign countries.

Moreover, Beijing's description of its human lunar program explicitly makes it international, beginning with the very name of the overall project, the "International Lunar Research Station." Chinese descriptions of the ILRS effort make clear that not only is the project open to all nations, but that its focus is on facilitating international scientific cooperation.[41] From its construction to the scientific tasks undertaken, all aspects of the ILRS will, ostensibly, involve a multinational effort.

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[38] Rui C. Barbosa, "China Lands Chang'e-4 Mission on Far Side of the Moon," NASASpaceFlight.com (January 3, 2019) https://www.nasaspaceflight.com/2019/01/china-returning-moon-change-4-mission/

[39] PRC State Council Information Office, "China Offers Int'l Cooperation Opportunity via Chang'e Lunar Missions," Xinhua (November 25, 2022) http://english.scio.gov.cn/internationalexchanges/2022-11/25/content_78537226.htm

[40] Andrew Jones, "China Seeks New Partners for Lunar and Deep Space Exploration," *Space News* (September 28, 2022) https://spacenews.com/china-seeks-new-partners-for-lunar-and-deep-space-exploration/

[41] CNSA Deep Space Exploration Laboratory, "International Lunar Research Station," Presentation at COPUOS Plenary (June 1, 2023) https://www.unoosa.org/documents/pdf/copuos/2023/TPs/ILRS_presentation20230529_.pdf

One consideration is that China's lunar exploration program (whether manned or unmanned) is more recent than its interest in human spaceflight. As far as is publicly known, the lunar program was not part of Plan 863. The Commission on Science, Technology, and Industry for National Defense (COSTIND), which oversaw much of the Chinese military-industrial establishment and major strategic R&D projects, only began to study a lunar exploration program in 1998. The program itself was formally announced in 2004, with a three-phase program of an orbiter, a lander, and a sample retrieval mission.[42] That program was completed with the Chang'e-5 mission and the successful return to Earth of the probe with a payload of lunar samples. Chinese statements reflect the idea that the original lunar exploration program has now been completed. The Chinese Academy of Sciences stated, for example, "The success of the Chang'e-5 lunar mission marks the completion of the three-step plan of China's lunar exploration program."[43]

Another consideration may be the apparent difference in how the lunar exploration program has been managed, compared with the human spaceflight effort. The human spaceflight program's leading small group has generally been led by a senior PLA officer, such as the head of the General Armaments Department or (since 2015) the

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[42] "Factbox: China's Timeline of Lunar Exploration," Xinhua (December 17, 2020)
http://www.xinhuanet.com/english/2020-12/17/c_139597269.htm

[43] CHEN Na, "Chang'e-5 Completes Moon Sampling and Reentry Mission," Chinese Academy of Sciences
https://english.cas.cn/Special_Reports/rd/2020/202210/t20221018_321769.shtml

Equipment Development Department.[44+] By contrast, the lunar exploration program has often had a civilian at its head.

These considerations may suggest that the Chinese leadership views the lunar program in a different light than the human spaceflight program. Civilian leadership of the former suggests, for example, that it may not be as influenced by strategic military (as opposed to political) considerations. This may mean that there are more options for international engagement within the lunar exploration program than in the human spaceflight program—with unclear implications for when the two elements merge.

For example, will the head of the human lunar mission program and any associated leading small group be drawn from the PLA, or from the civilian leadership? What role, if any, will be accorded the PLA in the administration and management of the ILRS? The role accorded the PLA may affect China's choices of partner astronauts. There has thus far been little public discussion of what the ILRS staffing procedure will be.

Separate but related is where future astronaut crews for the ILRS will be trained. While China has offered to train astronauts at its facility to staff the Chinese space station, the joint Russo-Chinese

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[44+] Leading small groups (*lingdao xiaozu*; 领导小组) are Chinese organizational entities that combine top Party and state officials, linking policy-setting and policy-implementation figures and bureaucracies by bringing together all of the relevant stakeholders. These groups exist at all levels of bureaucracy and indicate a priority issue at that level. For a more extensive discussion of leading small groups, see Alice Miller, "The CCP Central Committee's Leading Small Groups," *China Leadership Monitor* (Fall 2008, #26) (https://www.hoover.org/sites/default/files/uploads/documents/CLM26AM.pdf

role in planning the ILRS raises questions about the balance between the two states in staffing.

Indeed, Russia has a far longer track record of training foreign astronauts and mission specialists. It likely has both more experience and potentially more capacity to train a number of astronauts and mission specialists. Notably, aside from some earlier dispatch of Chinese astronauts to train at Russian facilities in the 1990s, there is little public information regarding Sino-Russian space cooperation in human spaceflight, including whether there have been any recent moves to expand joint or cross-training.

The political situation due to Ukraine, moreover, may mean that third parties interested in participating in ILRS may have little choice but to train in the PRC. Indeed, Sino-Russian announcements regarding the ILRS suggest that broader political considerations already are influencing at least some of the public messaging.

From the initial announcement of the establishment of the ILRS in 2021, Russia has been acknowledged as a partner in the effort. This would leverage Moscow's extensive history with human spaceflight, and especially the effect of prolonged exposure to microgravity conditions, as well as extended periods of operating in the confined environment of a space station. In the wake of the Russian invasion of Ukraine, both Beijing and Moscow are also incentivized to varying extents to demonstrate shared strategic perspectives, especially in defying Western pressure.

Nonetheless, Russia's role was downplayed in Chinese materials at both the International Astronautical Conference in September 2022

and at the UN COPUOS meetings in June 2023.[45] This may have been in reaction to the broader international condemnation of Russia since its invasion of Ukraine. Although there is no evidence that Russia is no longer part of the ILRS effort, it does raise the question of whether Russia and China are still nominally equal in the effort, or whether the PRC will be the "majority shareholder" in the project across financial, technological, and administrative functions.

Chinese partnerships regarding ILRS may be further complicated by the ongoing tensions between the PRC and the United States with regard to space activities. The UAE has had to withdraw its planned rover from the Chang'e-7 mission, due to US arms export control restrictions.[46] Similar obstacles may arise with other countries who might be interested in going to the ILRS.

This may be exacerbated by a budding rivalry between the Chinese-sponsored ILRS and the American-supported Artemis Accords. Each effort is not only intended to draw other states into a coalition for lunar missions, but express potentially divergent views of space governance, space traffic management, and operational and

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[45] Andrew Jones, "China Seeks New Partners for Lunar and Deep Space Exploration," *Space News* (September 28, 2022) https://spacenews.com/china-seeks-new-partners-for-lunar-and-deep-space-exploration/ and CNSA Deep Space Exploration Laboratory, "International Lunar Research Station," Presentation at COPUOS Plenary (June 1, 2023) https://www.unoosa.org/documents/pdf/copuos/2023/TPs/ILRS_presentation20230529_.pdf

[46] Andrew Jones, "China Loses UAE as Partner for Chang'e-7 Lunar South Pole Mission," *Space News* (March 24, 2023) https://spacenews.com/china-loses-uae-as-partner-for-change-7-lunar-south-pole-mission/

equipment standards for lunar activity. Notably, the UAE is a signatory to the Artemis Accords, even as it is interested in cooperating with the PRC.

In April 2023, China publicly invited Venezuela to participate in the ILRS.[47] This is the first country formally invited to join Russia and China. As such, it is striking since China has not publicly invited any nation to send an astronaut to the Chinese space station (as opposed to general statements "welcoming" foreign participation), nor has Venezuela generally been discussed as a potential initial visitor. Moreover, whereas Peru is a member of APSCO, Venezuela is not, nor is it involved with BRICS or SCO.

Conclusions

The PRC has long viewed space as a vital theater of international competition. Human spaceflight epitomizes many aspects of this, as manned missions inevitably garner more attention, and demonstrate multiple aspects of comprehensive national power.

For the PRC, international engagement in all aspects of spaceflight, but especially in the area of crewed missions, does not appear to be driven by financial considerations (a major animating element in Western cooperative space programs). Moreover, as China's space industrial complex appears capable of meeting mission requirements, Beijing does not have to rely on international partners for critical technologies or capabilities. China's own astronaut corps and body of potential mission specialists will also most likely meet most of its own mission requirements. In short, Beijing can afford to

[47] Andrew Jones, "China Invites Venezuela to Joint Moon Base Project," *Space News* (April 6, 2023) https://spacenews.com/china-invites-venezuela-to-join-moon-base-project/

choose whether, when, and how to engage others in space, especially in such high-profile aspects as human spaceflight.

In that light, PRC decisions to undertake cooperative crewed missions, whether to the Chinese space station or eventually to the Moon, are likely to reflect Chinese priorities that extend beyond the space realm. Enhancing Chinese prestige to domestic and foreign audiences, using a mission to incentivize terrestrial trade or security deals, strengthening ties with key partners, or undermining key Western (especially American) relations will likely be key considerations. Because of the Chinese space program's relative financial and technological independence (i.e., Beijing has not joined other states to gain financial support or access to key technologies), international cooperation is far more "nice to have," rather than essential. This affords Beijing significant freedom of action in its choices and enables *engagement* rather than *cooperation*.

China's Space Efforts Beyond Earth Orbit

Over the past several years, space analysts of the People's Republic of China (PRC) have increasingly turned to the issue of Earth-Moon space (*diyue kongjian*; 地月空间). This region is defined by Chinese writers as near-Earth space (including the common orbital regimes), lunar space or the lunar gravitational well, and the Earth-Moon transfer space.[48]

This aligns closely with what Western analysts term "cis-lunar space," which is variously defined as the volume of space "lying between the Earth and the Moon or the Moon's orbit";[49] "the area between geosynchronous orbit and the moon's orbit";[50] and

> the spherical volume that extends outward from Earth's geosynchronous region to encapsulate the moon's orbit and its Lagrange points, or "L points"—defined as the locations where the

[48] "Earth-Moon Space Development and Intelligence Autonomous Aerospace Systems," *China Science Newspaper* (December 19, 2019), http://www.zggxkjw.com/content-20-5194-1.html

[49] Laura Duffy and James Lake, "Cislunar Space Power: The New Frontier," *Space Force Journal* (December 31, 2021) https://spaceforcejournal.org/3859-2/

[50] Jeff Baxter, "Growing Interest in Cislunar Space Activities," AGI (February 10, 2020) https://www.agi.com/missions/space-operations-missions/growing-interest-in-cislunar-space-activities

> combined gravitational acceleration due to the Earth and moon allow a small object, such as a spacecraft, to orbit the Earth at the same rate as the moon.[51]

For the purposes of this paper, the third, most expansive definition will be used in referring to Western concepts of cis-lunar space unless otherwise specified. To differentiate Chinese from Western discussions, we will employ the Chinese term "Earth-Moon space" when referring to Chinese concepts and discussions.

Chinese Interest in Outer Space

The leadership of the Chinese Communist Party (CCP) has demonstrated a consistent interest in the outer space domain since the dawn of the Space Age. Chinese leaders, beginning with Mao Zedong, have expressed the belief that the PRC must field its own space effort. Mao himself called for an indigenous Chinese space program, stating at the Second Plenum of the Eighth Party Congress, in May 1958, that "we should also manufacture satellites (*women yie yaogao renzhao weixing*; 我们也要搞人造卫星)."[52] As a result, the PRC established the Fifth Research Academy of the Ministry of National Defense, responsible for missile development, with Qian Xuesen at its head. Chinese histories of their space, missile, and strategic weapons programs generally date their start to the founding of the Fifth Academy. The initial space program,

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[51] Michael Byers and Aaron Boley, "Cis-lunar Space and the Security Dilemma," *Bulletin of the Atomic Scientists* (January 17, 2022) https://thebulletin.org/premium/2022-01/cis-lunar-space-and-the-security-dilemma/

[52] DENG Liqun, ed., *China Today: Defense Science and Technology*, Vol. I (Beijing, PRC: National Defence Industry Press, 1993), p. 356.

Project 581, reflects this 1958 start date. This interest has been sustained by the current Chinese leader Xi Jinping. Xi has called for China to become a major aerospace power by 2045.[53]

This longstanding interest has been motivated by a combination of factors, including political prestige, strategic deterrence, fostering technological innovation, and bolstering economic development. Space capabilities are seen as supporting each of these elements, enhancing China's overall "comprehensive national power." China's efforts to develop satellites were part of the "two bombs, one satellite" effort, highlighting China's ability to indigenously develop advanced technologies (nuclear fission, fusion weapons design, and satellite and rocket engineering), and in turn, enhancing China's strategic deterrence capacity.

This perception of space capabilities as tied to, and enhancing, broader "comprehensive national power" remains in place. As the 2022 Chinese space white paper notes, the effort to become a major space power (*hangtian qiangguo*; 航天强国) will help China to also become a major scientific and technological power (*keji qiangguo*; 科技强国), major manufacturing power (*zhizao qiangguo*; 制造强国), major network power (*wangluo qiangguo*; 网络强国), and major transportation power (*jiaotong qiangguo*; 交通强国).[54]

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[53] CAI Yangshe, "Accelerate the Push to Become a Major Aerospace Power," *Financial Daily* (June 10, 2021), http://www.xinhuanet.com/techpro/2021-06/10/c_1127549434.htm

[54] PRC State Council Information Office, *China's Space Program: A 2021 Perspective* (Beijing, PRC: SCIO, 2022), http://english.www.gov.cn/archive/whitepaper/202201/28/content_WS61f35b3dc6d09c94e48a467a.html

The PRC has employed its space capabilities to enhance its foreign policy, as well as improve its military capabilities.[55] China's economy benefits from systems integration and systems engineering skills nurtured in the aerospace industrial sector. The CCP gains in stature and reinforces its legitimacy by making major aerospace accomplishments. Xi himself has praised the aerospace community for its advances, which help mark the 100th anniversary of the founding of the CCP.[56]

Similarly, the PRC has exploited its space capabilities to help effect deterrence. The People's Liberation Army (PLA) operates more effectively thanks to weather data derived from space; communications and data relay satellites that allow forces to coordinate across vast distances; and China's domestic position, navigation, and timing (PNT) Beidou constellation that enables the employment of precision-guided munitions.

By creating a major space infrastructure of its own, the PRC has also gained a better understanding of the capabilities, advantages, and disadvantages of space systems. Now that China has developed its own space planes, for example, it probably has a better understanding of the capacities and limits of the X-37B. Similarly, it is likely that the PLA has a much better understanding today of what space capabilities can provide terrestrial operations, but also the limits of that support.

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[55] Dean Cheng, *How China Has Integrated Its Space Program into Its Broader Foreign Policy*, China Aerospace Studies Institute (March 2021) https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/CASI%20Articles/2021-03-29%20China%20Space%20and%20Foreign%20policy.pdf?ver=kfO2J-IInVZmNQSjwfM0Yg%3D%3D

[56] CAI Yangshe, "Accelerate the Push to Become a Major Aerospace Power," *Financial Daily* (June 10, 2021), http://www.xinhuanet.com/techpro/2021-06/10/c_1127549434.htm

Throughout the Space Age, the PRC has pursued space development in ways that are not congruent with American, Russian, or European approaches. This is because the CCP has fit its space program to its own perceived interests and objectives, as well as national conditions; unsurprisingly, it has not simply replicated foreign space programs or policies.

This will be even more true in the realm of cis-lunar space. At present, no nation has undertaken major efforts to exploit the volume of space encompassing the Earth-Moon system as well as associated gravitational wells and such areas as the Lagrange points. While various spacecraft have transited this region, the focus has largely been on scientific exploration (e.g., the James Webb Space Telescope, and the crewed and uncrewed landings on the Moon). Using the region to support terrestrial missions or in order to generate revenue has thus far been limited at best.

In examining Chinese writings, while there is a fair amount of discussion of exploiting cis-lunar space in a variety of Chinese language sources, it is not clear that there is an official policy in place for cis-lunar space, whether in terms of exploration, exploitation, or strategic approach. Chinese writings *do* suggest that Beijing has at least a nascent effort underway to actively exploit the region, beginning with the establishment of longer-term goals and associated programs to support these goals.

One element that is likely to emerge is a Chinese focus on space applications, rather than space science. At least as early as 2007, Chinese analyses of future space development trends suggested that they saw satellite applications as central to both space development

but also national economic development.[57] In 2011, consistent with the 11th Five Year Plan, Chinese aerospace planners prioritized "application satellites and satellite applications," incorporating it into that year's space white paper.[58]

In the cis-lunar context, it is notable that China is the first nation to deploy an "applications satellite," rather than a scientific satellite (such as the James Webb Space Telescope) to a Lagrange point. Given China's emphasis on deploying "application satellites（*yingyong weixing*; 应用卫星）," i.e., satellites that specifically support national economic or military purposes, it is likely that a similar priority will exist in Chinese satellites deployed to the Earth-Moon space. That is, there is likely to be more of a focus on deploying satellites that can support various terrestrial missions rather than those oriented towards purely or primarily scientific exploration. "Application satellites" would include data relay satellites, communications satellites, and potentially space surveillance satellites. It might also include PNT systems to support operations on the lunar surface.

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[57] State Development and Reform Commission and Commission on Science, Technology and Industry for National Defense, "Some Views on Promoting the Satellite Applications Industry" (November 16, 2007) http://www.cnsa.gov.cn/n615708/n620168/n620180/130839.html

[58] State Council Information Office, "White Paper: China Will Preferentially Plan for Application Satellites and Satellite Applications," Xinhuanet (December 31, 2011) http://www.scio.gov.cn/ztk/dtzt/69/11/Document/1073605/1073605.htm

China's Official Goals Regarding Earth-Moon Space

Some of these goals that at least implicitly involve cis-lunar space are enumerated in the 2022 PRC space white paper "China's Space Program: A 2021 Perspective." Chinese space white papers, issued every five years, are the most authoritative open-source documents on their space program. They seem to be keyed to the five-year plans, and provide more detailed information, including programmatic objectives, in support of the broader goals laid out in the five-year plans.

Consequently, the white papers are the product of bureaucratic agreement and compromise, involving all the relevant stakeholders, much like the more extensive five-year plans. This presumably includes not only the military, the Ministry for Industry and Information Technology (MIIT) and its subordinate entities (e.g., the State Administration for Science, Technology, and Industry for National Defense, the China National Space Administration), and the relevant state-owned enterprises (CASC, CASIC), but also budget authorities such as the State Development and Reform Commission (SDRC) and Ministry of Finance.[59]

The 2022 space white paper lays out China's space-related goals over the next five years, presumably in line with the 14th Five-Year Plan (2021-2025). According to this new space white paper, China's space program will be pursuing several goals in this timeframe. In addition to completing the Chinese space station, and construction

[59] Conversations with PLA officers regarding the formulation of China's defense white papers indicate that those white papers are the product of various inter-departmental meetings. The author is inferring a comparable approach for the space white papers.

of a number of new satellite programs, operations in cis-lunar space are expected to include:

- A sample retrieval mission to an asteroid.
- Lunar resource cataloging and surveys to support the eventual establishment of a lunar facility. In addition, there will be a sample retrieval mission aimed at one of the lunar poles.
- Research and development on technologies associated with a mission to Jupiter and its moons.[60]

To achieve these missions, the PRC will have to develop the necessary supporting capabilities and infrastructure. The white paper notes that one key area of development will be space launch systems. This will include expanding the current Long March family, to include new human-rated launchers, "high-thrust, solid-fuel carrier rockets," and new heavy-lift launch vehicles. It will also include research on reusable launch systems, with the expectation that this five-year period will see flight tests of such systems. Subsequent Chinese statements indicate that the Long March-8 and Long March-10 are part of this new family.

Notably, another area of research will be in rocket engines, "in response to the growing need for regular launches."[61] The white paper also notes the need to establish an improved TT&C

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[60] PRC State Council Information Office, *China's Space Program: A 2021 Perspective* (Beijing, PRC: SCIO, 2022), http://english.www.gov.cn/archive/whitepaper/202201/28/content_WS61f35b3dc6d09c94e48a467a.html

[61] PRC State Council Information Office, *China's Space Program: A 2021 Perspective* (Beijing, PRC: SCIO, 2022), http://english.www.gov.cn/archive/whitepaper/202201/28/content_WS61f35b3dc6d09c94e48a467a.html

architecture, to allow for mission support not only for terrestrial orbits but also lunar and Martian missions.

According to the white paper, there will not only be improvements in technology, but additional efforts to strengthen organizational and policy aspects. For example, the white paper notes that China will improve its "space environment governance system," which will include:

- Space traffic control
- Space debris monitoring
- In-orbit maintenance of spacecraft
- Collision avoidance and control[62]

These various goals are consistent with a number of Chinese articles and discussions regarding Earth-Moon space, including the development of the "Earth-Moon space economic zone (*diyue kongjian jingji qu*; 地月空间经济区)." These additional articles and discussions, while not as authoritative as the space white paper, do provide some possible indications of Chinese lines of effort in developing Earth-Moon space.

One area of Chinese interest is in space traffic management. From the PRC perspective, research and development in space traffic management, and associated investments in relevant computing technologies can support the development of greater "intelligence-ization" in the PRC, with rippling benefits affecting the broader economy.

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[62] PRC State Council Information Office, *China's Space Program: A 2021 Perspective* (Beijing, PRC: SCIO, 2022), http://english.www.gov.cn/archive/whitepaper/202201/28/content_WS61f35b3dc6d09c94e48a467a.html

"Intelligence-ization (*zhineng hua*; 智能化)" is the natural effect of the ongoing revolution in information technologies. From the Chinese perspective, if "informationization" (*xinxihua*; 信息化) of the Chinese economy and society involved improving information technology to facilitate communications between people and among organizations, then "intelligence-ization" is the next step, as machines talk directly to other machines.

The concept of intelligence-ization goes beyond incorporating more artificial intelligence and machine learning into various platforms and systems. It involves "edge computing," where data is processed and analyzed at or close to where it is created (e.g., at the sensor), coupled with the Internet of Things.[63] Intelligence-ization also incorporates big data and cloud computing, with the overall goal of better handling the huge amounts of data that are now flowing through the various networks.

Successful space traffic management, especially in the face of proliferated constellations and expanding numbers of space players, makes intelligence-ization an absolute necessity. The speed of satellites, and the potential numbers of satellites, will require responses faster than earth-bound human controllers can likely accommodate. Moreover, incorporating more onboard sensors (and the ability to respond autonomously) will arguably improve flight safety while maintaining mission assurance.

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[63] "What Is Edge Computing?" IBM https://www.ibm.com/topics/edge-computing#:~:text=Edge%20computing%20is%20a%20distributed,times%20and%20better%20bandwidth%20availability.

Chinese Interest in the Earth-Moon Space

Two regular Chinese commentators on the importance of the Earth-Moon space are Lieutenant General ZHANG Yulin and Dr. BAO Weimin.[64*] It should be emphasized that it is not clear, in reviewing their writings and interviews, in what capacity (personal, bureaucratic, official governmental) they are promoting the Chinese development of Earth-Moon space. (Their biographies are included as appendices at the end of this paper.)

What is clear is that Zhang and Bao, together, lay out a number of considerations that appear to be animating Chinese interest in the Earth-Moon space. Both authors note that Earth-Moon space would provide significant resources to support both further space missions and terrestrial economic activities. Both also note that pushing the development of Earth-Moon space would lead to significant technological advances in a variety of fields.

To support the development of Earth-Moon space, and especially to realize an Earth-Moon space economic zone, both authors recognize the importance of improving China's foundational capabilities. This includes modernization and expansion of its launch sites, TT&C, and space industrial support, to reduce costs of spaceflight generally. Notably, these considerations are enumerated in the 2022 space white paper.

Each author also separately identifies additional considerations for expanding China's capacities to operate in and exploit Earth-Moon space.

[64*] Chinese names will be presented in this paper with the surname capitalized.

Zhang Yulin

In several articles, Zhang describes the Earth-Moon space as vital to Chinese interests for several reasons.[65]

- It is a region that contains vital orbital regimes. These include lunar transfer orbits, as well as Earth-Moon stationary orbits, which may refer to the Lagrange points. Zhang notes that these are the orbits that will most likely see significant development, including the construction of facilities.[66]
- Spacecraft launched from Earth-Moon space require less energy to go elsewhere than if launched from the Earth's surface. Zhang notes that a spacecraft could more easily reach a passing asteroid from geosynchronous orbit than from Earth's surface.[67]
- There are significant resources in Earth-Moon space. He notes, for example, the potential utility of water from the Moon.

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[65] China Automatization Committee, "CAC2019 Guiding Report—LTG ZHANG Yulin: Earth-Moon Space Development and Intelligence-ized and Autonomous Aerospace Systems" (January 30, 2020), https://www.gongkongke.com/posts/9y5jQuODmEVK

[66] ZHANG Yulin, "Earth-Moon Space Development and Intelligence-ized, Autonomous Aerospace Systems," *China Science and Technology Newspaper* (December 19, 2019), http://news.sciencenet.cn/sbhtmlnews/2019/12/352145.shtm

[67] ZHANG Yulin, "Earth-Moon Space Development and Intelligence-ized, Autonomous Aerospace Systems," *China Science and Technology Newspaper* (December 19, 2019), http://news.sciencenet.cn/sbhtmlnews/2019/12/352145.shtm

In order to take full advantage of the orbits, energy savings, and various resources, Zhang notes the importance of accelerating the development of artificial intelligence and autonomous space vehicles. Operations in Earth-Moon space will often involve proximate flight activities (*linjin feixing*; 临近飞行), or rendezvous and proximity operations (RPOs). This will be necessary both for the conduct of some missions (e.g., in-space construction activities), as well as for in-flight servicing of satellites. One Chinese analysis notes that the various Chinese Tiangong spacelabs and space station are providing excellent opportunities to practice in-orbit refueling. According to this analysis, China had, as of 2019, undertaken three refueling missions transferring some 700 kg of fuel from the Tianzhou robotic supply vessel to the Tiangong space labs.[68]

As activities in Earth-Moon space increase, there will be a concomitant increase in the number of proximate flight activities, as well as increased traffic in the region in general (including the transfer orbits). This is implicit in the idea of routinized space transportation through this volume of space. This increased pace of activities in turn means that they cannot rely upon human operators on Earth, because of the time lag and frequency. Instead, they require intelligence-ized, autonomous aerospace systems (*zhineng zizhu de hangtian xitong*; 智能自主的航天系统), wherein "the spacecraft and the terrestrial control and surveillance are isolated," that is, the former is no longer directly controlled by the latter.[69]

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[68] "Earth-Moon Space Development and Intelligence Autonomous Aerospace Systems," *China Science Newspaper* (December 19, 2019), http://www.zggxkjw.com/content-20-5194-1.html

[69] China Automatization Committee, "CAC2019 Guiding Report—LTG ZHANG Yulin: Earth-Moon Space Development and Intelligence-ized and Autonomous Aerospace Systems" (January 30, 2020), https://www.gongkongke.com/posts/9y5jQuODmEVK

This, in turn, will lead to a need for more sophisticated artificial intelligence capabilities, and devolution of decision-making to onboard systems and sensors.

From Zhang's perspective, then, successful operations in the Earth-Moon space will necessitate advances in artificial intelligence and the broader "intelligence-ization" of spacecraft, allowing them to engage in formation flying and RPOs, both in terms of conducting their missions but also in terms of routine servicing.

Zhang also suggests that autonomous robots will be an essential part of cis-lunar operations, including the initial construction of any kind of Moon-based facility. This is consistent with the 2022 Chinese space white paper's discussion of future lunar missions. The white paper did not indicate how China might develop either manned or unmanned facilities, but as subsequent announcements have indicated, Beijing is intent on landing a human crew on the Moon. That does not mean, however, that it would not also pursue one or more *unmanned* facilities on the Moon.

Bao Weimin

BAO Weimin, like Zhang, has been writing about the Earth-Moon region for a number of years. He has noted that most space-faring powers have focused on scientific missions to the Moon, asteroids, and Mars.[70] Bao, however, seems to conceive of a far more ambitious and comprehensive approach. Bao's writings and media commentary suggest that he sees a routinized space transportation

[70] LIU Lili, "BAO Weimin: New Economic Views on Developing the Earth-Moon Space Economic Region," *China Science Newspaper* (December 13, 2018), http://www.cas.cn/zjs/201812/t20181213_4673769.shtml

system as an absolute prerequisite to the development of a true Earth-Moon space economic zone.

The initial focus would be on improving transportation from the Earth's surface to space and making it a regular service. This would include supporting the construction of the Chinese space station and deploying new generations of satellites (including proliferated constellations). Eventually, this would evolve into an Earth-Moon transportation system-of-systems, including Earth-space, space-space, and space-Moon and space-Lagrange point activities.

At various times, Bao has provided more details regarding this approach. At a 2019 conference commemorating the 40th anniversary of the establishment of the CASC First Academy (China Academy of Launch Technology) Science and Technology Committee (of which Bao is a member and may have headed at the time), Bao presented a report, "Some Thoughts Regarding the Development of Earth-Moon Space (*Guanyu Kaifa Diyue Kongjian de Ruogan Sicao*; 关于开发地月空间的若干思考)."[71]

According to Chinese press coverage of the CASC meeting, Bao laid out a series of steps that could be taken to establish an Earth-Moon space economic zone, beginning with less expensive, more reliable rockets, and then the creation of a routinized Earth-Moon space transportation network. This would facilitate space resource exploration and the construction of key space facilities, some of which would be in orbit. The end result would be an Earth-Moon space economic zone which would promote enormous economic activity.

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[71] "Our Nation Strives in This Century to Build an Earth-Moon Space Economic Zone," *China Science and Technology Newspaper* (November 1, 2019), http://www.xinhuanet.com/politics/2019-11/01/c_1125179024.htm

Bao's report apparently breaks this development effort into two phases. The first, taking up the decade of the 2020s, would involve research on key technologies and processes. Beginning in 2030 through 2040, the actual space transportation system would then be built.

Notably, this aligns with a comparable two-part program proposed by CASC to help make China a "major aerospace power (*hangtian qiangguo*; 航天强国)" by the 2040s.[72] In the first phase, which would run through 2030, CASC would become a world-class aerospace business, supporting national defense and military modernization goals, and helping establish China as one of the world's foremost aerospace powers. In the second phase, through 2045, by promoting comprehensive improvement of quality and development, CASC would help elevate China's science and technology, economy, and military to make China the foremost global aerospace power.

The key prerequisite, in Bao's framework, is a routinized space transportation system, centered around more reliable, less expensive launch vehicles. The Chinese space station supports the development of such a system. Given the station's larger size, a number of launches are necessary for its construction. Each of the modules, for example, will require a separate flight. Keeping the station staffed and supplied also requires a steady series of flights to replace the crew and provide consumables. Indeed, even at this stage, the PRC has massively increased the frequency of its crewed flights, as it has dispatched seven crews to the Chinese station since the Tianhe core module was deployed in 2021, averaging one every six

[72] SUN Zhifa, "CASC: By 2045, Comprehensively Building a Global Aerospace Power," China News Net (August 30, 2018), https://www.chinanews.com.cn/m/gn/2018/08-30/8614400.shtm

months. This compares with a previous launch tempo of a single manned mission every 2-3 years.

Bao's characterization of the PRC's human spaceflight program, as a means of establishing the technological and industrial footing to support China's cis-lunar activities is echoed by ZHANG Yulin. Zhang at one point notes that the development of human-rated spacecraft and associated launchers has had the ancillary effect of also making *all* Chinese spacecraft and launchers more reliable.[73] This trend would help in the routinization of flights to cis-lunar space.

In a subsequent paper, Bao suggests that a comprehensive space transportation system should include three elements:

- Using space systems to transport products and people from point to point on Earth in about two hours.
- A transportation network between Earth and orbital destinations
- A space-to-space transfer network[74]

To construct this system, Bao suggests that several technological shifts will be necessary. One will be a heavier reliance on hypersonic transports *(gao chaoshengshu yunshu* ; 高超声速运输), in order to be able to rapidly reach any point on Earth. To keep costs down, the launchers and transports will also have to be reusable. Finally, they would employ a different set of engines. Bao suggests a shift from

[73] ZHANG Yulin, "Shifting from an Earth-Centric to a Earth-Moon Space Focus," *People's Daily* (May 8 2019), http://scitech.people.com.cn/gb/n1/2019/0508/c1007-31072780.html

[74] BAO Weimin, WANG Xiaowei, "Academician BAO Weimin: Routinized Aerospace Transportation System Development Outlook," *Satellites and Networks* (June 26, 2021), https://jishuin.proginn.com/p/763bfbd5e019

current systems that rely on toxic fuel to one that would be more green (presumably meaning less toxic). Interestingly, he suggests a combination of "low-temperature" propulsion systems and high-power electric systems. This may refer to a shift from hypergolic fuels towards cryogenically fueled engines (which use less toxic fuels), and electric propulsion systems for sustained power across cis-lunar space. An additional element he notes is that the systems would also have to be built to common standards, implying modularity.

In the reviewed literature, Bao does not discuss the importance of space traffic management, but a routinized transportation system will implicitly require a space traffic management system, including an expanded PNT network to facilitate satellite navigation and monitoring. It is unlikely, given China's strategic considerations, that it would choose to rely upon the United States or a multinational organization to provide such a system. Instead, Beijing would prefer to have an indigenous space traffic management infrastructure. Interestingly, in 2024 a group of Chinese scientists proposed the construction of a comprehensive lunar space support infrastructure that would provide PNT, data communication, and space situational awareness capacity.[75]

PLA Interest in Cis-Lunar Space

As has been extensively discussed in a variety of Chinese reports and assessments, the PLA has had a longstanding interest in outer space, as a key domain for future warfare. Moreover, the PLA is the

[75] YANG Mengfei, PENG Jing, LI Jionghui, NI Yanshuo, ZHU Shunjie, DU Ying, XU Baobi, HUANG Xiaofeng, ZHANG Zhengfeng. Architecture and Development Envision of Cislunar Space Infrastructure. Chinese Space Science and Technology, (XLIV, 3, 2024).

operator of most of China's space-related infrastructure, first under the General Armaments Department, then the PLA Strategic Support Force, and now under the Aerospace Support Force (ASF). Consequently, any expansion of Chinese efforts into cis-lunar or Earth-Moon space will necessarily involve the PLA, most likely the ASF as well as elements of the Central Military Commission Equipment Development Department (EDD).

It is not clear, however, the extent to which the PLA is currently planning on conducting military activities in the cis-lunar space region. This uncertainty is in part due to the increasing difficulty in accessing Chinese journals and articles, as well as the limits imposed by COVID to visit China and to interact with PRC officials.

Given the continued centrality of the PLA in overall PRC space operations, however, as well as what is known of Chinese views on civil-military fusion, any advances in PRC space capabilities associated with cis-lunar space will ultimately benefit the PLA. Conversely, the PLA is almost certainly considering the implications of greater access to Earth-Moon space for its own operations.

The need for *improved space situational awareness and space domain awareness* in order to accommodate a significant increase in traffic transiting through the higher orbital planes, as well as lunar transfer orbits, will mean that the PLA will have a substantially improved space surveillance network, likely rivaling that of the US Space Force. Indeed, if the PRC is successful in establishing an effective, comprehensive space traffic management system for cis-lunar space, it may well be the premier provider of space traffic control, setting the standards for all players (including non-state actors such as commercial space operators) who transit through this region. This would give the PLA the kind of informational and reputational dominance currently enjoyed by the US Space Force.

This, in turn, would enhance broader PRC, and PLA, *political warfare* activities. The PRC has long associated space with political messaging. A greater PRC presence, much less a dominant one, in cis-lunar space would facilitate PRC efforts to undertake political warfare activities against neighbors and potential adversaries, especially space-capable ones such as Japan, India, and South Korea.

In particular, the Chinese pursuit of the so-called "three warfares" of public opinion warfare, psychological warfare, and legal warfare would likely find new expression through the exploitation of the cis-lunar region. Importantly, all three elements are typically expected to work together, as they are mutually supporting.

Public opinion warfare. Chinese writings emphasize that public opinion warfare is constant and ongoing, regardless of whether there is open conflict or warfare. The ability of the PRC to rival the United States in the strategically higher ground of cis-lunar space could be used in a number of ways. One would be portraying the United States as a declining power (and the PRC, by comparison, still a rising power), as the PRC becomes at least the American equal (and ahead of Europe and Russia). Another would be messaging that China is the dominant Asian space power, vastly ahead of Japan and India. This may or may not coerce and intimidate Tokyo and Delhi, but would be strategically messaged to other Asian states to influence those states, ideally drawing them away from the United States.

Psychological warfare. In the event of a crisis, the ability of the PRC to exploit the cis-lunar volume of space would provide the PLA with opportunities to unveil new capabilities that would, ideally, influence or intimidate Chinese adversaries. If the PRC were to be able to activate spacecraft that had been “lost” in cis-lunar space, or even moved to graveyard orbits at the putative end of their

operational life, this could complicate any assessment of the PLA's space order of battle. This could be easier to accomplish if there is constant, significant traffic through this region of space, providing opportunities to shuffle various spacecraft.

Legal warfare. PRC writings emphasize the importance of waging legal warfare as an integral part of political warfare. As Chinese writings note, "legal warfare" is not about determining the legality of a given action, but exploiting laws, regulations, treaties, law enforcement agencies, and courts to create beneficial political conditions and to support broader strategic objectives. Chinese writings have already indicated concern with the potential role of commercial space operators such as Elon Musk and SpaceX/Starlink in the Ukraine conflict. It should be expected that Beijing, if it is a central player in the establishment of space traffic standards and norms in the cis-lunar region, will exploit that position to hamper and intimidate commercial (and adversary) space operators through legal means. This could range from declaring a space defense identification zone (requiring states to announce their mission and intentions) to rights of inspection of transiting spacecraft to interference (through legal means) of various launches to alter launch windows. Notably, interference with launch windows is an explicit element of Chinese concepts of space blockades.

From a technology perspective, the development of *artificial intelligence systems* to support various satellite and transportation operations in Earth-Moon space would have a number of potential applications for PLA activities. PLA writings and documents indicate that the next phase of PLA modernization will be through "intelligence-ization (*zhineng hua*; 智能化)." Where the PLA had long focused on becoming "fully mechanized and fully

informationized," it now includes a new modernization goal of intelligence-ization.[76]

PLA writings suggest that "intelligence-ized" warfare is a new form of warfare, evolving within the broader trend of informationized warfare (*xinxihua zhanzheng*; 信息化战争) by incorporating artificial intelligence, the Internet of things, and other advanced information and communications technologies.[77] The rise of edge computing, artificial intelligence, big data, and cloud computing, is seen as allowing more data processing to occur within weapons and platforms, allowing much faster decision cycles.

Space systems will play an essential role in intelligence-ized warfare. PNT networks, especially satellite-based ones, are an essential part of intelligence-ized warfare, according to at least one PLA analysis.[78] Chinese concepts of advanced, networked space operations would seem to be rooted, in turn, in intelligence-ized space systems.

For example, ZHANG Yulin specifically notes the importance of autonomous operations and artificial intelligence in the context of proximity operations. If the PRC were to field a significant number of co-orbital anti-satellite systems, or even servicing satellites, all

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[76] XIAO Tianliang, Chief Editor, *Science of Military Strategy* (Beijing, PRC: National Defense University Press, 2020), p. 334, and PRC Ministry of Defense press conference transcript (November 26, 2020) http://www.mod.gov.cn/jzhzt/2020-11/26/content_4874643.htm

[77] ZHAO Xiangang, HAN Yanzhe, "Intelligence-ized Warfare Must Emphasize the Safeguarding of Software," *People's Liberation Army Daily* (April 7, 2022), http://www.81.cn/jfjbmap/content/2022-04/07/content_313120.htm

[78] TAN Shusen, "Satellite Navigation on the Informationized Battlefield," *People's Liberation Army Daily* (November 12, 2021), http://www.workercn.cn/34066/202111/12/211112100201571.shtml

equipped with advanced artificial intelligence systems, the PLA could theoretically then mount a "time-on-target" attack on a variety of satellites, allowing for near-simultaneous effects across multiple constellations and multiple orbital planes.

In addition to general improvements in Chinese capabilities through greater operation in the Earth-Moon space, the PLA may also seek to derive more direct benefits from operations in this region of space.

PLA writings on space deterrence, for example, include a discussion of "space strength deployment (*kongjian liliang bushu*; 空间力量部署)" as one means of effecting deterrence (or compellence). Considered a medium to high method of deterrence (or compellence), such measures include deployment of additional assets, retrieval of certain assets and payloads, and adjustments in orbits.[79] From the PLA's perspective, the ability to reinforce space forces, especially in times of crisis in unexpected ways, would complicate an adversary's calculations (whether of coverage or of forces necessary to counter such additional assets), which in turn would enhance Chinese compellence capacity (which includes deterrence).

Similarly, PLA writings on space offensive operations emphasize the importance of surprise and deception. The more an adversary can be surprised, the more effective space offensive operations will be. One method is to lull an adversary into not noticing one's actions.[80]

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[79] JIANG Lianju and WANG Liwen (eds.), *Space Operations Teaching Materials* (Beijing, PRC: Military Science Press, 2013), pp. 128-129.

[80] JIANG Lianju and WANG Liwen (eds.), *Space Operations Teaching Materials* (Beijing, PRC: Military Science Press, 2013), p. 141.

The exploitation of cis-lunar space for the deployment of reserve satellites, such as in graveyard orbits or higher, would serve both of these ends. Satellites, for example, may be retired early, yet retain sufficient fuel to conduct some maneuvers (such as to redeploy into lower orbits). Or they may have "failed" after launch or in their orbital insertion, becoming "space junk" in "inappropriate" orbits, perhaps beyond GEO, but available for reactivation.

This is not necessarily limited to surveillance, communications, or weather satellites. One possibility is the deployment of anti-satellite systems into higher orbits. Chinese writings specifically note that in peacetime, one should analyze the adversary's space operations theory and combat system-of-systems, in order to determine theoretical and system gaps to exploit and generate surprise.[81] As most space surveillance networks are focused on systems deploying from Earth, an attack from beyond geosynchronous orbit against systems closer in would most likely catch decision-makers off-guard. Regardless of whether the attack was successful or not, the demands for greater surveillance of the volume of space in higher orbital regimes would immediately grow, stretching available resources.

Assessing China's Efforts in Earth-Moon Space

China's interest in the cis-lunar region appears to be rooted in several aspects. Some Chinese analysts seem to believe that it is the next milestone in the wake of its successful completion of the construction and operation of an indigenous space station. This suggests the possibility that there is significant bureaucratic support within the broader Chinese space industrial complex to establish a

[81] JIANG Lianju and WANG Liwen (eds.), *Space Operations Teaching Materials* (Beijing, PRC: Military Science Press, 2013), p. 142.

substantial presence in cis-lunar space in order to maintain the workforce and budget that had supported the space station and human spaceflight programs.

At the same time, any effort to go to the Moon or other planets would require transiting through the cis-lunar volume of space. Thus, from a strategic and scientific perspective, developing a better understanding of that volume of space, as well as establishing a long-term presence, would make logical sense apart from bureaucratic imperatives and pressures.

The Chinese leadership has long associated aerospace endeavors with improvements in China's comprehensive national power. It should therefore not be surprising that they should view advances in the ability to operate in the cis-lunar region as enhancing China's military, economic, scientific and technological, diplomatic, political, and cultural security situation.

Moreover, PRC analysts, who have long viewed aerospace as a means of guiding and promoting advances in various high technologies, are likely to be predisposed to viewing cis-lunar space, especially routinized space travel, as a comparable means of promoting PRC development of more advanced technologies and, as important, human talent.

Indeed, Chinese writings suggest that one major impetus for developing human spaceflight capabilities was that it would foster improved human talent to sustain future Chinese space activities. It would inspire Chinese youth to pursue careers in aerospace engineering. This has been of some concern, as China's first generation of aerospace engineers (e.g., Qian Xuesen) have passed from the scene, and the gap in human talent development due to the

Great Proletarian Cultural Revolution (1966-1976) has made itself felt.[82]

Meanwhile, aerospace programs promote the development of systems integration and systems engineering processes and mindsets. It is arguably one reason that several senior members of CASC (China Aerospace Science and Technology Corporation) were shifted to COMAC (Commercial Aircraft Corporation of China) in the early 2000s. This has included ZHANG Qingwei and JIN Zhuanlong.[83]

Given the view of several potentially influential individuals that developing this region would generate such benefits as more reliable and cheaper rockets or more advanced artificial intelligence, cis-lunar space efforts are likely seen as fulfilling the promise of being a "locomotive" or "pathfinder" for key technological and industrial areas. Serial production of more advanced rockets could lead to better systems integration and systems engineering across industrial sectors. It would also generate additional demand for a variety of human talent across a number of different fields, ranging from aeronautical engineering and computer science to systems integration.

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[82] During the GPCR, China's entire educational system from primary through post-secondary and graduate schooling was disrupted and often shut down. Consequently, an entire generational cohort of Chinese youth was effectively denied an education, which in turn has affected the ability to create successors to that first generation of scientists and engineers.

[83] Marcus Clay, "The Re-Emergence of an 'Aerospace Clique' in Chinese Politics?" *The Diplomat* (February 19, 2022) https://thediplomat.com/2022/02/the-re-emergence-of-an-aerospace-clique-in-chinese-politics/, and http://www.parabolicarc.com/2020/01/01/chinese-leaders-with-aerospace-backgrounds/

It is important to note here that the PRC's general space effort has not been an effort to imitate or replicate the American (or Soviet/Russian) space programs. China's space development effort has followed a very different path from either of the other two major space powers. Notably, the Chinese have devoted far less effort to deploying a constellation of space-based missile early warning satellites. As the Chinese scientific and technological base has modernized and expanded, there is even less reason to think that the PRC will necessarily follow in Western footsteps. As important, Chinese writings have long emphasized the importance of "leapfrog-style development in aerospace (*hangtian kuayue fazhan*; 航天跨越发展)."[84]

Consequently, PRC efforts in the cis-lunar (or Earth-Moon) space region should not be seen as a reaction to American (or other nations') actions and initiatives. Instead, those efforts are likely to be driven by Chinese priorities and follow Chinese paths.

Conclusions

The PRC has long viewed space activities as supporting terrestrial strategic goals, whether enhancing national prestige, promoting national economic development, or helping improve China's military defenses. This is likely to be as true for the region of cis-lunar space as for the more traditional orbital regimes.

Technologically and financially, the PRC is the greatest challenger to the United States throughout outer space. No other state has the

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[84] GAO Liying and WANG Lingshuo, "From a Major Aerospace Power to an Aerospace Superpower, China's Aerospace Determines 'China's Speed,'" *People's Liberation Army Daily* (July 14, 2022), https://export.shobserver.com/toutiao/html/507589.html

combination of space-industrial capacity and necessary human and financial resources to rival the United States across the entire cis-lunar region. As important, Xi Jinping, who looks to remain in power for at least another decade, has indicated that making China a leading aerospace power, and eventually *the* foremost aerospace power, is part of "the China Dream."

The United States needs to look at the cis-lunar region as not simply an area of outer space where American and Chinese interests overlap and are in competition but as part of the broader US-China strategic rivalry, spanning military, economic, technological, economic, and diplomatic domains. Gains in this region should be used as leverage for terrestrial benefits, and losses in this region will have terrestrial costs as well.

The Accelerating PRC Lunar Program

Ever since the People's Republic of China (PRC) joined the ranks of nations that have orbited their own astronauts, observers have wondered when the PRC would initiate a human mission to the Moon. The PRC itself has long been reticent about its human lunar program. Although the most recent Chinese space white paper, published in early 2022, indicated that there would be studies on such an effort, there was no indication that there would be a crewed lunar mission within the 14th Five Year Plan (2021-2025), which this white paper is keyed to. Moreover, the White Paper gave little indication that the studies were intended to support an imminent lunar mission.

After the White Paper's publication, however, senior Chinese scientists and engineers began to give interviews suggesting that the PRC was accelerating its crewed lunar mission planning. Chen Xiaofei of the Chinese Academy of Launch Vehicle Technology (CALT), a subsidiary of the China Aerospace Science and Technology Corporation (CASC), in an August 2022 interview suggested that China was about to complete the relevant flight tests for reusable launch vehicles to support a lunar mission in the current five-year plan.[85] Ye Peijian, a senior Chinese scientist who has worked on the Chang'e lunar missions and longstanding

[85] Leonard David, "China Crew on the Moon: Around 2030?" *Inside Outer Space* (August 21, 2022)
https://www.leonarddavid.com/china-crew-on-the-moon-around-2030/

advocate for a crewed Chinese mission, has been prominently interviewed as well.[86]

Perhaps the most striking was an interview given by Wu Yansheng (吴燕生), chairman of CASC, one of the two main state-owned enterprises (SOEs) that dominate China's space industrial complex. In a December 2022 interview with China Central Television (the state-run broadcasting network), Wu indicated that China was intent on pushing a crewed lunar landing.[87] Moreover, this was portrayed as part of a strategic plan promulgated by Chinese Communist Party (CCP) General Secretary Xi Jinping during the 20th Party Congress (when Xi was accorded a third term as Party chief) to forge China into a major space power (*hangtian qiangguo*; 航天强国).[88] This suggested that a lunar mission was at least under consideration by the highest-level authorities.

In May 2023, the China Manned Space Agency (also referred to as the China Manned Space Engineering Office) formally announced that the PRC was actively planning for a crewed mission to the Moon. The deputy director of the agency, Lin Xiqiang, declared that "the moon landing phase of China's crewed lunar exploration

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[86] "China to Put Man on the Moon by 2030," *China Today* (LIX, #12 December 2010), http://www.chinatoday.com.cn/ctenglish/se/txt/2011-10/10/content_397016.htm, and Andrew Jones, "Chinese Crewed Moon Landing Possible by 2030 Says Senior Space Figure," *Space News* (November 15, 2021) https://spacenews.com/chinese-crewed-moon-landing-possible-by-2030-says-senior-space-figure/

[87] https://www.youtube.com/watch?v=5GQfw4Ij6tw

[88] Andrew Jones, "China Sets Out Clear and Independent Long-Term Vision for Space," *Space News* (December 22, 2022) https://spacenews.com/china-sets-out-clear-and-independent-long-term-vision-for-space/

program has started," and indicated that China intended to land its astronauts on the Moon by 2030.[89]

China's Planned Crewed Lunar Mission

In July 2023, CMSA Deputy Chief Designer Zhang Hailian gave a briefing at the 9th China (International) Commercial Aerospace Forum and provided additional details about China's plans for its crewed lunar mission.[90] According to Zhang, the mission is envisioned as involving two Long March-10 super-heavy boosters, one with the crew, and the other with the lunar landing vessel. The two would dock in lunar orbit, with a two-man crew landing on the Moon and conducting a six-hour mission. The crew would then return to lunar orbit, and return to Earth. In addition to the human crew, Zhang indicated that the mission would include a lunar rover.

Such an approach would be more complex than that attempted by the American Apollo missions, which involved a single rocket carrying both the crew module and lunar landing elements. Given the expected payload of the Long March-10 rocket to translunar orbits, which is projected to be some 27 tons, two would be required (with an overall payload of about 54 tons) to match that of a single

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[89] Andrew Jones, "China Sets Sights on Crewed Lunar Landing Before 2030," *Space News* (May 29, 2023), https://spacenews.com/china-sets-sights-on-crewed-lunar-landing-before-2030/

[90] Andrew Jones, "China Sets Out Preliminary Crewed Lunar Landing Plan," *Space News* (July 17, 2023) https://spacenews.com/china-sets-out-preliminary-crewed-lunar-landing-plan/

Saturn-5, which could reach translunar orbits with a 45-50 ton payload.[91]

In 2024, the Chinese provided further details. At a press conference at the Jiuquan Satellite Launch Center, CMSA deputy director Lin Xiqiang (林西强) stated that the designs for the Chinese lunar crew module Mengzhou (or "Dream Vessel"), lunar lander module Laiyue (or "Moon Embrace"), and space suits, as well as the LM-10 rocket, were all completed and were now undergoing initial testing. He also indicated that the plan was for the Chinese to land on the Moon before 2030.[92]

Chinese Space "Firsts": Outmatching Others' "Firsts"

Any Chinese effort to land people on the Moon would carry enormous political significance. Although it would come some 60 years after the Apollo missions, it would nonetheless firmly establish the PRC as the second foremost space power, exceeded only by the United States. Depending on the pace of the American Artemis efforts, and given ongoing problems with the Starliner program, it

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[91] Andrew Jones, "China to Debut Large, Reusable Rockets in 2025 and 2026," *Space News* (March 5, 2024) https://spacenews.com/china-to-debut-large-reusable-rockets-in-2025-and-2026/

[92] Zhang Ruijie, Gao Rui, Wang Hui, "Our Nation's Manned Mission to the Moon Is Proceeding According to Planned Development for R&D, Fourth Class of Astronauts Will Soon Complete Selection," Xinhuanet (April 24, 2024), http://www.news.cn/tech/20240424/42c490bf02ca4ad4a2a6f9bee26c7681/c.html

might even have China land before the United States could return to the Moon.

In the past, when the PRC has undertaken major space efforts, such as launching its first satellite or its first astronaut, Beijing has often sought to outmatch other nations' corresponding firsts. That is, the Chinese spacecraft has been heavier, or the duration of the mission is longer, or the array of tasks undertaken has been more extensive than other nations' corresponding programs.

Dong Fang Hong-1. Dong Fang Hong-1 (DFH-1) was China's first satellite, launched in April 1970. When the Chinese leadership decided to develop an indigenous satellite, Mao made it clear that he wanted it to be more capable than Explorer-1, the first American satellite. Mao reportedly insisted that it weighs at least two tons, to distinguish it from "that chicken egg of the Americans," referring to the 14 kg Explorer-1 satellite.[93] DFH-1 weighed some 173 kg, nearly double that of Sputnik-1 and over ten times Explorer-1. Notably, DFH-1 remains in orbit today (although not operational), while Sputnik-1 burnt up within months, and Explorer-1 remained in orbit for 12 years.

Shenzhou 5. Shenzhou 5 was China's first manned spacecraft. Launched in October 2003, Lieutenant Colonel Yang Liwei became China's first astronaut, as he orbited the Earth 14 times over the course of 21 hours. By comparison, Yuri Gagarin made one orbit in Vostok-1 in a one-hour, 48-minute flight, and John Glenn made 3 orbits during his four-hour, 55-minute flight in Friendship-7.

Shenzhou 7. During the Shenzhou-7 mission, China conducted its first spacewalk. Chinese astronaut Zhai Zigang engaged in

[93] Yanping Chen, China's Space Activities, Policy and Organization, 1956-1986, 1999, unpublished dissertation, p. 72

extravehicular activities for 22 minutes. By comparison, Soviet cosmonaut Alexei Leonov's spacewalk during the Voskhod-2 mission lasted 12 minutes. US astronaut Ed White, who conducted America's first spacewalk during the Gemini-4 mission, was outside the spacecraft for 23 minutes.

Chang'e-3. In December 2013, China's first lunar lander, Chang'e-3, landed on the Moon. This lander was much heavier than Luna-9 or Surveyor-1, the first lunar landers of the Soviet Union and the United States, respectively. This was due, in part, to the Chang'e-3 carrying a lunar rover, a capability not present when the American and Soviet space programs deployed their first lunar landers some fifty years previously. The rover, Yutu ("Jade Rabbit"), operated for some 31 months, 20 months longer than the Soviet Lunokhod-1, the first rover on another celestial body that landed on the Moon in 1970. This was not necessarily planned, however, as Yutu's officially designed lifespan was only for three months.

Chang'e-4. On January 3, 2019, China landed the Chang'e-4 probe on the far side of the Moon. This marked the first time that any nation had landed a vehicle on the lunar far side. The Chang'e-4 communicates with Earth through the Queqiao data relay satellite, located at the L-2 Lagrange point. That satellite is itself the first communications/data relay satellite to be deployed at any Lagrange point.

Tianwen-1. On February 10, 2021, China's first Mars probe, Tianwen-1 entered orbit. Approximately three months later, the Zhurong rover was successfully landed and deployed. The PRC is only the second nation to successfully land on the Red Planet; all other successful Mars landers have been American. Notably, the Chinese succeeded on their first try to land a craft on Mars, something that has eluded the European and Soviet/Russian space

programs. The Tianwen-1 is heavier than the American Viking-1, the first probe to successfully land on Mars.

This effort to make high-profile Chinese firsts more capable than foreign efforts is likely driven by several considerations. One is the advancement of the general level of technology. The computing power available to the Chinese space program is multiple orders of magnitude greater than that available to NASA in the 1960s. Modeling, simulation, and navigation are all therefore much more capable. Similarly, advances in materials allow more capable or larger payloads (in terms of scientific instruments) than would have been available four decades ago. The Chinese deployment of rovers clearly benefits from advances in robotic and materials technology.

It is also likely driven, however, by the association of space with national prestige. As Mao exemplified, Chinese leaders see a national space capability as reflecting a nation's great power status. That view has been sustained by every Chinese leader since then, as reflected in their presence at key space events, as well as the sustained financial and programmatic support for the broader PRC space effort. Such a presence indicates the leadership's endorsement of the space program but also means that they enjoy the reflected glory of Chinese space achievements.

Nor is prestige purely a domestic consideration. By many metrics, China's space program is significantly ahead of its Asian neighbors' efforts. China is the only Asian nation that has a complete, global position, navigation, and timing (PNT) network, as well as the ability to place its own astronauts in orbit. Japan, although a key partner in the International Space Station, does not have a man-rated launch vehicle or crewed spacecraft. The QZSS constellation supplements and supports GPS, but is not a PNT network on its own. The Indian space program is significantly less

capable than the Chinese one by most metrics. South Korea's space program is still nascent. Major Chinese space achievements, especially ones that outpace those of the older, established space programs (i.e., the US, Russian, and European space programs) therefore underscore the gap between China and its Asian space competitors.

It is also useful to note that beyond prestige, China's space program is also an indicator of the growing sophistication of China's industrial, scientific, and technological base. Major space achievements, especially where they outpace older, established space programs, can also serve as an advertisement for Chinese technology and products writ large. This, in turn, can facilitate Chinese efforts to sell satellites and space services, but also other high-tech items such as sensors and high-precision machinery. In essence, China's space program is an excellent advertisement for the level of Chinese advanced technology.

For their first crewed expedition to the Moon, the Chinese leadership is therefore likely to again try to make their effort more extensive, of longer duration, or otherwise outmatch the Apollo 11 mission. This is likely to be accompanied by extensive coverage of the mission, highlighting Chinese advantages and achievements and downplaying the 5-6 decade gap.

Potential "First" Parameters for a PRC Crewed Lunar Mission

Given the political visibility and global impact of a Chinese manned lunar landing, as well as the Chinese efforts to have their first effort top those of other space powers, it is therefore likely that any Chinese manned effort to the Moon will try to minimize risks, while

nonetheless exceeding the Apollo 11 mission (and potentially other Apollo missions) statistics.

As Chinese statements have indicated, one parameter is to *have the landing party spend more time on the Moon* than Neil Armstrong and "Buzz" Aldrin. The two Americans spent approximately 2.5 hours on the Moon, ranging up to 300 feet away from the lunar lander. Recent statements indicate the Chinese plan for the two astronauts to spend some 6 hours on the lunar surface. Whether that is time spent outside the Laiyue, or time generally spent on the lunar surface, it is clear that Beijing intends to eclipse the duration of Apollo 11.

The man-hour aspect could be more complicated if the Chinese choose to *have the crew range over the lunar surface*. By going farther from the Lanyue than Aldrin and Armstrong did from the Eagle Lander, the Chinese would again be setting a new first. Given reports that the initial Chinese mission will also include a rover, the two Chinese astronauts may also be the first to operate such a vehicle from the lunar surface.

A somewhat riskier option would be for the Chinese to *have their first crewed mission land at a lunar pole, or on the lunar far side*. The PRC has photographed the entire lunar surface at seven-meter resolution, so it has theoretically surveyed the entire Moon for potential landing sites.[94] What is unknown is whether there are suitable sites at the lunar poles for landing a crewed vehicle; it should be remembered that the Apollo 11 crew maneuvered the Eagle lunar module during its final approach to avoid a crater and

[94] "China Releases 'World's Highest Resolution' Lunar Images," Solar System Exploration Research Virtual Institute, https://sservi.nasa.gov/articles/china-releases-worlds-highest-resolution-lunar-images/

boulders at the initially planned landing site. A landing on the far side would mean that communications would have to be via a relay satellite, rather than directly beamed to Earth. For the PRC, this means accepting a higher level of risk than has been typical in the past.

However, a crewed landing at the poles or on the far side would certainly be unprecedented (if it outpaced the American Artemis efforts) and would cement China's achievement alongside that of the United States. It would potentially rebut any claim that China was "merely" repeating an American action some six decades in the past. For the CCP leadership, the political benefits of achieving a global first may be sufficient to offset the risks involved.

An important prerequisite for any landing on the far side of the Moon would be secure communications. If the Chinese choose to pursue this, they are likely to deploy additional relay and communications satellites. In 2018, China deployed the Queqiao relay satellite at the L2 Lagrange point, to support the Chang'e-4 lunar exploration mission. This was the first time a relay satellite had been placed at a Lagrange point, and the satellite has supported subsequent Chinese lunar missions.

In addition, in 2024, the Chinese launched two distant retrograde orbit satellites (DRO-A and DRO-B). They are reportedly intended to test the use of the stable retrograde orbital regime for potential communications and positioning functions. The upper stage of their mission reportedly had problems, and the satellites were placed into the wrong orbit.[95] Subsequent maneuvering, however, indicates

[95] Reuters, "China Launch of DRO-A/B Satellite on Wednesday Not Successful—State Media," *US News & World Report* (March 14, 2024), https://www.usnews.com/news/world/articles/2024-03-14/china-launch-of-dro-a-b-satellite-on-wednesday-not-successful-state-media

that the Chinese have been able to reposition the satellites into their proper orbit. “This successful recovery, if confirmed, would bolster the country’s deep space capabilities and demonstrate resilience in overcoming in-orbit challenges.”[96] It will also facilitate testing that orbit for lunar mission support applications.

Other possible elements that the Chinese might incorporate into their first crewed lunar mission would be more complex, but not necessarily more risky. For example, the Chinese could *soft-land one or more modules in advance of the human mission*. These modules could carry consumables, instruments, or other supplies, and allow the Chinese crew to spend more time on the lunar surface, without necessarily sacrificing scientific instruments or other mission elements. This would certainly ensure that China’s first human lunar mission would exceed the Apollo 11 characteristics.

Similarly, the Chinese are likely to *incorporate ethnic and gender considerations* into their first crewed mission. If the Chinese were to outpace the American Artemis efforts, they would likely want to include a female crew member, so that the first woman on the Moon was Chinese. Even if they did not beat the Artemis effort, this may remain a consideration, as it would feed the Chinese (and other) propaganda arguments that China pays more attention to gender equity than the United States. For internal propaganda purposes, the Chinese authorities are likely to pay attention to the ethnic make-up of the crew, and may strive to include one or more official Chinese minorities to counter accusations of "Han chauvinism."

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[96] Andrew Jones, “Chinese Spacecraft Appear to Reach Lunar Orbit Despite Launch Setback,” *Space News* (August 20, 2024) https://spacenews.com/chinese-spacecraft-appear-to-reach-lunar-orbit-despite-launch-setback/

Implications of a Successful PRC Crewed Lunar Mission

The PRC has almost certainly planned to undertake a crewed mission to the Moon since it began its human spaceflight program in the late 1980s. Given the financial, industrial, and human talent costs to develop human spaceflight capability, as well as China's lunar exploration program, it is questionable that the entire goal of China's manned space program was simply to place one or more Chinese astronauts into orbit, and not seek to land Chinese astronauts on the Moon or other celestial bodies.

Indeed, the debates among various Chinese design bureaus of the first Chinese manned spacecraft indicate that there were both technological and prestige elements at work. In Plan 863, also known as the National High-Technology Research and Development Plan (*guojia gao jishu yanjiu fazhan jihua*; 国家高技术研究发展计划), research and development in the aerospace field were labeled "863-2." [97] Within this field were "863-204," a large-scale launch vehicle and space transportation system, and "863-205," a manned space station.[98] Soon after the announcement of Plan 863 in 1986, a series of conferences were convened to determine the direction "863-204" should pursue.

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[97] Material drawn from *Guojia Gao Jishu Yanjiu Fazhan Jihua 863*, in FBIS-CHI (July 21, 2000). For further discussion of the creation of Plan 863, see Evan Feigenbaum, *China's Techno-Warriors* (Stanford, CA: Stanford University Press, 2003), esp. pp. 141-143.

[98] Shi Lei, Zhou Wu, Feng Chunping, et. al., *Launching the Shenzhou* (Beijing, PRC: China Machine Press, 2003), p. 6, Zuo Saichun, *Chinese Astronaut Flight Documentary* (Beijing, PRC: People's Publishing House, 2003), p. 31, and Shu Wen, *"Shenzhou-VI" Background and Story* (Beijing, PRC: Chinese Language Press, 2005), p. 209.

According to various Chinese reports, the resulting debate over the design of China's first crewed space vehicle was heavily influenced by foreign approaches, with many advocating a shuttle or spaceplane approach. Part of the argument was the economics of reusable space vehicles, but it would also appear that the more traditional space capsule design was seen as less impressive and prestigious, especially compared with the American Space Shuttle. Indeed, at a 1988 conference in Harbin, several hundred Chinese specialists, after significant debate, divided almost evenly between pursuing a space shuttle-type solution (apparently a design dubbed "Great Wall-1"), and a more traditional space capsule design.

Consistent with the consensus model of decision-making, this led to a subsequent high-level meeting in 1989, where the merits of the two different designs were intensively debated. While the details differ, several accounts indicate that the advocates of a more traditional spacecraft design were able to marshal support from both experts outside Beijing, including some drawn from Shenyang, Xi'an, and Chengdu, and from Qian Xuesen, the father of China's space program, himself. Qian provided key political cover for the ultimately winning design of the Shenzhou space capsule. He noted that a high-profile program, such as the "two bombs, one satellite" development effort that had fostered China's nuclear and missile programs, was inherently more political than technological. In this context, pursuing a less technologically advanced approach as an initial step, even if it was less prestigious, was acceptable.[99]

There is little reason to think that the relevance of political considerations as a factor has receded in Chinese thinking about space (or other high-profile, advanced technology projects). At the

[99] Zuo Saichun, *Chinese Astronaut Flight Documentary* (Beijing, PRC: People's Publishing House, 2003), p. 34.

same time, given the resources involved in China's human spaceflight program, and the associated political impact, it is hard to imagine that China's leaders did not intend for it to lead, at a minimum, to landing a Chinese crew on at least the Moon. Indeed, a successful Chinese manned flight to the Moon would have significant domestic and international ramifications.

Domestic Impact

Xi Jinping has undertaken a fundamental realignment of Chinese domestic politics since taking power in 2012. He has systematically overturned much of Deng Xiaoping's political legacy, including limitations on the power of the top leader, constitutional term limits on the head of state, and a semi-mandatory retirement age for senior CCP leaders. As importantly, in the course of his decade in power (with at least five more years and probably more), he has alienated a variety of Chinese interest groups and power blocs. His anti-corruption campaign, while addressing a key vulnerability of the CCP, has also involved the arrest of thousands of Chinese leaders at all levels of the Chinese polity, in the military as well as the civilian sides of the CCP. His more recent efforts against several Chinese billionaires, such as Guo Guangchang (head of Fosun International) and Jack Ma (founder of Alibaba and Ant Group), underscore that Xi will brook no potential challengers to his authority.

This centralization of power is risky, however. Deng pushed for consensus leadership, with responsibility at least publicly distributed among the members of the CCP Politburo and Politburo Standing Committee; Xi's arrogation of power to himself means that he bears responsibility for all outcomes, positive and negative. The COVID lockdown policies and their subsequent

sudden removal, which has disrupted China's economy while giving little indication of successfully combating the spread of the disease, appear to be attributed primarily to Xi. A sustained economic slowdown in the PRC would also likely be seen as ultimately Xi's responsibility.

But if problematic policy outcomes may be blamed on Xi, major successes would likely benefit him in terms of domestic Chinese debates and political competition. In particular, he could reasonably claim credit for major space programs that were largely completed on his watch. With regard to China's human spaceflight efforts, Chinese spacecraft docking and completion of its first space station have already occurred during Xi's time in power. While China's lunar exploration program began under Hu Jintao (with roots even earlier), the lunar lander and sample retrieval missions, key precursors to a manned landing, occurred under Xi. A crewed Chinese landing on the Moon could be portrayed as a logical culmination of both China's manned spaceflight and lunar exploration programs—all occurring during the reign of Xi Jinping and under the leadership of the CCP.

There could also be regional political benefits. In the last several years, China has sought to establish regional "national aerospace industrial bases," to reduce the concentration of aerospace firms and production in Beijing and Shanghai. Xi'an and Wuhan have already

established regional aerospace production centers.[100] Being part of the first Chinese crewed lunar mission would draw attention to these regions and enhance their reputation (and potentially generate additional business).

A major space achievement would also be a politically "safe" one, as there would be limited political downsides in the mid- and long-term. In other technologies, such as artificial intelligence, major advances could have domestic political consequences (e.g., the ability to avoid the current censorship infrastructure). By contrast, the CCP, in addition to Xi, would gain significant reputational enhancement, as China demonstrated its technological prowess and joined the leading ranks of space powers, with minimal prospect of unanticipated complications or contradictions.

Foreign Impact

A successful Chinese manned flight to the Moon would have a major international political impact as well. It would, at a minimum, elevate China's space program to a peer level with the United States, placing it ahead of every other national space program. By landing a crew on the Moon, China will have achieved something that neither the former Soviet Union nor European space powers could. Even though it would occur some fifty years after Apollo 11, the fact that

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[100] "China's Wuhan Steers Commercial Aerospace Industry Into Broader Space," Wuhan Government website, https://english.wuhan.gov.cn/H_1/NWP/202311/t20231118_2303288.shtml, and "Xi'an National Civil Aerospace Industrial Base: A New Paradigm for Chinese Path to Modernization," CRI Online (July 11, 2023), https://news.cri.cn/20230711/a361bf2e-90d2-5481-72c8-bb67d1a6b14f.html

no other state has landed on the Moon would demonstrate that China's achievement cannot be dismissed lightly.

Such an achievement would also rebut arguments that China is not capable of independent innovation or scientific achievement and that it is reliant on intellectual theft. This would especially be the case if the Chinese mission has a variety of "firsts" that exceed the Apollo 11 mission, particularly if it lands at a pole or the lunar far side.

Notably, a successful Chinese lunar landing would also be a direct challenge to the United States, as it would mark the end of a key example of American exceptionalism. For decades, the fact that the United States was not only the first nation to land on the Moon, but the *only* nation to do so, has been emblematic of American uniqueness, as well as its technological prowess. It has been used, explicitly and implicitly, as a symbol of the power and capabilities of "the American way." For the PRC to be able to land on the Moon as well would constitute a direct challenge to that mythology, as "the Chinese way" would now be demonstrably capable of something that was once solely the purview of the United States. (China's Mars mission has constituted a comparable achievement, in that prior to the deployment of the Zhurong rover, all images from the Martian surface had been from American systems.)

One should therefore expect that a successful Chinese manned landing on the Moon will be accompanied by a global propaganda campaign with the message that the PRC is the rising power, comparable to if not displacing the United States as the world's foremost power. This messaging will likely be targeted, not at the United States itself, but at a variety of third parties, especially in such regions as the Middle East, Southeast Asia, Africa, and Latin America. It would be possible, for example, for Beijing to exploit a

successful manned lunar mission to invigorate the Asia-Pacific Space Cooperation Organization (APSCO), or to create a space subsidiary as part of the Shanghai Cooperation Organization (SCO), which numbers Russia, India, and Pakistan as current members, and Iran and Belarus as candidates.

In either case, the Chinese goal may be to expand membership in a "space bloc" that it leads, presenting an alternative to the Artemis Accords (which is described as an American-led effort at establishing international norms and standards). Similarly, Beijing may well use the prospect of future participation in Chinese lunar missions to create bilateral deals with various states to build or establish facilities that would improve Chinese space domain awareness.

Economic and Commercial Impacts

China's ability to successfully undertake such a complex mission will also likely be exploited to expand Chinese commercial and economic opportunities. China already is a leading exporter of turnkey satellite systems. A successful Chinese manned landing on the Moon would likely be incorporated into expanded sales efforts for Chinese satellites. Given the importance of relay satellites in maintaining communications with any landing on the lunar far side, Chinese sales of such systems would likely expand.

But the success of a manned space mission would probably extend beyond satellite sales. For example, it would be likely that the PRC will argue that the communications required to support such a mission demonstrate the capabilities of Chinese information and communications technology (ICT). China would therefore be selling systems that are inexpensive yet capable—and states should

not allow themselves to be dissuaded by the United States from contracting with the PRC. This would not only apply potentially to Huawei but also any Chinese competitor to Starlink or other commercial space systems and space services.

One potential beneficiary might be China's "Belt and Road Initiative" (BRI). The Chinese have raised the prospect of a "space Silk Road," with a space infrastructure component to its various foreign investments. It is possible that Beijing would try to exploit its manned space achievement by using it as a "calling card" for space-related investments (telescopes, radars, and other systems that could contribute to Chinese space domain awareness) in BRI partners.

Technological Impacts

A successful PRC crewed lunar mission will not be a single event. That is, the Chinese are not simply aiming to land a Chinese crew on the Moon, plant their flag, and claim success. A Chinese effort to land on the Moon would be part of a larger program aimed at establishing a longer-term presence on the Moon, possibly a permanent one.

Consequently, the first landing will most likely be followed by a succession of subsequent missions that would establish facilities and infrastructure at the lunar surface. (This is one reason why an accelerated Chinese crewed effort is less likely because the follow-on efforts would not necessarily be ready or funded.) Such an effort, in turn, is likely to involve ancillary efforts which would have broader impacts.

For example, it is quite likely that the first nation to establish a substantial, long-term presence on the Moon would be in a position

to establish a lunar navigation and positioning standard, whether in terms of grid references or even a lunar position, navigation, and timing (L-PNT) network. Notably, the Chinese Academy of Sciences (CAS) filed a patent with the United States Patent Office for establishing "A Method for Achieving Space-Based Autonomous Navigation of Global Navigation Satellite System (GNSS) Satellites." Patent 11,442,178 B2 involves linking an Earth-Moon space satellite in a distant retrograde orbit to a low earth orbit data relay satellite and GNSS network.[101] That CAS would choose to file such a patent application with the *United States* Patent Office suggests an attempt at gaining international acceptance and recognition of such a network. The international acceptance of a Chinese L-PNT network could have both the technical and political impact that the American GPS network has had terrestrially, establishing the international standard for multilateral use.

Conclusions

The prospect of the PRC launching a crewed mission to the Moon is very real, as it is a logical culmination of two major lines of effort: China's Manned Space Engineering Project and the Chinese Lunar Exploration Project. It would have a range of potential benefits for the PRC's public diplomacy efforts. It would also demonstrate that the PRC is the foremost space power in the world after the United States and ahead of every other Asian power.

What remains unclear is why the Chinese have apparently accelerated their human lunar efforts. The Chinese Tiangong space station was mentioned in various white papers for over a decade

[101] United States Patent Office, Patent Number US 11,442,178B2 (September 13, 2022).

prior to its deployment in 2020. By contrast, the Chinese have had minimal public mention of a human mission (as opposed to robotic lunar missions) in their own reports and discussions.

Indeed, the decision to forge ahead without a super-heavy lift vehicle is surprising. Chinese discussions of a manned lunar landing had generally been associated with the projected Long March-9 booster. This vehicle would have been in the same class as the Saturn V.[102] But the Long March-9 was canceled in 2022, ostensibly in order to incorporate features that would allow it to be reusable.[103] Yet, the PRC, which had not made any formal announcements about plans for a manned landing (and therefore did not have any public target dates), nonetheless proceeded to announce its manned mission and even to set target dates. Moreover, given the dockings required, this will be a much more complex mission, with more potential points of failure.

This suggests additional underlying considerations that are opaque to outside observers. What is clear is that the PRC intends to join the United States as one of the only states whose citizens have walked on another celestial body by the end of the decade.

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[102] Andrew Jones, "China Reveals Details for Super-Heavy-Lift Long March-9 and Reusable Long March-8 Rockets," *Space News* (July 5, 2018) https://spacenews.com/china-reveals-details-for-super-heavy-lift-long-march-9-and-reusable-long-march-8-rockets/.

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

Implications of China's Cis-Lunar Efforts

At this point in time, it is unclear what the ultimate Chinese approach will be to cis-lunar space. China's most recent space white paper makes it clear that the PRC bureaucracy and leadership is committed to expanding its range of missions to the Moon; launching exploratory missions to asteroids, Mars, and the Jovian system; and undertaking sample retrieval missions from at least asteroids and Mars, and potentially the Jovian system, as well. Just these missions will make China the foremost American competitor in deep space, as no other country has made a sustained effort to explore the outer planets or engage in studies of deep space. It is noteworthy that, until the Chinese Tianwen mission, every image but one from the Martian surface had been from an American spacecraft.

Since the publication of the 2022 space white paper, however, China has clearly accelerated its deep space efforts. The PRC is also now committed to sending a human mission to the Moon and undertaking a sample retrieval mission from Mars by 2030. Such efforts are clearly intended to challenge American space supremacy, especially as the United States currently has no serious plans for a sample retrieval mission from Mars before the early 2030s at best.

Given China's public intent to undertake a robust lunar exploration program, with multiple missions to the Moon (including to the far side and the polar regions), and to begin substantial exploration

efforts deeper into the solar system, it is clear that China will be working extensively in and through the cis-lunar region.

Strategic Implications

For the PRC, as noted earlier, space activities are seen as contributing to the broader calculation of comprehensive national power. The Chinese integrate their space program into their general foreign policy (e.g., APSCO, Belt and Road Initiative), and trade and economic efforts, as well as integrating it into their military thinking. This comprehensive approach will certainly apply to their activities in cis-lunar space.

Should the PRC undertake even a moderately extensive development effort in cis-lunar space, this will underscore that it is the greatest challenger to American preeminence. No other nation, at this time, has demonstrated the same level of interest in developing lunar capabilities as the PRC. This is not only reflected in public statements such as the white paper but in actual activities such as the Chang'e-6 lunar sample mission. Should a Chinese astronaut set foot on the Moon before the United States is able to send an American, it will not have the same effect as losing the Moon race to the USSR, but it will send a clear message that China is the only space competitor of note. That the United States could not *return* to the Moon before China could send its first astronaut will also be an exploitable message for the Chinese leadership.

This is especially important as China's economy appears, in the fall of 2024, to be faltering. Xi Jinping's "China Dream" of "the great revival of the Chinese people" would be given a significant boost, both at home and abroad, if Beijing could demonstrate that it can

beat the United States in major achievements—especially one where the US was once preeminent.

China is apparently also investigating the deployment of a position, navigation, and timing (PNT) constellation around the Moon. Chinese engineers and spokespersons from a variety of institutions have laid out plans for possible PNT constellations and even an "information superhighway" to the Moon. A Chinese presentation at the 2023 International Astronautics Congress in Baku noted that the various Chinese plans for lunar research facilities and exploratory missions "put high demand on communication, navigation and remote sensing... so we propose the Queqiao constellation."[104] This would build upon the already deployed Queqiao-1 and Queqiao-2 data relay satellites, and expand in the future to provide position and navigation functions.

Subsequent Chinese publications and statements have indicated that research is ongoing along these lines. In 2024, Chinese researchers from the China Academy of Space Technology (CAST) and the Beijing Institute of Spacecraft System Engineering published an article examining the deployment of a network of satellites and lunar ground stations that would support communications, navigation, and space situational awareness. "The goal is to enable 20 or more travelers to simultaneously communicate with Earth, via images, audio, or video."[105] The satellites and ground stations would

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[104] Andrew Jones, "China Wants a Lunar Satellite Constellation to Support Deep Space Missions," *Space News* (October 5, 2023) https://spacenews.com/china-wants-a-lunar-satellite-constellation-to-support-deep-space-missions/

[105] Ling Xin, "Chinese Scientists Propose Information Superhighway Between Earth and the Moon," *South China Morning Post* (July 20, 2024) https://www.scmp.com/news/china/science/article/3270910/chinese-scientists-propose-information-superhighway-between-earth-and-moon

also allow precise navigation on the Moon as well as monitor objects as small as one meter in cis-lunar space. Notably, one of the contributors to the paper, Yang Mengfei had earlier specifically called for China to seize the opportunity to lead the development of cis-lunar infrastructure.[106]

It is not clear what, if any, constraints might exist to prevent the Chinese from deploying such a constellation.[107*] If the PRC is the first to deploy such a system, especially well in advance of any American or European constellation, then the PRC will have the first-mover advantage of establishing the standards for lunar PNT. Given the unique characteristics of lunar orbits (including the limited number of "frozen orbital planes" and the absence of a luna-stationary orbit), this could give the PRC a significant advantage.

The Chinese will, in turn, leverage cis-lunar achievements to advance programs such as the Belt and Road Initiative (BRI). The Chinese already tout the "Space Silk Road" and incorporate elements of aerospace activities into their BRI efforts. China has forged ties with nations as varied as Namibia and Argentina through the construction of space-related infrastructure. It has sold turn-key space operations complete with satellites, launch services, ground station construction, and crew training, to a variety of nations including Venezuela, Bolivia, Nigeria, and Ethiopia. High-profile

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[106] Andrew Jones, "Space Official Calls for China to Seize Crucial Opportunity to Establish Lunar Infrastructure," *Space News* (March 31, 2023)
https://spacenews.com/space-official-calls-for-china-to-seize-crucial-opportunity-to-establish-lunar-infrastructure/

[107*] One possibility would be ITU guidance regarding the frequencies used. As there are no current competitors, however, it is not clear how much of a delay obtaining ITU permission would entail.

achievements in cis-lunar space will only increase the appeal of Chinese aerospace sales efforts.

Beyond political messaging, a strong Chinese presence in cis-lunar space will give China a substantial voice in the formulation of both business and industrial standards for activities in cis-lunar space, as well as governmental norms governing broader behavior. This is not to suggest that China would necessarily claim sovereignty over, for example, the Lagrange points; the PRC is a signatory to the Outer Space Treaty (OST).

However, it is not clear that China's interpretation of the terms of the OST is necessarily congruent with those of other states. One need only look at how China has interpreted the UN Convention on the Law of the Sea (UNCLOS) in its behavior in the South China Sea to see how differently the PRC may view customary international law. Where UNCLOS treats a nation's exclusive economic zone (the 200 nautical mile region extending from a nation's coast) or EEZ as essentially *international* waters with the owning state having first claim on any resources there, the PRC interprets EEZs as essentially *national* waters through which foreign states may transit, but only after requesting permission.

Theoretically, then, China might choose to try and proclaim a space defense identification zone, or a space EEZ (with obligations aligned with the Chinese interpretation of maritime EEZs) in the cis-lunar region (such as over a lunar transfer orbit zone or in a Lagrange point). Just as China has also built artificial islands in the South China Sea to support its expansive claims over that area, China might also engage in analogous efforts in cis-lunar space. For example, could the PRC deploy satellites and announce a 20 nautical mile keep-out zone around its satellites, grounded not in sovereignty but in the safety of flight? Some American analysts have

already proposed "safety zones" or "keep out zones" around satellites, both for safety reasons but also to limit the ability of potential adversaries to engage in unwanted RPOs.

At present, there is neither an accepted radius or volume for such a keep-out zone, nor is it clear what satellite might lay claim to one. Such a "safety zone" might be eminently logical in areas distant from Earth where there is unlikely to be constant monitoring, such as the Lagrange points, especially L2 (lunar far-side). However, it would therefore be possible for a state (or even non-state) actor to deliberately "daisy chain" a series of satellites, possibly even microsatellites, so that their "safety zone" laid claim to a band of space. This would not even violate the OST, as the zone would be rooted in the safety of flight, rather than sovereignty, considerations. Given the limited number of “frozen orbits” around the Moon at 27°, 50°, 76°, and 86° inclination, establishing “safety zones” could limit the ability of other states to use those orbital planes.[108]

Such "safety zones" might also be applicable to key areas on the Moon, such as the lunar poles which are posited to have higher concentrations of accessible water. That the PRC is already indicating both that it will have a robust lunar exploration program and is interested in possible human facilities at the poles underscores that they are thinking very hard about those regions. Establishing safety zones around work sites, habitation sites, and communications nodes would not be unreasonable, even as they also closed off access to other nations.

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[108] Antonio Elipe and Martin Lara, “Frozen Orbits Around the Moon,” *Journal of Guidance, Control, and Dynamics* (XXVI, #2, March-April 2003). https://arc.aiaa.org/doi/abs/10.2514/2.5064?journalCode=jgcd

Meanwhile, China's avowed effort to retrieve a sample from Mars and return it to Earth faces little competition. Only the United States, with NASA's Mars Sample mission announced in July 2022, is even potentially going to be in the same timeframe.[109] Here, it is quite likely that China will outpace the United States since the NASA mission will not occur until 2033 at the earliest, whereas the Chinese have now stated that they intend to mount such an effort before the end of this decade.[110]

The purposeful transfer of material from another planet to Earth would be an epochal event. It would signify mankind's continuing efforts to explore the heavens and to move beyond the boundaries of Earth. Should the PRC succeed in beating the US in such an achievement, the political significance would be great. Beijing would reasonably argue that they are the ones leading the way into the future, throughout the solar system. That this was under the guiding hand of the Chinese Communist Party, and specifically Xi Jinping, would also be emphatically stressed.

Operational Implications

Chinese writings seem to consistently argue that it would be cheaper, and possibly easier to move spacecraft, satellites, and other materials from one location in space to another, rather than launch

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[109] "NASA Will Inspire World When It Returns Mars Samples to Earth in 2033," NASA Press Release (July 27, 2022) https://www.nasa.gov/press-release/nasa-will-inspire-world-when-it-returns-mars-samples-to-earth-in-2033

[110] Ling Xin, "China Sets Historic Mars Mission for 2028 While US Plan Remains in Limbo," *South China Morning Post* (September 6, 2024) https://www.scmp.com/news/china/science/article/3277436/china-sets-historic-mars-mission-2028-us-plan-remains-limbo

from Earth's surface. This would seem to indicate, then, that there is an interest in building certain payloads in space, such as Earth orbit, and then transferring them to a new location. What remains unclear is where additional material would come from, such as the lunar surface, passing asteroids, or launched separately from Earth.

One possibility would be undertaking in-orbit manufacturing. Additive manufacturing (i.e., 3-D printing) might mean that structural components, modules, and sub-assemblies, could be printed in orbit, and then moved to their final destination, whether in Earth orbit, lunar orbit, or even Lagrangian orbit with the use of robotic assemblers. If the "printer cartridges" are more easily handled, it might even make sense to deploy the printer system directly to the expected orbital plane or region, and moving parts after they have been "printed."

There may be a significant advantage gained in terms of overall payload for a craft assembled in space (or completed in space after initial launch), compared with one tied to launches from Earth. A spacecraft bound for Mars, for example, launched from an Earth or lunar orbit would, for the same "displacement," potentially be able to operate longer on the Martian portion of the mission than if that craft were launched from Earth's surface.

Alternatively, might there be an analogy to US aircraft carrier flight operations? An aircraft's take-off weight is often less than its in-flight weight. A combat aircraft might therefore be launched off an aircraft carrier with a full weapons load but a limited fuel load, to meet takeoff weight limitations. Once airborne, it can then be refueled to its maximum flight weight. It is possible that the Chinese might envision a spacecraft taking off from Earth with a full cargo load but reduced fuel load, and then being refueled in orbit before going onwards to the Moon and vice versa.

Chinese comments on their planned crewed lunar mission would seem to be following this latter line of thinking. Because the current Chinese space launch vehicles do not have sufficient throw-weight to launch the mission atop a single booster, Beijing will instead launch two vehicles, one with the crew and one with the lunar lander, with the two docking in lunar orbit. Future missions to Lagrange points or Mars might take advantage of prepositioned fuel or consumables in orbit.

Any of these steps could complicate other states' efforts to undertake monitoring of Chinese space systems. A spacecraft that had significant additions installed after initial deployment, or which was constructed or printed in orbit, may have different functions and capabilities compared with how they might be initially characterized. Microsatellites or cubesats printed in space could be even harder to detect and track. These difficulties would be massively compounded if they were undertaken in lunar or cis-lunar space, given the volumes where they could occur and the distance from Earth.

Military Implications

A substantial Chinese cis-lunar presence and capability would also have military implications. At this time, there is limited expectation for military activity in the cis-lunar arena, much less in lunar orbit or on the Moon's surface. But a substantial Chinese cis-lunar presence would almost certainly entail a significant improvement in China's ability to maintain space situational awareness in the cis-lunar volume, including to the Lagrange points. This would give the PRC an ability to maintain a close watch on orbiting objects that are in the more traditional orbital regimes—which is where most militarily relevant space systems currently operate.

Similarly, a regular space transportation network spanning the Earth, Moon, and potentially the Lagrange points would encourage a Chinese space industrial ecosystem that could produce significant numbers of launch vehicles. This would in turn benefit both Chinese ability to deploy satellites and other payloads, as well as the PLA Rocket Force (PLARF) with cheaper (and probably more reliable) launchers for China's various missile forces. The 1999 Cox Commission report noted that improvements in Chinese space launch systems in the wake of the Loral and Hughes incidents ultimately benefited China's ICBM forces.[111]

Chinese efforts to enhance "intelligence-ization" in its military would also benefit from the development and incorporation of "intelligence-ization" measures in its space systems. At a minimum, all Chinese satellite constellations could operate more effectively in an autonomous manner through the incorporation of more intelligent systems, including on-board computing and data analysis. As important, Chinese military satellite constellations would potentially be able to better meet operational demands and be more responsive even in the face of external interference, if their operating algorithms were more intelligent.

However, the resulting improvements in intelligent processing, including for artificial intelligence and machine learning purposes, would potentially benefit non-space systems as well. The software for space systems could serve as a test bed for improvements that could then be applied to drone swarms, autonomous vehicles, and other extended networks of systems.

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https://www.govinfo.gov/content/pkg/GPO-CRPT-105hrpt851/pdf/GPO-CRPT-105hrpt851.pdf

Challenging the United States

For the United States, the Chinese development of a substantial cis-lunar infrastructure constitutes a direct challenge to American claims of being the preeminent space power. As important, it raises serious doubts about American ability to lead deep space development.

Given the comprehensive manner in which the PRC exploits its space capabilities, space industries, and space services, Chinese advances in this next volume of space will be portrayed as demonstrating not only China's improvements in space capabilities but its overall techno-economic capacity and the capabilities of the "Beijing way." Just as the first Space Race was a competition for influence between the United States and the Soviet Union, so, too, is Space Race 2.0 a part of the growing rivalry between Beijing and Washington.

As important, improvements in the PRC's space capabilities derived from expansion into cis-lunar space will redound to China's benefit in other orbital regimes and other technological fields. Advances in AI and machine learning that allow Chinese satellites to operate autonomously can be applied to other networked systems, be they drones, unmanned underwater vehicles, smart cars, or smart cities. A better ability to find and characterize objects in cis-lunar space will certainly improve China's overall space domain awareness.

Appendix I: Some Notable Chinese Commentators on Cis-Lunar Space

Two Chinese officials who most frequently seem to comment on cis-lunar space are Dr. BAO Weimin and LTG ZHANG Yulin. Both are clearly senior figures in China's aerospace efforts (Zhang, for example, was deputy head of the China Manned Space Engineering Office).

It is not clear, however, whether their comments reflect personal support and interest (even passion) for developing cis-lunar space; striving for bureaucratic resources for their respective offices; or representing a broader national objective of developing cis-lunar space—or some combination of all three.

BAO Weimin was born in 1960 in Harbin, Heilongjiang province. He is currently the dean of the School of Aerospace Science and Technology (SAST) of Xidian University and the director of the Science and Technology Committee of the China Aerospace Science and Technology Corporation (CASC).[112]

He obtained a bachelor's and a master's degree in information processing from the department of electronic engineering,

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https://sast.xidian.edu.cn/info/1132/2098.htm+&cd=2&hl=en&ct=clnk&gl=us&client=firefox-b-1-d

Northwest Institute of Telecommunications, now Xidian University. He obtained a doctorate in precision instruments and machinery from the Beijing University of Aeronautics and Astronautics in 2010. Bao has been a member of the Chinese Academy of Engineering (CAE) since 2005. Bao has also served as the director of CASC First Academy 10th Research Institute (Near Space Flight Vehicle Institute); director of the CASC S&T Committee; and deputy director of the GAD Precision Guidance Experts Group.[113] Bao specializes in control systems for aerospace vehicles, as well as overall design of aerospace vehicles.

ZHANG Yulin was born in 1958 in Shaanxi province. He is an LTG in the PLA and is currently the deputy commander of the PLA Central Military Commission Equipment Development Department (successor to the General Armaments Department).

He attended NUDT, where he focused on liquid fuel rocket engines, and obtained both a bachelor's and master's degree. He then obtained a doctorate from Zhejiang University and did post-doctoral research at the University of Waterloo in Canada. In previous postings, he has served as head of the Academy for Command Equipment and Technology (of the then-GAD); commander of the PLA Jiuquan Satellite Launch Center; commandant of the National University of Defense Technology (equivalent to deputy commander of a military region); a deputy commander of the PLA GAD; and a deputy commander of the China Manned Space Engineering Office.

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[113] Roger Cliff, Richard Hallion, et. Al, The Chinese Air Force: Evolving Concepts, Roles, and Capabilities (Washington, DC: GPO, 2012), p. 63.

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Prior to joining the Heritage Foundation, he worked at the Center for Naval Analyses (CNA), a Federally Funded Research and Development Center, Science Applications International Corporation (SAIC), and as an analyst with the US Congress' Office of Technology Assessment.

He is the author of the volume *Cyber Dragon: Inside China's Information Warfare and Cyber Operations* (Praeger Publishing, 2016), and has written extensively on Chinese views of deterrence, Chinese views of space power, and Chinese mobilization, and contributed to a number of volumes on the Chinese People's Liberation Army.

He has testified before Congress numerous times, and spoken at the National Space Symposium, the US National Defense University, the USSTRATCOM Deterrence Symposium, Harvard, and MIT.