China's Space and Counterspace Capabilities and Activities

Prepared for:

The U.S.-China Economic and Security Review Commission

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March 30, 2020

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KEY FINDINGS

The development of the People's Republic of China's (PRC, China) civilian and military space programs over the last few decades has proceeded alongside the PRC's broader rise in the international system. Questions regarding China's capabilities and intentions in space are indubitably linked to larger geostrategic questions about China's role in the world. Buoyed by recent successes and impressive advancements in space technology, China has emerged as a leading player in space. The implications for United States policy are numerous, and the capabilities China either currently possesses or is in the process of developing certainly pose a strategic risk to the United States' ability to operate in the Indo-Pacific region.

Investments into space-related research and development (R&D) drive military capabilities and fill gaps in intelligence, reconnaissance, and surveillance. Space-based infrastructure is increasingly important for People's Liberation Army (PLA) out-of-area operations. An advanced presence in space is indicative of China's renewed status as a great power in the international system.

The advent of the PLA Strategic Support Force (PLASSF) Space Systems Department represents an organizational innovation that places all major components of China's space program under a unified command structure, thereby increasing efficiency and efficacy. The SSF operates a vast bureaucratic apparatus that manages operations and allocates a sizable R&D budget to various aspects of its space program, all parts that move China closer toward achieving its stated goal of becoming a major space power.

China's significant investments in space and counterspace capabilities may prove threatening to U.S. space assets and military efficacy. China's space infrastructure is complemented by its growing capacity to deny adversarial powers access to the same space assets, as evidenced by advancements in kinetic and non-kinetic counterspace capabilities. China's approach to modernizing its space presence includes an emphasis on military-civil fusion (MCF) and the development of dual-use technology that buoys both military and economic growth. Should China's capabilities surpass those of the United States, the erosion of the U.S. military's ability to contest the PLA in a potential future conflict will be at risk.

The Chinese Communist Party (CCP) is executing a long-term strategy to exploit U.S. technology, talent, and capital to build up its military space and counterspace programs and advance its strategic interests at the expense of the United States. China's zero-sum pursuit of space superiority harms U.S. economic competitiveness, weakens U.S. military advantages, and undermines strategic stability. In short, it represents a threat to U.S. national security. Barring significant action to counter China's space-related programs and activities of concern, it is likely that this strategic competitor's efforts will continue to adversely affect U.S. interests.

RECOMMENDATIONS

- Congress should enact new or enhance existing laws to prohibit U.S. government departments and agencies, national labs, universities, companies, fund managers, and individual investors from supporting China's space program and activities that are inherently military in nature.
- Congress should consider mandating and funding the production of a routinely updated, publicly available list of entities supporting China's space programs and activities.
- Congress should consider mandating and funding public education to enhance general knowledge of China's space programs and activities, including more targeted congressional hearings and the allocation of grants for think tank and university research programs, public conferences, public-private consultative talks, and media outreach.
- Congress should consider reviewing the budgets of the National Aeronautics and Space Administration and the United States' leading aerospace university programs to ensure they have the education funding necessary to support young and emerging scientists and technology innovators.
- Congress should consider how funding the establishment of a potential new U.S. Space Force may better enable the military to organize, train, and equip future leaders needed to keep the United States competitive with China's growing military space enterprise.
- Congress should pass legislation that incentivizes science, technology, engineering, and mathematics-focused high-skilled labor immigration from China (as well as other countries), including special visas earmarked for these students and a public-private effort to find them work.
- Congress should direct the U.S. Department of Defense to produce an annual unclassified report on PLA space/counterspace developments and other major players in space security. This report should assess developments, setbacks, and efficacy of these powers' space programs. The report should also outline methodologies to assess the source of sub-kinetic attacks on U.S. space assets and potential military responses. In addition, it should assess the vulnerabilities of U.S. space/counterspace systems and how best to improve U.S. space systems' survivability in the event of disruption or conflict.
- Congress should direct the U.S. Department of Education to produce an annual report on the proportion of doctoral graduates in space-related fields who are from China and other foreign countries and how many return home upon graduation. This information would be geared toward understanding how best to attract and retain foreign talent as well as how many students remain within the United States upon graduation.

INTRODUCTION

As the People's Republic of China (PRC) emerges as a global space power, the international economic and security implications of its strategic modernization are mounting. Growing investments in space and counterspace have raised questions concerning Beijing's capabilities and intentions in space. Full of confidence in the wake of success in its lunar exploration and crewed space programs, the PRC is emerging as a leading space player. What are the implications of China's growing investment in military space technology for the United States? What is the potential to achieve disruptive breakthroughs, and what are the implications for the United States' ability to operate in the Indo-Pacific region and beyond? What is known about China's space and counterspace strategy and doctrine, and what organizational and bureaucratic dynamics within China help shape potential success or failure? How might Chinese space assets be employed in future joint military operations? How have the People's Liberation Army (PLA) and civilian counterparts leveraged foreign technology to advance China's competitive position in space?

Managed by a diverse set of military and civilian organizations, Chinese political authorities view space power as one element of a broader international competition in comprehensive power and science and technology (S&T). With the preservation of its monopoly on power as an overriding goal, the Chinese Communist Party (CCP) maintains its legitimacy in part through achievements in space. Adopting an integrated civilian and military perspective in its plans and programs, the PRC's investment in space technology supports economic development and advances national defense modernization. Successes in space signify the emergence of the PRC as a world power.

The PRC's programmatic successes in space are significant. Notable achievements include crewed space platforms, reliable space launch vehicles and satellites, and landing a lunar probe on the far side of the moon. China has made substantial progress in developing peaceful and practical uses of space technology. In addition to supplying cost-effective international commercial launch services, the PRC's space program supports economic development and humanitarian assistance and disaster relief (HADR). At the same time, the space program facilitates the advancement of a modern, high-technology military force.

While the State Council produced space policy white papers in 2000, 2006, 2011, and 2016, China's space ambitions are inherently dual-use in nature. Freedom of action in space offers the PLA potential military advantages on land, at sea, and in the air.[1] In the past, PLA space and

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[1] For examples of U.S. overviews of China's space modernization, see Dean Cheng, "Prospects for China's Military Space Efforts," in Roy Kamphausen, David Lai , and Andrew Scobell, eds., *Beyond The Strait: PLA Missions Other than Taiwan*, Strategic Studies Institute, 2009, 211–252. *http://www.strategicstudiesinstitute.army.mil/pdffiles/pub910.pdf*; Gregory Kulacki, "A Space Race with China," *Harvard Asia Pacific*, 12–15; Eric Hagt and Matthew Durnin, "China's Antiship Ballistic Missile: Developments and Missing Links," *Naval War College Review* 62:4 (Autumn 2009): 87–115; Andrew S. Erickson, "Eyes in the Sky," *U.S. Naval Institute Proceedings*, 136:4 (April 2010): 36–41; Gregory Kulacki and Jeffrey G. Lewis, "A Place

counterspace programs did not appear integrated from an organizational, operational planning, or acquisition perspective. This has changed because the effects of the ongoing reform and reorganization are now bearing fruit. The PLA's capacity for space and counterspace operations will advance significantly with the consolidation of research, development, and acquisition (RD&A); training; and operations under a single integrated command. Defense industrial development of key space technologies over the next 15 years is likely to provide a further boost to the PLA's operational capabilities. Such advances will erode traditional advantages the United States has enjoyed in space.

A Taiwan contingency is the main strategic direction driving PLA force modernization. From the perspective of the PLA, success in such a scenario requires a credible ability to deter, delay, or deny possible intervention of U.S. forces in a cross-Strait conflict. Space assets enable extended-range precision strike operations intended to deny the United States access to or an ability to operate within a contentious area in the Indo-Pacific region.[2] U.S. military experts tout sophisticated conventional ballistic and ground-launched cruise missiles as an effective means of suppressing regional air defenses and military operations from airbases and carriers at sea. The PLA's ability to complicate U.S. access to space assets is likely to grow over the next ten to 15 years.

This report examines China's national and military space program. The first section addresses strategic, doctrinal, and organizational drivers behind China's civil and military space programs. The report then details the role of the PLA Strategic Support Force (PLASSF) in PLA space systems acquisition, transporting payloads, and maintaining space systems in orbit. The report also outlines the role of the PLASSF in developing space requirements and, to some extent, leveraging space assets for integrated joint operations. The discussion then turns to China's space research

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for One's Mat: China's Space Program, 1956–2003," *American Academy of Arts and Sciences*, 2009. *http://www.amacad.org/publications/spaceChina.pdf*; Kevin Pollpeter, "The Chinese Vision of Space Military Operations," in *China's Revolution in Doctrinal Affairs: Emerging Trends in the Operational Art of the Chinese People's Liberation Army*, James Mulvenon and David Finklestein, eds., CNA Corporation, December 2005, 329–369. *http://www.defensegroupinc.com/cira/pdf/doctrinebook_ch9.pdf*; Larry M. Wortzel, "The Chinese People's Liberation Army and Space Warfare: Emerging United States-China Military Competition, " *American Enterprise Institute*, 2007. *http://www.aei.org/paper/26977*; Michael P. Pillsbury, "An Assessment of China's Anti-Satellite and Space Warfare Programs, Policies, and Doctrines," Report for the U.S.-China Economic and Security Review Commission, January 19, 2007. *http://www.uscc.gov/researchpapers/2007/FINAL_REPORT_1-19-2007_REVISED_BY_MPP.pdf*; Alanna Krolikowski, "China's Civil and Commercial Space Activities and their Implications," testimony before the U.S.-China Economic and Security Review Commission *Hearing on the Implications of China's Military and Civil Space Programs*, May 11, 2011. *http://www.gwu.edu/~spi/assets/docs/11_05_11_krolikowski_testimony.pdf*; Dean Cheng, "China's Space Program: Civilian, Commercial, and Military Aspects," *CNA Corporation Conference Report*, May 2006; Phillip C. Saunders, "China's Future in Space: Implications for U.S. Security," *Ad Astra* (Spring 2005): 21–23. *http://www.space.com/adastra/china_implications_0505.html*; Joan Johnson-Freese, "China's Space Ambitions," *IFRI Proliferation Paper*, Summer 2007. *www.ifri.org/downloads/China_Space_Johnson_Freese.pdf*.

[2] Wayne A. Ulman, "China's Emergent Military Aerospace and Commercial Aviation Capabilities," testimony before the U.S.- China Economic and Security Review Commission *Hearing on China's Emergent Military Aerospace and Commercial Aviation Capabilities*, May 20, 2010. *https://www.uscc.gov/sites/default/files/5.20.10Ulman.pdf*.

and development (R&D) and industrial base and an overview of selected national and military programs. Finally, the report addresses the relevance of China's military-civilian fusion policies and international space cooperation. All Chinese-language sources listed have been translated for the purposes of this analysis.

SECTION ONE
DRIVERS FOR CURRENT AND FUTURE PLA SPACE/COUNTERSPACE CAPABILITIES

Authoritative Chinese government documents and policy statements indicate that the CCP views space as a domain of strategic competition.[3] The CCP considers itself to be in a space race with the United States—a race it intends to win.[4] To that end, the CCP is investing heavily across a broad range of programs that will expand its space capabilities and advance its associated political, economic, scientific, technological, and military objectives.

As China has become a space power, it has developed a number of weapons systems targeting other countries' space capabilities. According to the U.S. Department of Defense (DOD), China is developing multiple counterspace capabilities intended to degrade and deny a potential enemy's use of space. China's counterspace capabilities include directed-energy weapons, satellite jammers, and antisatellite (ASAT) missiles.[5] China's current programs of record include a crewed space station operated by the PLA and dual-use space systems capable of rendezvous and proximity operations.[6]

The CCP conducts an active propaganda and deception campaign to conceal the drivers of its space program, capabilities, and operations. China's latest white paper on space activities, released in 2016, omitted any mention of the military and state security aspects of its space program.[7] The PRC's state media outlets routinely obscure the missions of military intelligence payloads, often

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[3] PRC State Council Information Office, *China's National Defense in the New Era*, July 2019, 19. *http://www.xinhuanet.com/english/2019-07/24/c_138253389.htm*. See also: Ministry of Science and Technology, *Notice Regarding the Release of "The 13th Five-Year Action Plan for the Development of Military-Civil Fusion in Science and Technology"* (关于印发'十三五科技军民融合发展专项规划'的通知), April 12, 2017. *http://kyy.nuaa.edu.cn/2018/0109/c5794a96521/page.htm*; PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划)July 28, 2016. *http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm*.

[4] PRC State Council Information Office, *China's National Defense in the New Era*, July 2019, 19. *http://www.xinhuanet.com/english/2019-07/24/c_138253389.htm*. See also: Ministry of Science and Technology, *Notice Regarding the Release of "The 13th Five-Year Action Plan for the Development of Military-Civil Fusion in Science and Technology"* (关于印发'十三五科技军民融合发展专项规划'的通知), April 12, 2017. *http://kyy.nuaa.edu.cn/2018/0109/c5794a96521/page.htm*; PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划) July 28, 2016. *http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm.*

[5] U.S. Department of Defense, Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, May 2, 2019, 49–50. *https://media.defense.gov/2019/May/02/2002127082/-1/-1/1/2019_CHINA_MILITARY_POWER_REPORT.pdf.*

[6] PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划), July 28, 2016. *http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm*.

[7] PRC State Council, *Full Text of White Paper on China's Space Activities in 2016*, December 28, 2016. *http://english.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm.*

reporting them as civilian satellites launched for scientific or economic purposes.[8] According to Chinese government sources, China's national space program is largely managed by the PLA, and Chinese space assets are probably assigned as either military or dual-use (military-civil) assets to be mobilized in the event of a crisis or war.[9]

Space-Related Policy Statements

Although China's space-related white papers and state media reporting are often vague, the CCP has publicly released some authoritative government policy documents that are candid. In July 2016, the State Council released its *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan*, a planning document that provides authoritative, space-related policy statements. This plan states that China will develop next-generation space and near-space systems with a focus on improving satellites, launch vehicles, and "long duration near-space information support capabilities."[10] From 2016 to 2020, the plan aims to "strengthen comprehensive space technology applications supporting and serving national defense and state security, economic and social development, and the deployment of strategic power around the globe."[11]

To meet the 13th Five-Year Plan objectives, CCP authorities at all levels have been told to focus on the development of new remote sensing payloads and platforms, "super agile satellites and smart space-earth networks," precision positioning, navigation, and timing (PNT) services, big data analysis, and "earth simulation capabilities drawing from numerous sources."[12] The 13th

[8] For example, see *Xinhua*, "China Successfully Launches Yaogan 32 Group 01 Satellite" (我国成功发射遥感三十二号０１组卫星),October 9, 2018. *http://www.xinhuanet.com/politics/2018-10/09/c_1123533360.htm*; China National Space Administration, *China Successfully Launches Yaogan 29 Satellite* (我国成功发射遥感二十九号卫星), November 27, 2015. *http://www.cnsa.gov.cn/n6758823/n6758838/c6770322/content.html*. Yaogan 31 is almost certainly a military ocean surveillance satellite system used for tracking (and targeting) naval ships, and Yaogan 29 a military SAR system capable of capturing imagery at night and through clouds.

[9] For example, see *Xinhua,* "First Annual National Forum on the Standardization of Military-Civil Fusion Held in Qingdao" (全国首届标准化军民融合年会在青岛举行),December 21, 2018. *http://www.xinhuanet.com/mil/2018-12/21/c_1210021739.htm*; Zhu Hong et al., "An Initial Examination of China's Standardization of Military-Civil Fusion Developments" (我国标准化军民融合发展初探),*China Standardization*9 (2018): 144–145; Ministry of Science and Technology, *Notice Regarding the Release of The 13th Five-Year Action Plan for the Development of Military-Civil Fusion in Science and Technology* (关于印发'十三五科技军民融合发展专项规划'的通知), April 12, 2017. *http://kyy.nuaa.edu.cn/2018/0109/c5794a96521/page.htm*.

[10] PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划), July 28, 2016*. http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm*.

[11] PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划), July 28, 2016*. http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm*.

[12] PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划), July 28, 2016*. http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm*.

Five-Year Plan states that China will develop and test technologies for nuclear-powered spaceflight vehicles and new-concept space transportation systems.[13]

The plan specifies six primary lines of effort China will take related to the exploration, development, and exploitation of the space domain.[14] Many, but not all, are on track to be accomplished by the end of the five-year period. The six lines of effort are:

- *Space science satellite series:* According to its five-year plan, China will launch satellites to explore dark matter particles and seek to make major discoveries and breakthroughs in the study of dark matter, quantum mechanics, black holes, microgravity, and space life sciences. By around the year 2020, China will endeavor to have produced and launched a satellite capable of taking panoramic images of the interaction between solar winds and magnetic layers, a global water cycle observation satellite, and an advanced space-based solar observatory satellite. The advanced space-based solar observatory satellite has been delayed and is currently scheduled to be launched in 2022.[15]

- *Deep space exploration:* Beijing achieved an important planning goal when it successfully landed its Chang'e-4 lunar probe on the far side of the moon on January 3, 2019.[16] The five-year plan states that sometime in 2020, China will have made significant progress on the critical technologies needed for its future programs to explore an asteroid, explore Jupiter and its moons, and conduct follow-on lunar missions.

- *China's first mission to Mars:* In May 2019, Wang Chi, the director of China's National Space Science Center in Beijing, said China was on schedule for launching its first Mars mission in 2020.[17] If this mission is successful, Chinese scientists envision a future mission to bring back Martian soil samples to Earth by 2030.[18] In the near term, a scientific probe, the Huoxing-1, is planned to survey Mars' atmosphere, landscape, and geological and magnetic environment.[19]

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[13] PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划), July 28, 2016. *http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm*.
[14] Unless otherwise noted, the following section draws from PRC State Council, *State Plan for Science and Technology Innovation in the Period of the 13th Five-Year Plan* ('十三五'国家科技创新规划), July 28, 2016. *http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm.*
[15] ASO-S Group, "The Advanced Space-Based Solar Observatory (ASO-S)." *http://aso-s.pmo.ac.cn/english/index.php.*
[16] Paul Rincon, "Chang'e-4: Chinese Rover Now Exploring Moon," *BBC News*, January 4, 2019*https://www.bbc.com/news/science-environment-46760729.*
[17] Andrew Jones, "China's First Mars Spacecraft Undergoing Integration for 2020 Launch," *Space News*, May 29, 2019. *https://spacenews.com/chinas-first-mars-spacecraft-undergoing-integration-for-2020-launch/.*
[18] Dave Mosher, "China Wants to Launch to Mars Next Year - Part of an Ambitious Plan to Bring the First Martian Soil Samples Back to Earth," *Business Insider*, January 16, 2019. *https://www.businessinsider.com/china-mars-spacecraft-launch-2020-rover-sample-return-2019-1.*
[19] Leonard David, "This Is the 1st Photo of China's Mars Explorer Launching in 2020," *Space*, October 26, 2019. *https://www.space.com/china-moon-lander-rover-first-picture.html.*

- *Earth observation and navigation:* The five-year plan states that China will become self-reliant in earth observation and navigation and will make breakthroughs in the acquisition of precision information from space and the use of large-scale remote sensing capabilities. In April 2019, the *South China Morning Post* reported that China was on track to deliver global Beidou satellite navigation services in 2020, which is ahead of schedule. Global Beidou is an achievement Chinese space industry experts estimate will generate a services market worth $298 billion dollars (2 trillion RMB) and make China less reliant on the U.S.-built and -maintained Global Positioning System (GPS).[20] In October 2019, China launched the Gaofen-10 earth imaging satellite.[21] This followed the launch in March of two earth observation satellites, Gaofen-5 and Gaofen-6, and completed China's goal of having a system of seven high-resolution satellites of this type in orbit.[22]

- *New space vehicles:* The plan states that China will develop super capable (超强性能) space vehicles and platforms, satellites that can be repaired on-orbit, satellites that can be reused, and space robots (空间机器人). In 2016, China launched the Aolong-1 and Tianyuan-1 spacecraft, which tested satellite robotic arm grappling and satellite refueling in orbit, respectively.[23] From 2016 to 2018, China's Shijian-17 satellite conducted a series of space rendezvous and proximity operations in geosynchronous orbit (GEO).[24] These tests led U.S. military analysts and space experts to conclude this was a capability that could permit China to direct its spacecraft to rendezvous and interfere with U.S. early warning satellites.[25]

- *Heavy-lift rockets:* The plan states that to advance its deep space exploration and crewed lunar landing goals, China will develop a rocket capable of lifting 100 tons into low-earth orbit (LEO). By 2020, China plans to make breakthroughs in the core technologies needed for a rocket with a diameter over 10 meters and rocket engines powered by 500 tons of liquid oxygen/kerosene and 220 tons of liquid hydrogen and liquid oxygen, respectively. Chinese space industry representatives have said that China's LM-9 super-heavy-lift rocket

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[20] Sarah Dai, "China's Satellite Navigation System Beidou Expected to Generate $298 Billion Services Market by 2020," *South China Morning Post*, April 15, 2019. *https://www.scmp.com/tech/big-tech/article/3006172/chinas-satellite-navigation-system-beidou-expected-generate-298.*

[21] *Xinhua*, "China Launches HD Observation Satellite, "October 5, 2019. *http://www.xinhuanet.com/english/2019-10/05/c_138448867.htm.*

[22] *Xinhua*, "Two Chinese Earth Observation Satellites Put into Service, "March 21, 2019. *http://www.xinhuanet.com/english/2019-03/21/c_137913427.htm.*

[23] Todd Harrison et al., "Space Threat Assessment 2019,"*Center for Strategic and International Studies*, April 2019, 13. *https://aerospace.csis.org/wp-content/uploads/2019/04/SpaceThreatAssessment2019-compressed.pdf.*

[24] For details, see Brian Weeden and Victoria Samson, "Global Counterspace Capabilities: An Open Source Assessment," *Secure World Foundation*, April 2019. *https://swfound.org/media/206408/swf_global_counterspace_april2019_web.pdf.*

[25] Jim Sciutto, *The Shadow War: Inside Russia's and China's Secret Operations to Defeat America*, Harper-Collins, 2019), 161, 179–181. See also Todd Harrison et al., "Space Threat Assessment 2019,"*Center for Strategic and International Studies*, April 2019, 13. *https://aerospace.csis.org/wp-content/uploads/2019/04/SpaceThreatAssessment2019-compressed.pdf.*

will be operational around 2030, and, if successful, will be the most powerful rocket in the world.[26] According to U.S. company SpaceX, its Falcon Heavy rocket is currently the most powerful rocket available, with the ability to lift almost 64 tons into LEO.[27]

On December 15, 2016, the PRC State Council released its *State Plan for Informationization in the Period of the 13th Five Year Plan.* This planning document states that China will develop a space-based infrastructure to provide seamless internet and other information services to customers anywhere on the earth's surface using a dispersed array of floating platforms (浮空平台) high in the atmosphere, communications satellites in LEO, and networked space capabilities in higher orbits.[28]

The informationization plan calls for China to integrate remote sensing and telemetry systems associated with the Beidou global navigation satellite system (GNSS), other satellites, near space flight vehicles, and crewed aircraft, while "coordinating the construction of ground-based infrastructure and the development of military-civil fusion, in order to obtain global service capabilities as fast as possible."[29] The document states that as part of this five-year effort, China will accelerate the deployment of broadband satellites in high-earth orbits (高轨) as well as LEO, and improve its use of the frequency spectrum to "satisfy the needs of the state's major strategies."[30]

Underscoring the military nature of China's space program, the informationization plan says that CCP and state authorities at all levels will "accelerate the construction of military-civil and dual-use global mobile communications satellite systems," and states that China will "advance military-civil fusion in the space domain and construct an integrated space-to-earth cyberspace infrastructure" (天地一体网络空间基础设施).[31] Notably, the Beidou GNSS "informationization programs" are primarily run by the Office of the Central Cyberspace Affairs Commission, the Central Military Commission (CMC) Equipment Development Department (EDD), and the CMC Joint Staff Department.[32] According to the PRC State Council, China's space-related

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[26] Zhao Lei, "Super-Powerful Long March 9 Said to Begin Missions around 2030," *China Daily*, March 11, 2019. *http://www.chinadaily.com.cn/a/201903/11/WS5c859b62a3106c65c34edcc0.html.*
[27] SpaceX, "Falcon Heavy." *https://www.spacex.com/falcon-heavy.*
[28] For details on the 13th Five-Year Plan (十三五国家信息化规划), see PRC State Council, *State Plan for Informationization in the Period of the 13th Five Year Plan* ('十三五'国家信息化规划), December 15, 2016. *http://www.gov.cn/zhengce/content/2016-12/27/content_5153411.htm.*
[29] PRC State Council, *State Plan for Informationization in the Period of the 13th Five Year Plan* ('十三五'国家信息化规划), December 15, 2016. *http://www.gov.cn/zhengce/content/2016-12/27/content_5153411.htm.*
[30] PRC State Council, *State Plan for Informationization in the Period of the 13th Five Year Plan* ('十三五'国家信息化规划), December 15, 2016. *http://www.gov.cn/zhengce/content/2016-12/27/content_5153411.htm.*
[31] PRC State Council, *State Plan for Informationization in the Period of the 13th Five Year Plan* ('十三五'国家信息化规划), December 15, 2016. *http://www.gov.cn/zhengce/content/2016-12/27/content_5153411.htm.*
[32] Other responsible authorities are listed as the National Development and Reform Commission; Ministry of Industry and Information Technology; Ministry of Science and Technology; Ministry of Finance; Ministry of Public Security; State Administration of Science, Technology, and Industry for National Defense; and State Survey and

"informationization programs" all involve the State Administration for Science, Technology, and Industry for National Defense (SASTIND) and "relevant military departments."[33]

China's July 2019 defense white paper highlights the relevance of space in its national competitiveness. It states:

> *Outer space is a critical domain in international strategic competition. Outer space security provides strategic assurance for national and social development. In the interest of the peaceful use of outer space, China actively participates in international space cooperation, develops relevant technologies and capabilities, advances holistic management of space-based information resources, strengthens space situation awareness, safeguards space assets, and enhances the capacity to safely enter, exit and openly use outer space.*[34]

Strategic Drivers and Doctrine

Chinese military writings indicate the PLA's likely future direction as a space-enabled force. Internal PLA materials, which appear to be indicative of doctrine, point out that China's space program has "national political significance" because it affects the country's image and is a symbol of great power status. Moreover, these writings argue that China's space assets will be critical enablers for the execution of future joint operations.[35] They assert that China's space program should focus on the warfighting missions and scenarios identified as national priorities.[36] This is imperative, according to the writings, because space capabilities will be the "central pillar" upon which future joint operations rely.[37]

Writings produced by teams of Chinese military theorists at the PLA Army Command Academy and PLA Equipment Academy indicate that advanced space assets are perceived as vital to helping the PLA overcome legacy operational problems.[38] Presumably, these problems still exist. The theorists argue that the PLA had several challenges that negatively affected its ability to fight and win modern wars. One of the shortcomings was the difficulty of collecting battlefield intelligence

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Mapping Bureau. See Major Work Project Number 41 in the appendixes of PRC State Council, *State Plan for Informationization in the Period of the 13th Five Year Plan* ('十三五'国家信息化规划), December 15, 2016. *http://www.gov.cn/zhengce/content/2016-12/27/content_5153411.htm.*

[33] See Major Work Project Number 6 and Number 8 in the appendixes of PRC State Council, *State Plan for Informationization in the Period of the 13th Five Year Plan* ('十三五'国家信息化规划), December 15, 2016. *http://www.gov.cn/zhengce/content/2016-12/27/content_5153411.htm.*

[34] PRC State Council Information Office, *China's National Defense in the New Era*, 2019, 13–14. *http://www.xinhuanet.com/english/2019-07/24/c_138253389.htm.*

[35] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 74–75.

[36] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 27–32.

[37] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 33–34.

[38] Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 128; Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 39.

in contested environments with legacy platforms. For example, they noted that the PLA's ground-based intelligence collection centers monitoring enemy communications traffic and radar emissions could be defeated by hostile deception operations and electronic jamming, and reconnaissance aircraft could become easy targets for an enemy with modern air defenses.[39] To fill coverage gaps, the theorists envision networks of satellites, space stations, and near-space vehicles capable of continuous reconnaissance and surveillance missions over potential battlefields.[40]

These Chinese military writings foresee future satellites working in tandem with advanced communications platforms and relay systems deployed aboard ships, tethered aerostats, and aircraft that would provide redundant communications networks.[41] Another challenge the theorists anticipate is conducting air operations during inclement weather. They expect that China's Beidou GNSS will overcome weather problems that might otherwise ground essential flight operations.[42] Chinese military literature has emphasized the importance of space support for precision strike operations and special operations conducted behind enemy lines.[43] In addition, PLA writings have frequently highlighted the use of military intelligence satellites for strategic early warning of possible U.S. intervention during a conflict against a third party like Taiwan. Chinese theorists seem to share a widely held view that satellite reconnaissance is the principal means available for assessing the intentions and operations of U.S. forces in a conflict or crisis.[44] If true, Beijing is likely to consider space assets associated with this mission to be the most operationally valuable in its entire space enterprise.

Chinese military writings have identified perceived shortcomings in China's space program. One frequently mentioned vulnerability is the possibility that essential Chinese satellites could be affected by hostile counterspace operations. They anticipate that in a conflict, enemy forces could

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[39] Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 128; Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 39.

[40] Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 128; Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 39.

[41] Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 138–139.

[42] Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 149–152.

[43] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 194–197, 219–220.

[44] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 169–171, 190–193, 240–242. See also Yuan Wenxian, ed., *Course Book on Joint Campaigns and Information Operations* [联合战役信息作战教程], National Defense University, 2009, 279–288; Cao Zhengrong, Wu Runbo, and Sun Jianjun,eds., *Informatized Joint Operations* [信息化联合作战], Liberation Army Press, 2008,45–163; Zhang Yuliang, ed., *Science of Campaigns* [战役学], National Defense University Press, 2007, 312–330.

jam Chinese satellites in orbit and sabotage their ground support infrastructure.[45] To mitigate this threat, PLA writings recommend hardening satellites, camouflaging and concealing their operations centers, maneuvering when under attack, and augmenting the protection of ground stations.[46] They further recommend using civilian satellites for military missions and stockpiling military satellites as a reserve that can be launched to fill coverage gaps and meet wartime needs.[47] Chinese military theorists express concern that Beidou satellites could be accidentally jammed by friendly air defense units. To reduce the risk of "red-on-red" jamming, they recommend that commanders coordinate operations and carefully control when and where electronic jamming is used.[48]

General Trends since the Late 1990s

China's space program has made tremendous progress over the past two decades. In 1999, China launched its first uncrewed spacecraft, Shenzhou-1, a test bed for future crewed spaceflights. In 2003, China launched its first crewed mission. In 2007, it conducted a successful test of an ASAT missile, and that same year a Chinese lunar probe orbited the moon. In 2008, Chinese taikonauts completed their country's first spacewalk, and China launched its first space lab in 2011, followed by a second lab in 2016.[49] At the same time, China's military space capabilities have grown rapidly and made progress across a broad range of applications. In 2018 alone, China successfully launched 38 space launch vehicles, putting approximately 100 satellites in orbit.[50] China expects to carry out more than 40 launches in 2020.[51]

According to DOD:

> *China's space industry is rapidly expanding its ISR (Intelligence, Surveillance, and Reconnaissance), navigation, and communication satellite constellations and making substantial strides in its space lift capabilities, human spaceflight, and*

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[45] See Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 128; Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 164–165, 187, 212, 232, 248.

[46] See Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 128; Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 164–165, 187, 212, 232, 248.

[47] See Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 128; Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 164–165, 187, 212, 232, 248.

[48] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 239–240.

[49] Jessica Meyers and Mitchell Landsberg, "A Growing Competition: China and the U.S. Space Program, Year by Year," *Los Angeles Times*, May 11, 2007. *https://www.latimes.com/world/asia/la-fg-china-hainan-space-timeline-2017-htmlstory.html.*

[50] U.S. Department of Defense, Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, May 2, 2019, 50. *https://media.defense.gov/2019/May/02/2002127082/-1/-1/1/2019_CHINA_MILITARY_POWER_REPORT.pdf.*

[51] *China Space News*, "CASC Commences 2020 Model Work Meeting" (中国航天科技集团有限公司召开 2020 年型号工作会议), January 3, 2020. *http://spacechina.com/n25/n2014789/n2014804/c2819421/content.html.*

lunar exploration programs. China is looking to expand its space launch vehicle industry to support commercial launches and make rapid satellite launch services available to foreign customers. China is planning to launch, assemble in-orbit, and operate a crewed Chinese space station before 2025.[52]

Current trends suggest that China's civilian officials and military officers may become increasingly reliant upon space for decision making during times of crisis—and more vulnerable to having it denied to them.

Space Support for Warfighting Campaigns

To further understand the role of space in Chinese military operations, it may be useful to examine the nature of China's envisioned warfighting operations.[53] PLA sources indicate that Chinese military strategists focus on five major conflict types, which may overlap as part of a larger war. Potential war plans constructed around these operations would require varying degrees of space-enabled military forces. Generally referred to in Chinese literature as joint campaigns (联合战役) or joint operations (联合作战), it seems likely these imagined future wars drive China's military space buildup to a significant degree.[54] The PLA's main joint operations are as follows:

- Joint Firepower Strike Operations against Large Island (大型岛屿联合火力突击作战)[55]
- Joint Blockade Operations against Large Island (大型岛屿联合封锁作战)
- Joint Attack Operations against Large Island (大型岛屿联合进攻作战)[56]
- Joint Anti-Air Raid Operations (联合反空袭作战)[57]
- Joint Border Area Operations (边境地区联合作战)

[52] U.S. Department of Defense, Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, *Department of Defense*, May 2, 2019, 98. *https://media.defense.gov/2019/May/02/2002127082/-1/-1/1/2019_CHINA_MILITARY_POWER_REPORT.pdf.*

[53] This section draws from Ian Easton, "China's Top Five War Plans," *Project 2049 Institute*, January 6, 2019. *https://project2049.net/2019/01/06/chinas-top-five-war-plans/.*

[54] See Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informatized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 109–314; Yuan Wenxian, ed., *Course Book on Joint Campaigns and Information Operations* [联合战役信息作战教程], National Defense University Press, 2009, 271–326; Cao Zhengrong, Wu Runbo, and Sun Jianjun, eds., *Informatized Joint Operations* [信息化联合作战], Liberation Army Press, 2008, 145–323.

[55] While the direct translation of 大型岛屿 is simply "a large island or islands," it is clear from PLA texts that they are referring specifically to Taiwan and not an abstraction or large islands in general. It might therefore be risky to assume the PLA would use the exact same planning assumptions for notional operations against Luzon, Okinawa, or Guam.

[56] This is also sometimes referred to as Joint Landing Operations against Taiwan (大型岛屿联合登岛作战).

[57] Note that some PLA writings, such as *Informatized Joint Operations*, refer to this as "Joint Coastal Area Defense Operations" (*Binhai Diqu Lianhe Fangwei Zuozhan*). It is also sometimes called "Counter-Intervention Operations."

In the event of conflict, what types of space assets are likely to be assigned to PLA commanders, and how would they notionally be used? The following descriptions briefly outline how Chinese military writings foresee the use of space capabilities in the future operations identified above.

Joint firepower strike operations: Chinese military writings portray space assets as critical for carrying out joint firepower strike operations against Taiwan. They portray ISR satellites as being particularly important. These satellites would be tasked with collecting intelligence used by the PLA to build and update lists of Taiwanese and U.S. targets, monitor and target U.S. ships and planes within 3,000 kilometers (km) of the PRC, and produce battle damage assessments after the initial wave of strikes.[58]

Joint blockade operations: If China's leaders opted to blockade Taiwan in a coercive manner (as opposed to a prelude to an invasion), PLA theorists believe operations would be centralized and relatively constrained. Operations in this scenario would be prolonged and "highly political," with Beijing likely interjecting to manage intensity levels and choose targets. Space capabilities would be expected to provide target intelligence and secure communications to commanders in the field, allowing the central leadership to "reach down" and micromanage the blockade in a manner they believed best advanced their strategic goals. If the blockade was intended to soften up Taiwan as a precursor to invasion, space assets would most likely be focused on assessing the optimal time for crossing the Taiwan Strait based on the weather and the status of Taiwanese and U.S. forces.[59]

Joint attack operations: PLA writings portray the invasion of Taiwan as the most challenging and important future mission of the Chinese military. To prepare for this operation, China's military space units are expected to continuously collect and analyze intelligence on Taiwan's beaches, currents, tides, roads, bridges, waterways, electric power grid, reservoirs, oil and gas stocks, airports, seaports, command posts, ground force units, and air defense networks. During wartime operations, China's space assets would be expected to provide 24/7 intelligence on the cross-Strait battlefield and strategic early warning should the United States intervene. Chinese satellites and near-space drones would be called upon to provide wideband, high-capacity, jam-resistant, encrypted communications to all the units involved in the operation. Envisioned future Chinese space architecture will allow the PLA to merge and link all joint forces together into an organic system that allows operational commanders to: (1) find targets,(2) decide how to strike them, (3) send strike orders to forward units,(4) neutralize targets, (5) assess battle damage, and (6) consider whether or not re-strikes are required.[60]

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[58] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 153–163.
[59] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 174–176.
[60] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 197–199.

Joint anti-air raid operations: PLA writings state that intelligence provided by satellites would be vital to the success of joint anti-air raid operations. In peacetime, PLA space forces are expected to collect intelligence on U.S. airbases and aircraft carriers within range of potential targets in China. Space capabilities are to provide PLA commanders information on the numbers, parking sites, and types of aircraft at each base, and gather intelligence on the ranges and stockpiles of their munitions. In addition, space assets would be tasked with monitoring the movements of U.S. ships, including destroyers and submarines, which could launch cruise missiles at targets in China.[61] As such, PLA studies state that early warning of the first wave of U.S. strikes would be crucial for defending against an attack and disrupting follow-on operations. These PLA writings note that the United States could launch air raids from almost any direction, and assert that space assets should prioritize warning intelligence based on a three-tier system, with tier one representing critical political, economic, and military targets in the PRC's major cities. Tiers two and three would be important but less vital potential targets, which would receive warning intelligence from space assets later or may not receive any warning at all.[62]

Joint border area operations: Chinese military theorists anticipate that in the event of a border war, India would be unlikely to attack until it had amassed superior forces at its forward bases. As such, the priority mission of Chinese space assets during these operations would be to provide early warning intelligence of hostile enemy deployments and ensure China's leaders were not caught off-guard by a potential Indian surprise attack. After the outbreak of hostilities, the priority mission of China's space forces would be to provide reliable satellite communications to combat units in the mountains and provide combat commanders with imagery intelligence.[63]

The following table shows how one internal PLA handbook published by China's National Defense University envisions the role military-civil space assets will play in future joint operations.

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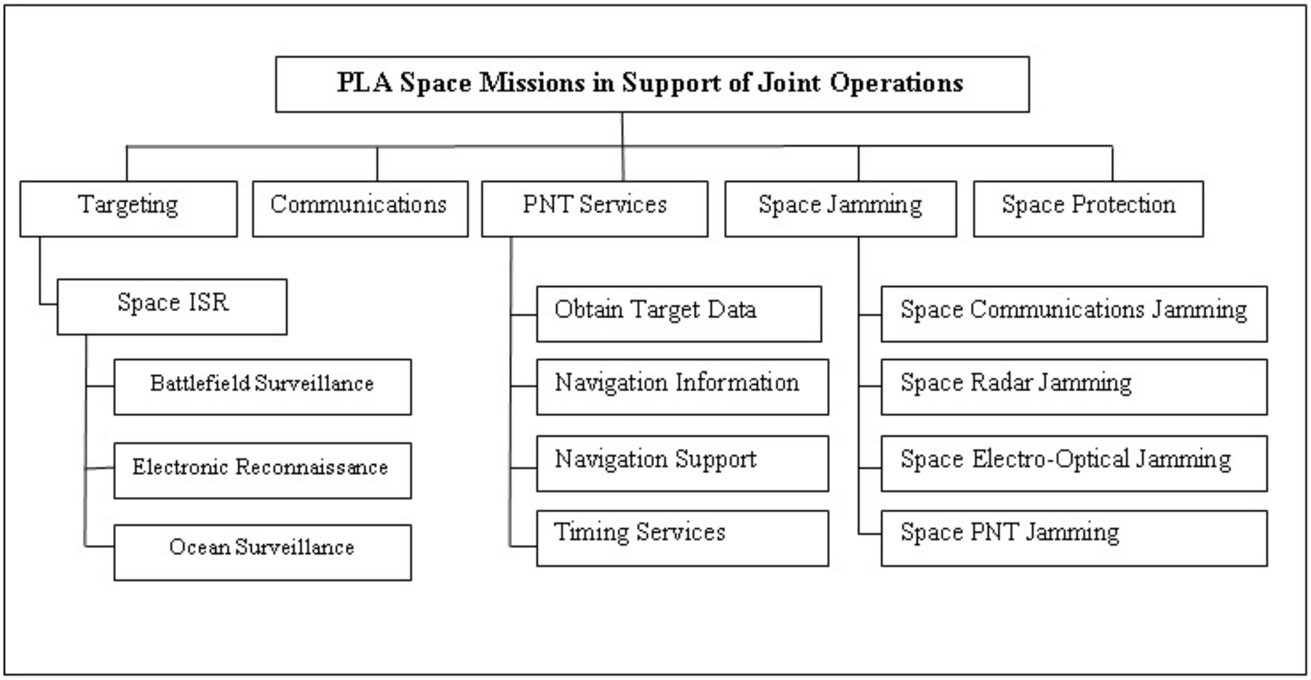
[61] In addition, note that other U.S. targets in the Pacific would include communications sites, command posts, intelligence collection centers, radars, fuel dumps, ammunitions dumps, aircraft repair hangars, spare parts garages, and other logistical facilities. See Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 240–247.

[62] Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 241–242. For further details, see Yuan Wenxian ed., *Course Book on Joint Campaigns and Information Operations* [联合战役信息作战教程], National Defense University, 2009, 314–326; Cao Zhengrong, Wu Runbo, and Sun Jianjun, eds., *Informatized Joint Operations* [信息化联合作战], Liberation Army Press, 2008, 236–262; Zhang Yuliang, ed., *Science of Campaigns* [战役学], National Defense University Press, 2007, 312–330.

[63] Note that the PLA writings reviewed focus primarily on the Sino-Indian border rather than other conceivable flashpoints along the PRC border. Wang Yongping, ed., *Space Information Support Operations* [空间信息支援作战], National Defense University Press, 2014, 220–222. For further details, see Cao Zhengrong, Sun Longhai, and Yang Yin, eds., *Informationized Army Operations* [信息化陆军作战], National Defense University Press, 2014, 216–314; Yuan Wenxian ed., *Course Book on Joint Campaigns and Information Operations* [联合战役信息作战教程], National Defense University, 2009, 302–313; Cao Zhengrong, Wu Runbo, and Sun Jianjun, eds., *Informatized Joint Operations* [信息化联合作战], Liberation Army Press, 2008,263–323.

Figure 1: PLA Space Missions in Support of Joint Operations



Source: Wang Yongping, ed., *Space Information Support Operations*(空间信息支援作战), National Defense University Press, 2014, 126.

Space, Distant Operations, and Outlook for the Future

The primary near-term focus of China's military space program is to enable successful joint operations along the PRC's periphery. Space capabilities being developed and fielded will increasingly allow the PLA to operate globally. The PLA Navy already has demonstrated an ability to sail and operate naval task forces around the world, including in the Mediterranean, Baltic, Bering, and Caribbean seas.[64] The PLA Air Force (PLAAF) is currently capable of conducting bomber operations past the first island chain and has deployed transport aircraft and airborne units as far from China as Turkey, Australia, and Venezuela.[65] RAND analysts expect that by the earlytomid-2020s, the PLAAF will deploy a next-generation long-range strategic bomber capable of threatening Hawaii, Australia, and possibly the U.S. mainland.[66]

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[64] Ridzwan Rahmat, "Chinese Navy Expands HADR Footprint with Medical Mission in Caribbean," *Jane's Navy International*, October 24, 2018. *https://www.janes.com/article/84035/chinese-navy-expands-hadr-footprint-with-medical-mission-in-caribbean*; Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities - Background and Issues for Congress," *Congressional Research Service*, August 1, 2018, 56. *https://fas.org/sgp/crs/row/RL33153.pdf*; *BBC News*, "Five Chinese Ships Seen Off Alaska Coast, Pentagon Says," September 3, 2015. https://www.bbc.com/news/world-us-canada-34131429.

[65] Cristina L. Garafola and Timothy R. Heath, "The Chinese Air Force's First Steps toward Becoming an Expeditionary Air Force," *RAND Corporation*,2017,36–37. *https://www.rand.org/content/dam/rand/pubs/research_reports/RR2000/RR2056/RAND_RR2056.pdf.*

[66] Derek Grossman et al., "China's Long-Range Bomber Flights: Drivers and Implications," *RAND Corporation*, 2018, 55. *https://www.rand.org/pubs/research_reports/RR2567.html.* See also Derek Grossman, "Envisioning a 'World-Class' PLA: Implications for the United States and the Indo-Pacific," *RAND Corporation*, July 1, 2019. *https://www.rand.org/pubs/testimonies/CT514.html*.

As China's space capabilities improve, so too will its ability to conduct larger and more complex operations at greater distances from China. U.S. policymakers should expect that by the early 2020s, space-based communications, navigation, and intelligence assets will enhance the PLA's lethality across a range of scenarios and allow China to project power in West Africa, Central America, South America, Antarctica, and the Arctic. Improved space architecture will enable the PLA to conduct precision strikes on targets at greater range, will guarantee Chinese forces access to PNT services provided by Beidou instead of GPS, and could significantly expand the operational ranges of Chinese strategic forces. Secure satellite communications could support long-distance nuclear submarine patrols. They may also enable strategic bomber patrols and ground-based missile deployments overseas.

Since 2016, China's government has sought to acquire airbases and other facilities in Greenland and the Azores that could be used for military power projection operations against the continental United States and U.S. forces in the North Atlantic and Europe.[67] While these efforts have been unsuccessful to date, China will likely continue making attempts to gain basing rights in unexpected geographical areas. Future Chinese overseas bases will require global satellite communications, precise PNT, and regularly updated remote sensing information on enemy targets. In addition to supporting peacetime presence and humanitarian operations, Chinese space assets will enhance the ability of Chinese marines and special operations forces to carry out unconventional missions around the world using satellite services, something they are beginning to include in their training.[68]

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[67] Michael Rubin, "Beware China's Inroads into the Atlantic," *National Interest*, June 26, 2019. *https://nationalinterest.org/feature/beware-chinas-inroads-atlantic-64391*; Aaron Mehta, "How a Potential China-Built Airport in Greenland Could Be Risky for a Vital US Air Force Base," *Defense News*, September 7, 2018. *https://www.defensenews.com/global/europe/2018/09/07/how-a-potential-chinese-built-airport-in-greenland-could-be-risky-for-a-vital-us-air-force-base/.*

[68] For example, in July 2018, it was reported that PLA special operations forces were utilizing satellite imagery in their exercises. See Yang Qingmin and Xu Chunlong, "PLA Army Conducts First Assessment of Its Special Operations Forces," *Ministry of Defense*, July 17, 2018. *http://eng.mod.gov.cn/news/2018-07/17/content_4819487.htm.*

SECTION TWO
PLA SPACE/COUNTERSPACE INFRASTRUCTURE: THE ROLE OF THE PLA STRATEGIC SUPPORT FORCE

In early 2016, the Chinese military undertook a sweeping reorganization and reform program with the stated objective of molding a joint force capable of a broad range of contingencies. Several drivers have influenced the Central Military Command's (CMC) ongoing restructuring and reform initiative. The reform and restructuring involved elimination of the four general departments: the General Staff Department (GSD), General Political Department (GPD), General Logistics Department (GLD), and General Armaments Department (GAD). In their place, the CMC established new departments, transformed the PLA Second Artillery Force into the PLA Rocket Force (PLARF), and established a new PLA Army headquarters and the PLASSF. The seven Military Regions were consolidated into five Theater Commands (TCs). Each of the service headquarters has reinforced their organizing, training, and equipping missions.

The ongoing reform and reorganization effort likely will improve China's ability to realize its space ambitions. First, the establishment of the PLASSF integrates space-related RD&A, operations, and training under a single authority. Discussion of an independent space force had been underway since the 1990s.[69] Before 2016, both the former GSD and GAD managed RD&A associated with their respective missions. The merger of space missions under a single authority is likely to create a more efficient and effective system for overseeing development and integration of new capabilities into the active force. With space-related training managed by a central authority, the reorganization also will likely create operational synergies that did not exist before 2016.[70]

The PLA is seeking to improve its space situational awareness and making rapid advances in its space-based early warning capabilities. China reportedly has been cooperating with Russia in

[69] Larry M. Wortzel, "The Chinese People's Liberation Army and Space Warfare: Emerging United States-China Military Competition," *American Enterprise Institute*, 2007. *http://www.aei.org/publication/the-chinese-peoples-liberation-army-and-space-warfare/.*

[70] The PLASSF is one of the most significant components of the ongoing military reform and reorganization. Established in December 2015 and still in a state of transition, the PLASSF is not a service, such as the PLA Army, PLA Air Force, PLA Navy, and PLA Rocket Force. However, as a force with the same grade as the four services and five TCs, the PLASSF is treated as a service. For background on the PLASSF, see Kevin L. Pollpeter, Michael S. Chase, and Eric Heginbotham, "The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations," *RAND Corporation*, 2017; Elsa Kania, "PLA Strategic Support Force: The 'Information Umbrella' for China's Military," *Diplomat*, April 1, 2017; Rachael Burton and Mark Stokes, "The People's Liberation Army Strategic Support Force Leadership and Structure," *Project 2049 Occasional Paper*, September 25, 2018. *https://project2049.net/wp-content/uploads/2018/09/180925_PLA_SSF_Leadership-and-Structure_Stokes_Burton.pdf*; John Costello and Joe McReynolds, "China's Strategic Support Force: A Force for a New Era," *China Strategic Perspectives*13 (October 2, 2018). *https://ndupress.ndu.edu/Media/News/Article/1651760/chinas-strategic-support-force-a-force-for-a-new-era/*; Marcus Clay, "Supporting the Infinitive Battlefield," *China Aerospace Studies Institute*, 2019.

developing an early warning capability.[71] China has cooperated with Ukraine on space debris monitoring and research on deep space issues.[72]

PLASSF senior officers manage at least three first-level administrative departments, two systems departments, and at least 12 corps leader-grade or corps deputy leader-grade base commands. The PLASSF Space Systems Department is central to China's ambitions in space. The PLASSF maintains space situational awareness through a corps leader-grade command headquartered in Xian, a corps leader-grade maritime space tracking command, and a control center in Beijing. This network integrates space tracking data from ground-based assets in China, sea-based units, and a number of international ground stations located in the Indo-Pacific region and elsewhere (see below).

The PLASSF also oversees an expanding space-based ISR network that enables monitoring of U.S. activities in the Indo-Pacific region and beyond. The expansion of this network is likely to enhance China's ability to conduct military operations farther from shore. Over the years, the PLA has fielded electro-optical (EO), radar, and other space-based sensor platforms that can transmit images of the Earth's surface to ground stations in near-real-time. China is investing heavily in EO, synthetic aperture radar (SAR), and electronic reconnaissance surveillance capabilities. Future deployments of potential sea-based imagery receiving stations, additional data relay satellite systems, or the further establishment of ground stations abroad could enhance China's extended-range near-real-time targeting capability.

Importantly, a growing body of Chinese military-technical literature suggests planning for a counterspace capability. The PLA also has deployed or is developing jamming and cyberspace capabilities, directed energy weapons, on-orbit capabilities, and ground-based ASAT missiles that can deny an adversary unimpeded use of its own satellite systems. The specific PLA service responsible for direct ascent ASAT operations remains unknown. However, technology demonstration testing of a space intercept system has been carried out since at least 2005. Testing of kinetic kill vehicles (KKVs), high-powered lasers, co-orbital satellites, electronic jamming, and—possibly—cyberattacks have been reported. The opacity surrounding China's space programs suggests other clandestine counterspace weapons programs may also exist.

The PLASSF plays a critical role in supporting national- and theater-level command and control. The CMC Joint Staff Department (JSD) manages the national military command system, with the CMC JSD Operations Bureau functioning as the core duty staff within the CMC Joint Command Center. PLASSF staff officers probably augment the CMC Joint Command Center's duty office during peacetime, and in higher readiness levels. CMC Joint Command Center operations are also

[71] Dmitry Stefanovich, "Russia to Help China Develop an Early Warning System," *Diplomat*, October 25, 2019. *https://thediplomat.com/2019/10/russia-to-help-china-develop-an-early-warning-system/*.
[72] Embassy of Ukraine in the People's Republic of China, *A Meeting of the Ukrainian-Chinese Subcommission on Cooperation in Space Field Was Held in Beijing*, November 12, 2018. *https://china.mfa.gov.ua/en/news/68681-u-pekini-vidbulosy-zasidannya-ukrajinsyko-kitajsykoji-pidkomisiji-z-pitany-spivrobitnictva-v-galuzi-kosmosu.*

augmented by at least ten dedicated support groups (保障大队) that are responsible for mission planning/targeting; survey, mapping, and navigation; network/electronic countermeasures; battlespace awareness; meteorology/hydrography; and other functions. Support groups likely rely heavily on PLASSF space assets.[73]

Space Systems Department and Subordinate Base Commands

The PLASSF Space Systems Department was created through the merger of the former General Armaments Department (GAD) China Launch and Tracking Control General (CLTC) and space-related organizations previously under the General Staff Department (GSD) Operations Department and GSD Intelligence Department. The Space Systems Department oversees at least six corps or corps deputy leader-grade operational commands responsible for space launch, tracking, and control. The PLASSF tracks and controls space assets through the Xian Satellite Control Center (Base 26) and the Beijing Space Command and Control Center in the northern suburbs of Beijing, which integrates space tracking data from ground- and sea-based units. Three corps leader-grade space launch base commands are in Jiuquan (Base 20, aka Shuangchengzi), Taiyuan (Base 25, aka Wuzhai), and Xichang (Base 27). Base 27 probably oversees the launch complex on Hainan Island. These space launch centers also support ballistic missile and kinetic space interceptor testing. New units, possibly corps deputy leader-grade and related to space applications, have been formed in Beijing and Wuhan. Newly established PLASSF corps-level units suggest possible direct operational support to TC leaders in a contingency.

Other base commands are responsible for space situational awareness. The Xian Satellite Tracking and Control Center (Base 26) is a corps leader-grade organization responsible for ground-based space tracking, telemetry, and control. Although unconfirmed, Base 26 may oversee the Beijing Space Flight Command and Control Center and its subordinate entities. The China Satellite Maritime Tracking and Control Department (Base 23, Jiangyin) is a corps leader-grade

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[73] The former designation of the Target Control Center (目标控制中心) was 61683 部队. For reference, see CMC Joint Command Center Survey and Navigation Group (军委联合作战指挥中心测绘导航大队)(依法履行检察监督职责体现使命担当), 人民监督, May 18, 2017. *http://www.fyfzw.cn/html/2017/jd_0518/25904.html.*The Network/Electronic Countermeasures Group appears to be founded upon a core element of the former GSD Fourth Department ECM Center. With most of the former 4PLA transferred to the PLASSF, the Network ECM Support Group may be an interface dedicated to joint command and control. For references to a CMC Joint Command Center Network/ECM Support Group, see (军委联指网电对抗大队)(31003 部队视频信息系统竞争性谈判采购公告), October 19, 2016. *http://www.bidchance.com/calggnew/2016/10/19/16801361.html* and (北京市人民检察院召开驻京部队市人大代表座谈会), People's Procurator of Beijing Municipality, December 5, 2016. *http://www.bjjc.gov.cn/bjoweb/jcyw/90801.jhtml*. The Battlespace Awareness Support Group (战场态势大队) may be assigned a Military Unit Cover Designator (MUCD) of 31004. For references, see (朱玉萍), (王海), and (路征), *PLA Daily*, "Electromagnetic Situation Fuses into Battlefield Situation—The Operational Situation Can Be Forecasted to Determine Enemy Intent" (电磁态势融入战场态势可预测作战态势判断敌方企图), February 8, 2018. *http://military.people.com.cn/n1/2018/0208/c1011-29812995.html.* The precise mission of the Battlespace Awareness Group (possible Unit 31004) remains unclear. However, it appears related to intelligence/reconnaissance. The Meteorological and Hydrological Group (Unit 31010) may be staffed by officers from the CMC Joint Staff Department Battlefield Environment Support Bureau. The group could be an outgrowth of the former GSD Meteorological, Hydrological, and Space Weather Command (Unit 61741), a division leader-grade unit.

organization that is responsible for sea-based satellite tracking, control, and launch vehicle transportation to Hainan.

The PLASSF's first-level departments are responsible for structural integration (or "cross-domain fusion") of space and network operations. The PLASSF Space Systems Department appears responsible for space launch operations, space tracking and control, and applied space operations. The Space Systems Department leaders are supported by headquarters staff, specifically the Staff Department, Political Work Department, Logistics Department, and Equipment Department.

Senior PLASSF leaders are responsible for military space operations. The PLASSF commander and political commissar have extensive experience in operations and theater-level leadership positions. Both are TC leader-grade officers, which extends significant stature within the PLA.[74] The PLASSF is equal in grade to the PLA Army, PLA Navy, PLAAF, PLA Rocket Force, and the five TCs. The PLASSF's first-level departments—Staff, Political Work, Logistics, Space Systems, and Network Systems—and the Discipline Inspection Commission are responsible for structural integration (or "cross-domain fusion") of space and network operations. A limited number of sources suggest the existence of a PLASSF Equipment Department as well.[75]

Space Launch Operations

PLASSF space launch operations are carried out from four launch complexes. Each is led by a corps or corps deputy leader-grade officer. The Jiuquan Satellite Launch Center (PLASSF Base 20) supports LM-2C, LM-2D, and LM-4 launches into LEO, as well as crewed space missions on the LM-2F. Base 20 is also a key facility for short-range ballistic missile, land attack cruise missile, and space intercept testing. Subordinate units are responsible for space launch operations, launch tracking, missile testing, impact area management, transportation, propellant loading, and communications.[76]

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74 The commander, Lieutenant General Li Fengbiao, is a career PLAAF officer with a background in the airborne corps. The political commissar, General Zhang Weiping, previously served as political commissar of the Eastern Theater Command. At least three deputy commanders and two deputy political commissars support the commander and political commissar in their duties. The PLASSF chief of staff previously directed the former GSD Operations Department, reflecting a merging of operations and strategic ISR.

75 Harbin Institute of Technology, "Assisting Military-Civil Fusion, The Important Tool for Casting the Nation: Changzhou Military-Civil Fusion Industrial Park Formally Established, Businesses Entering the Park Enjoy Comprehensive One-Stop Service!" (助军民融合、铸国之重器：常州军民融合产业园正式开园，入园企业享受全方位、一站式服务！), May 24, 2017. *http://edp.hit.edu.cn/2017/0524/c7876a178695/page.htm.* As a side note, the PLASSF is an anomaly because the Space Systems Department and Network Systems Departments are both first-level departments at the same grade as the Staff Department, Political Work Department, and Discipline Inspection Commission. As such, they cannot be subordinate to any of those departments. Furthermore, because of their grade, each of the directors serves as a concurrent PLASSF deputy commander and their political commissars serve as concurrent PLASSF deputy political commissars. Each of their second-level bureaus are corps deputy leader-grade organizations.

76 As of 2019, the commander/director of Base 20 was Major General Zhang Zhifen (张志芬). The Impact Area Department is probably headquartered in Korla.

The Taiyuan Satellite Launch Center (PLASSF Base 25), headquartered in Shanxi's Kelan County, functions as China's primary platform for satellite launches into sun-synchronous orbit (SSO) as well as testing of medium- and intermediate-range ballistic missiles. Like Base 20, subordinate units are responsible for space launch operations, missile testing, propellant loading, launch tracking, and communications.[77] More recently, Taiyuan established a maritime team and was responsible for the launch of the LM-11 in June 2019.[78]

The Xichang Satellite Launch Center (PLASSF Base 27) is China's primary platform for launch of communication and weather satellites into GEO. At one point, Xichang reportedly had capacity to launch between eight and ten satellites a year.[79] Base 27 was the launch point of the PLA's January 2007 test of a KKV against an aging Chinese weather satellite.[80] Although unconfirmed, Base 27 may oversee launch operations from the Wenchang Spacecraft Launch Center on Hainan Island. The Wenchang complex is responsible for LM-5 and LM-7 launch operations in support of China's crewed space program. Launch vehicles are transported to Hainan via ship from assembly facilities in Tianjin. Initial launches of the LM-5 and LM -7 took place in 2016 and 2017.[81] It is possible the LM-9 heavy-lift vehicle, scheduled to be operational before 2030, may also be launched from Hainan.

The PLASSF space launch infrastructure has improved its efficiency and effectiveness over time. DOD indicates China marked its largest space launch year to date in 2018, successfully launching

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[77] As of 2019, the commander/director of Base 25 was Yu Zhijian (于志坚) and political commissar was Wan Minggui (万明贵).

[78] Lu Jun (路俊) and Zou Weirong (邹维荣), "Commemorating Taiyuan Space Launch Center's Maritime Launch Mission Team" (记太原卫星发射中心海上发射任务团队), *PLA Daily*, June 11, 2019. *http://www.81.cn/jfjbmap/content/2019-06/11/content_235682.htm.*

[79] *China Space News*, "Xichang Satellite Launch Center Can Launch at Least 10 Satellites" [西昌卫星发射中心年发射能力达 10 颗以上], August 4, 2010.Launch campaigns average 25 days. Also see Fu Zhiheng (Vice President, China Great Wall Industry Corporation), "Chinese Launchers and COMSATs: Development & Commercial Activities," World Space Risk Forum, Dubai, February 28–March 1, 2012. Major General Zhang Xueyu (张学宇; b. 1963) is cited in 2017 reporting as the commander of the Xichang Space Launch Center. He previously directed the PLASSF Space Systems Department Equipment Department. Previous assignments include GAD deputy chief of staff (2013–2016) and commander of the GAD Base 32 (华阴兵器试验基地). As of 2019, the political commissar is Dong Chongqing (董重庆).

[80] Craig Covault, "Chinese Test Anti-Satellite Weapon," *Aviation Week & Space Technology*, January 17, 2007. *http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=space&id=news/CHI01177.xml.*

[81] Wenchang appears to still carry a designation of the 078 Engineering Command [078 工程指挥部]. Some reporting implies an operational subordination to Base 20 at Jiuquan. The Wenchang Space Launch Center Director is Major General Wang Weichang [王维昌]. For reference to the LM-5 Tianjin manufacturing facilities, see Xin Dingding, "New Carrier Rocket Series to Be Built," *China Daily*, October 31, 2007. *http://www.chinadaily.com.cn/china/2007-10/31/content_6217880.htm.*

38 of 39 space launch vehicles and orbiting approximately 100 spacecraft.[82] In 2019, China successfully carried out 32 of 34 launches.[83]

Space Situational Awareness and Control

As China's presence in space expands, so too does the importance of space situational awareness (SSA). The PLASSF manages a well-established SSA infrastructure. SSA entails near-real-time knowledge of a space flight vehicle's location, the ability to track and predict a space flight vehicle's future location, and cataloguing of all space objects. SSA also includes understanding a potential adversary's intent for their spacecraft. China's SSA system is gradually expanding in scope and sophistication to accommodate its own growing presence in space, and to address perceived challenges from other space-faring nations.[84]

The PLASSF's SSA network is probably able to search, track, and characterize satellites in all earth orbits, supporting both space operations and counterspace systems. The PLASSF space surveillance and control system consists of a tracking center in Xian, fixed land-based sites, at least one mobile system, and as many as seven Yuanwang tracking ships capable of operating throughout the Pacific, Atlantic, and Indian oceans. The PLASSF also operates foreign satellite ground stations (discussed in following section).[85]

Xian Satellite Tracking and Control Center: Headquartered in Shaanxi's Weinan City, the Xian Satellite Tracking and Control Center (PLASSF Base 26) is a corps leader-grade command responsible for land-based space tracking, telemetry, and control. Base 26 likely plays a role in monitoring and identifying debris and other objects in space. Although unconfirmed, Base 26 may oversee the Beijing Space Flight Control Center and its subordinate entities.[86] The Base 26 space surveillance system may fuse data from other sources, including the China Academy of Science's Space Target and Debris Observation and Research Center in Nanjing.[87] Passive satellite

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[82] U.S. Department of Defense, Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, May 2, 2019, 48.
[83] Stephen Clark, "China's First Launch of 2020 Lofts Mystery Payload," *Spaceflight Now*, January 7, 2020. *https://spaceflightnow.com/2020/01/07/chinas-first-launch-of-2020-lofts-mystery-payload/.*
[84] Among various sources, see Joint Chiefs of Staff, *Space Operations (Joint Publication 3-14)*, April 10, 2018. *https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_14.pdf.*
[85] The Xian Satellite Measurement and Control Center, which carries a military cover designator of Unit 63761, appears to be a subordinate to the Base 26 command in Weinan. Other subordinate elements are collocated with or near Base 26 general headquarters in the Weinan area: Qingdao (63756 Unit), Xiamen (63758 Unit), Nanning (63760 Unit), Xian (63761 Unit),and Shaxian (Fujian Province) Yangfang Village (63762 Unit).
[86] In years past, the Base 26 network included the 7010 space and missile radar system mounted on the side of Huangyang Mountain in Xuanhua County, north of Beijing. The PLA Air Force originally operated the system when first entering initial operating capability in 1976, but later was resubordinated to Base 26 (old MUCD of 89851 Unit). The system was dismantled in the late 1980s/early 1990s.For an excellent overview of Base 26, see Wangchao Network, "Loudouzi (The Leaker): Overview of Xian Measurement and Control Center" [漏斗子：西安测控中心概览], October 10, 2005. *http://www.1n0.net/Article/Print.asp?ArticleID=6279.*The author has a record of reliable reporting.
[87] The commander of Base 26 (63750 Unit) is equivalent in grade to a corps leader. Yu Peijun (余培军) was cited in 2017 reporting as director of the Xian Satellite Control Center. He previously served as deputy director.

surveillance information may be provided by the PLASSF Network Systems Department.[88] China's R&D community also has been exploring options for space-based SSA platforms.[89] Base 26 oversees deep space tracking facilities in northeast China. Base 26 may also oversee a tracking and control station on Duncan Island in the South China Sea. Construction on the site began in 2011.[90]

China Satellite Maritime Tracking and Control Department: The China Satellite Maritime Tracking and Control Department (Base 23, Jiangyin) is a corps leader-grade organization that is responsible for sea-based satellite tracking, control, and launch vehicle transportation to Hainan. As many as seven Yuanwang ships are in operation as of 2019.[91]

Beijing Space Command and Control Center: During peacetime, the PLASSF likely directs space operations from the Beijing Space Command and Control Center. Established in 1996, the center appears to be a division leader-grade unit manned 24 hours a day, with a PLASSF deputy chief of staff serving as a watch officer. Located on Beiqing Road in Beijing's northern suburbs, the facility hosts senior CMC, PLASSF, and civilian leaders during major events.[92]

Regarding international SSA cooperation, China is a member of the Asia-Pacific Space Cooperation Organization (APSCO). The organization manages a space surveillance initiative known as the Asia-Pacific Ground-Based Optical Space Object Observation System (APOSOS). In support of the initiative, China provided telescopes to Peru, Pakistan, and Iran that are capable of tracking objects in LEO and GEO. Tasking and data are funneled through the Chinese Academy

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[88] Although speculative, space tracking data from PLA Air Force radar systems may also contribute to a single integrated space picture. Very-long-baseline interferometry (VLBI) sites track space objects simultaneously via telescopes that are combined, emulating a telescope with a size equal to the maximum separation between the telescopes. Using electronic intelligence (ELINT) methodology, VLBI measures the time difference of arrival (TDOA) of radio waves at separate antennas. VLBI sites, presumably subordinate to the brigade or regimental-level 61540 Unit, are in Shanghai Sheshan; Kunming; Guizhou Qiaodongnan Huangping County; Wulumuqi Nanshan; and Beijing Miyun. See China Surveying and Mapping Yearbook [中国测绘年鉴编], *PLA 61540 Unit Successfully Joins Moon Satellite Tracking and Control* [解放军 61540 部队成功参与探月卫星测控], July 29, 2008. *http://zgchnj.sbsm.gov.cn/article//ljnjll/lbnj/tz/zdsj/200807/20080700039517.shtml.*

[89] Lu Jie, Wu Li, and Sun Bo[利用天基雷达观测低地轨道上的危险空间碎片], "Remote Sensing Technology and Application," April 2006, 103–108. *http://www.lw23.com/pdf_f45463dc-17f0-4895-b2ac-c9f054db3d58/lunwen.pdf.*

[90] Zou Weirong (邹维荣),Jia Baohua (贾保华), and Wang Tonghua (王通化),"Launch Complex 'Heart' Deals with Malfunctions on Eve of Launch" (发射场"心脏"发射前夜突现故障，变电站技师如何应对), *PLA Daily*, June 27, 2016. *http://www.81.cn/2016cz7h/2016-06/27/content_7120862.htm*; Zou Weirong (邹维荣),Jia Baohua (贾保华), and Wang Tonghua (王通化), "Expressing Confidence in the "'New Long March'" ("新长征"路上的自信表达), *PLA Daily*, August 18, 2016. *http://81.cn/2016wycz/2016-08/18/content_7214178_6.htm*.

[91] For PLASSF reporting on the Yuanwang, see Zou Weirong (邹维荣) and Wei Rong (魏龙), "Yuanwang-7 New Generation Survey Ship Officially Commissioned" (我国新一代远洋航天测量船远望 7 号船正式入列), *PLA Daily*, July 12, 2016. *http://zz.81.cn/content/2016-07/12/content_7149563_2.htm.*

[92] The center may be assigned a designation of 63920 部队.

of Science's (CAS) National Astronomical Observatory. APOSOS has near-full coverage of LEO and GEO, and is planning an improvement to its optical capabilities.[93]

ISR, Navigation, Communications, and Meteorological/Hydrological Capabilities

The PLASSF has launched a range of satellites that have significantly enhanced ISR capabilities, fielding advanced communications satellites able to transmit large amounts of data, space systems able to provide precise PNT services, and new weather and oceanographic satellites. PLA long-range precision strikes within the Indo-Pacific region would rely in part on high-resolution, dual-use space-based SAR, EO, and possibly electronic intelligence satellites for surveillance and targeting. Existing and future data relay satellites and other beyond-line-of-sight communications systems could convey targeting data to and from TC centers.[94] The PLASSF also manages the application of data from space-based systems. Corps or corps deputy leader-base commands appear responsible for managing the ground segments of the PLA's space-based ISR architecture, satellite communications network, China's Beidou GNSS, and space-based meteorological and oceanographic system. PLA officers have been noted engaged in international cooperation meetings with Russia.[95]

Space-Based ISR

The PLASSF has focused its resources on increasingly capable remote sensing satellites employing digital camera technology, as well as space-based radar for all-weather, 24-hour coverage. These capabilities are being augmented with electronic reconnaissance satellites able to monitor radar and radio transmissions. Electronic reconnaissance satellites monitor radiofrequency emissions from U.S. and other naval forces. Electronic reconnaissance systems can cue EO and SAR satellites.[96] The PLASSF Space Systems Department Space Reconnaissance Bureau

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[93] Members include Iran, Bangladesh, Mongolia, Indonesia, Peru, Turkey, and Thailand. See the APSCO website at *http://www.apsco.int/html/comp1/content/APSCOCouncil/2019-02-28/74-260-1.shtml.*

[94] *Xinhua*, "China Blasts Off First Data Relay Satellite," April 26, 2008. For an example of the data relay satellite being used for missile guidance, see Chen Lihu, Wang Shilian, and Zhang Eryang, "Modeling and Simulation of Missile Satellite-Missile Link Channel in Flying-Control Data-Link" (基于卫星中继的导弹飞控数据链链路分析), *Systems Engineering And Electronics*29:6 (2007).The chief designer of the satellite was Ye Peijian [叶培建]. Also see Wu Ting-yong, Wu Shi-qi, and Ling Xiang, "A MEO Tracking and Data Relay Satellite System Constellation Scheme for China," *Journal of Electronic Science and Technology of China* (December 2005).

[95] See Beidou Navigation Satellite System(中俄卫星导航重大战略合作项目委员会第六次会议在俄罗斯喀山举行), August 31, 2019. *http://beidou.gov.cn/zt/gfhd/201909/t20190909_18847.html.* Yang Changfeng (杨长风) and Ran Chengqi (冉承其) appear to be dual hatted as PLA officers and members of a national-level working group on satellite navigation.

[96] See Pan Changpeng, Gu Wenjin, and Chen Jie, "An Analysis on the Capabilities of Military Satellites to Support an ASBM in Offense and Defense Operations" [军事卫星对反舰导弹攻防作战的支援能力分析] No. 5 (2006). See also Gao Fei et al., "An Analysis on the Influence of Military Satellite Information Systems on Missile Operations" [军事卫星信息系统对导弹作战的影响分析] 29:4 (2008); Hu Xujie et al., "An Analysis on the

probably manages PLA equities in remote sensing satellites.[97]

Electro-Optical ISR: China's first experimental imagery system was launched in November 1975, and China has since gradually expanded its EO satellite network. EO satellites appear to be assigned Yaogan and Gaofen designations. SASTIND manages the Gaofen satellite engineering program, suggesting its dual-use nature. At least eight Gaofen satellites, many equipped with an EO sensor, have been launched since 2013, with the latest (Gaofen-11) launched in 2018. Other Gaofen satellites are equipped with SAR and hyperspectral sensors.[98] The PLA also has launched a number of what are probably EO satellites with Yaogan designations. The Yaogan-28 was launched in November 2015and at least two of the Yaogan-30 series satellites launched in 2016/2017 are believed to carry EO payloads. The China Aerospace Science and Technology Corporation (CASC) Fifth Academy (China Academy of Space Technology [CAST]) appears to serve as lead systems integrator for EO satellites.[99]

Synthetic Aperture Radar Satellites: SAR satellites are a core component of the militarily relevant surveillance architecture supporting over-the-horizon (OTH) targeting of surface assets. SAR satellites use a microwave transmission to create an image of maritime and ground-based targets. They can operate night or day and in all weather conditions, and are therefore well suited

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Effectiveness of Space-Based Information to Support Missile Offense and Defense Operations" [天基信息支援对导弹攻防作战的效用分析]18:1 (2009); Huang Xuan et al., "Graph Modeling Influence of Space-Based Information Supporting Aerospace Force Anti-Ship Missile Assault" [天基信息支援下航空兵对海导弹攻击的影响图模型], Vol. 2 (2007).

[97] The Space Reconnaissance Bureau likely is assigned an external designation of 61646 部队. It oversees the Beijing Institute of Remote Sensing Information (北京遥感信息研究所). As of 2018, Major General Jiang Bitao (江碧涛; b. 1967) serves as a deputy director or possibly director of the PLASSF Space Reconnaissance Bureau. She served as a chief designer for a satellite ground application system and played a key role in program validation for a number of programs. Jiang previously served as chief engineer (总工程师) and carries a researcher (研究员) designation. She has been affiliated with Unit 61646, the Space Reconnaissance Bureau, and the Beijing Institute of Remote Sensing Information. Among various sources, see *Scientist Committee* (学术委员会), CAS Key Lab for Space Utilization website. *http://lsu.csu.cas.cn/sysgk/xswyh/.* Also see "Xie Dong, Member of the Branch Party Committee, Leads Team to Visit PLA Strategic Support Force Bureau Director Jiang" (分行党委委员谢东带队拜会解放军战略支援部队某局江局长), August 8, 2018. *https://www.meipian.cn/1ibgek24.*

[98] See the Gaofen program information portal at *http://gaofenplatform.com/channels/487.html.* Among other sources, see China National Space Administration, *Successful Launch of China's Gaofen High-Resolution Earth Observation System*, (我国高分辨率对地观测系统重大专项首星发射成功航天发射任务迎来开门红), April 24, 2014. *http://www.cnsa.gov.cn/n1081/n7529/n308593/526166.html.* For reference to the PLA's role in the Gaofen program, see China Transport Telecommunications & Information Center [中国交通通信信息中心], "PLASSF Aerospace Reconnaissance Bureau Discusses Gaofen Remote Sensors Applications and Requirements for 'One Belt One Road' [战略支援部队航天侦察局交流高分遥感"一带一路"应用需求]," February 22, 2017. *https://www.cttic.cn/info/1613.* As of 2011, Chen Jianxiang (陈建祥), who was assigned to the former GAD Space Reconnaissance Bureau, served as chief engineer of the former GAD Gaofen program office.

[99] S. Chandrashekar and Soma Perumal, "China's Constellation of Yaogan Satellites & the Anti-Ship Ballistic Missile," *National Institute of Advanced Studies*, May 2016, 8–11. *http://isssp.in/wp-content/uploads/2016/05/Yaogan-and-ASBM-May-2016-Report.pdf.* For example, Li Jindong (李劲东)was cited in 2008 reporting as assigned to the Fifth Academy design department and appointed as chief designer of a user interface program in 2005. He is cited as chief designer of the Yaogan-28 and Gaofen-11. He was appointed as deputy chief designer of the CBERS (中巴地球资源卫星) program in 2004.

for the detection of ships in a wide area. SAR imagery is key for automated target recognition of ships at sea.[100] China is expected to have multiple types of space-based SAR systems in orbit over the coming years, often catering to various users. The PLA's first dedicated military SAR satellite likely was deployed in 2006.[101] Since then, remote sensing satellites with a SAR package include the Gaofen-3, Yaogan-1, Yaogan-6, Yaogan-10, Yaogan-13, Yaogan-18, and Yaogan-23, and possibly the Yaogan-29.[102] The CASC Shanghai Academy of Space Technology (SAST) likely serves as lead systems integrator for SAR satellites.[103]

Electronic Reconnaissance Satellites: To augment its SAR and EO systems, the PLA likely has fielded a space-based electronic reconnaissance architecture.[104] The PLA experimented with electronic reconnaissance satellites in the mid-1970s.[105] Design studies on a modern electronic reconnaissance satellite constellation for geolocation of surface targets began in the mid-1990s.[106]

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[100] Chen Deyuan and Tu Guofang, "SAR Image Enhancement Using Multi-Scale Products for Targets Detection, *Remote Sensing Journal* [*Yaoganxuebao*] (March 2007):185–192. The authors are from the Institute of Electronics, CAS.

[101] In development for a decade, the Yaogan-1 was launched from Taiyuan Satellite Launch Center on April 27, 2006. A subsequent system, the Yaogan-6, was launched on April 22, 2009, and at least three follow-on variants have been launched to date. Among these are theYaogan-8, developed over a four-year period, and the Xiwang-1 microsatellite, launched on an LM-4C from Taiyuan on December 16, 2009.Other possible follow-on variants, designated Yaogan-10 and Yaogan-13, were launched from Taiyuan in August 2010 and November 2011, respectively. See China Ministry of Science and Technology, *CASC Eighth Academy Successfully Launches Yaogan-10 Satellite* [航天八院为遥感卫星十号发射成功奋战发射场], November 1, 2010. *http://kjj.boluo.gov.cn/show.asp?id=481.*

[102] See, for example, Rui C. Barbosa, "Long March 2C Conducts Surprise Yaogan-23 Launch," *NASA Spaceflight*, November 14, 2014. *https://www.nasaspaceflight.com/2014/11/long-march-2c-surprise-yaogan-23/.*

[103] For example, Chen Junli (陈筠力; b. 1972) was cited in 2007 reporting as director of the 509th Research Institute's general design lab (总体室主任), and as directing designer on the Yaogan-1 satellite. Chen has published on distributed and synchronized SAR satellite architecture control issues. Chen was also chief designer for both the Yaogan-6 (遥感六号), which was launched from Taiyuan in April 2009, and the Yaogan-13 satellite, which was launched from Taiyuan on November 30, 2011.

[104] For early assessments on the utility of space-based electronic reconnaissance systems, see Yuan Xiaokang, "Satellite Electronic Reconnaissance, Antijamming," *Shanghai Hangtian*, October 9, 1996,32–37, in *FBIS-CST*-97-011; Yuan Xiaokang, "Some Problems of Space Electronic Reconnaissance," *Hangtian Dianzi Duikang*, March 1996,1–5, in *CAMA*, Vol. 3, No. 4. Yuan is a key engineer involved space-based antenna systems design, including both ELINT and SAR, from the SAST 509th Research Institute (Shanghai Institute of Satellite Engineering).

[105] The first electronic satellite was launched from Jiuquan in July 1975 on an FB-1 launch vehicle, which was specifically designed to meet the weight and orbital accuracy requirements of electronic reconnaissance platforms. The FB-1 launched two more experimental satellites in December 1975 and August 1976. For unknown reasons, the program was discontinued. Before the reorganization, the former GSD ECM and Radar Department (GSD Fourth Department) had the ELINT portfolio within the PLA's SIGINT apparatus. ELINT receivers are the responsibility of the Southwest Institute of Electronic Equipment. The former GSD 54th Research Institute supported the ECM Department in development of digital ELINT signal processors to analyze parameters of radar pulses. See Ping Kefu, "Capabilities of The GSD Third Department in Technical Intelligence," *East Asian Diplomacy and Defense Review* 96:5, 6. Information on China's SIGINT apparatus drawn from Desmond Ball, "Signals Intelligence in China," *Jane's Intelligence Review*, August 1, 1995, 365–375; Robert Karniol, "China Sets Up Border SIGINT Bases in Laos," *Jane's Defense Weekly*, November 19, 1994, 5.

[106] Also see Yuan Xiaokang, "Satellite Electronic Reconnaissance, Antijamming," *Shanghai Hangtian*, October 9, 1996, 32–37, in *FBIS-CST*-97-011; Yuan Xiaokang, "Some Problems of Space Electronic Reconnaissance," *Hangtian Dianzi Duikang*, March 1996, 1–5, in *CAMA*, Vol. 3, No. 4. Yuan was a key engineer involved space-

The PLA appears to be investing resources into constellations of two, three, or four satellites using time difference of arrival direction finding or geolocation techniques.[107] Leading candidates for electronic reconnaissance satellites include the Shijian-6, Yaogan-9, and Yaogan-16.[108]

The Yaogan-30 satellite series appears to be the most recent electronic reconnaissance system. As of October 2019, China had 15 Yaogan-30 military satellites in orbit.[109] These satellites appear to be part of a naval ocean surveillance system that enables the PLA to triangulate and target U.S. aircraft carrier strike groups and other warships of interest.[110] These satellites operate in trios and likely support China's antiship weapons programs, which include ballistic missiles, cruise missiles, and armed drones designed to evade or destroy the air defenses surrounding U.S. aircraft carriers.[111] According to one analysis of orbital data, China's 15 Yaogan-30 satellites provide the PLA with near-continuous global coverage of all U.S. naval activities relevant to Chinese security

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based antenna systems design, including both ELINT and SAR, from the SAST 509th Research Institute (Shanghai Institute of Satellite Engineering).

[107] Li Wenhua, "Research on Configuring Three-Satellites and Time Difference of Arrival for Precise Geo-Location" [三星构型设计与时差定位精度研究], *Journal of Astronautics* [宇航学报] (March 2010): 701–705. The author is affiliated with the Jiangnan Electronic Communication Institute in Jiaxing; Li Jianjun, "Research on Four-Satellite TDOA Location Algorithm" [四星时差定位算法研究], *Electronic Warfare Technology* [电子对抗技术] (July 2004): 3. The author is affiliated with the Southwest China Research Institute of Electronic Equipment (29th Research Institute) in Chengdu; Gao Qian et al., "A Correcting Algorithm of Single Source Reference Source for Three-Satellite TDOA Location System" [一种三星时差定位系统的校正算法研究], *Aerospace Electronic Warfare* [航天电子对抗]23:5 (2007). The authors are affiliated with the National University of Defense Technology. Wu Shilong, Zhao Yongsheng, and Luo Jingqing, "Performance Analysis of Two-Satellite Joint FDOA and TDOA Location System" [双星时差频差联合定位系统性能分析], *Aerospace Shanghai* [上海航空], No. 2 (2007): 47. Wu and Zhao are affiliated with the GSD Fourth Department 61541 Unit in Beijing, and Luo is affiliated with the PLA Electronic Engineering Institute in Hefei. The 61541 Unit is said to be located in "Space City" [航天城]north of the Zhongguancun section of Beijing, and appears to serve as an information fusion and R&D center focusing on phased lock loop receiving technology, among other issues.

[108] The Shijian-6A and Shijian-6B technology demonstration satellites were launched in tandem in September 2004. A second pair of Shijian-6 satellites (SJ-6C and SJ-6D) was launched in October 2006. A third pair (SJ-6E and SJ-6F) was launched in October 2008, and a fourth pair (SJ-6G and SJ-6H) was launched in October 2010.Responsible for the A satellite, Shen Cong [沈琮] had previously worked on programs previously believed to be related to electronic reconnaissance in the 1970s. CASC Fifth Academy's Wu Kailin [吴开林] was chief designer of the SJ-6B satellite [实践六号 B], which operated in conjunction with the SJ-6A.

[109] *Xinhua*, "China Successfully Launches Yaogan-30 Group 05 Satellites" (我国成功发射遥感三十号 05 组卫星),July 26, 2019. *http://www.xinhuanet.com/mil/2019-07/26/c_1210215704.htm*; *Gunter's Space Page*,"Yaogan-30-01, 30-02, 30-03, 30-04, 30-05, 30-06 (CX 5)."*https://space.skyrocket.de/doc_sdat/yaogan-30-01.htm.*

[110] For background on China's naval ocean surveillance system, see Ian Easton and Mark A. Stokes, "China's Electronic Intelligence (ELINT) Satellite Developments: Implications for U.S. Air and Naval Operations," *Project 2049 Institute*, February 23, 2011. *https://project2049.net/wp-content/uploads/2018/05/china_electronic_intelligence_elint_satellite_developments_easton_stokes.pdf.*

[111] Ian Easton and Mark A. Stokes, "China's Electronic Intelligence (ELINT) Satellite Developments: Implications for U.S. Air and Naval Operations," *Project 2049 Institute*, February 23, 2011. *https://project2049.net/wp-content/uploads/2018/05/china_electronic_intelligence_elint_satellite_developments_easton_stokes.pdf.* See also Ian Easton and L.C. Russell Hsiao, "The Chinese People's Liberation Army's Unmanned Aerial Vehicle Project: Organizational Capacities and Operational Capabilities," *Project 2049 Institute*, March 11, 2013. *https://project2049.net/2013/03/11/the-chinese-peoples-liberation-armys-unmanned-aerial-vehicle-project-organizational-capacities-and-operational-capabilities/.*

interests.[112] Major surface vessels, such as aircraft carriers, have prominent electromagnetic, acoustic, and infrared signatures and large radar cross sections. Although controlling emissions from carriers is feasible for limited periods of time, air operations depend on electromagnetic radiation.[113]

Organizations most likely responsible for space-based electronic reconnaissance, such as CASC Eighth Academy 509th Institute and the Southwest Institute of Electronic Equipment, have published detailed assessments of how best to track and target aircraft carriers and other large naval ships. [114] Chinese writings have indicated that while the numbers of electronic reconnaissance satellites are increasing, they have been unable to meet the demands placed on them from different intelligence consumers.[115] Technical studies also have assessed the utility of electronic reconnaissance payloads on satellites in GEO.[116] An electronic reconnaissance satellite

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[112] Gosnold, "The Yaogan-30 High-Revisit Constellation, *Satellite Observation Blog*, October 26, 2019. *https://satelliteobservation.net/2017/12/03/the-yaogan-30-high-revisit-constellation/.*

[113] U.S. Department of Defense, Office of the Under Secretary of Defense/Acquisition, Technology, and Logistics, *Defense Science Board Task Force on the Future of the Aircraft Carrier*, October 2002, 52–53.

[114] Huang Hanwen, "Maritime Target Surveillance Satellite System Analysis and Development Assumptions" [卫星海洋目标监视系统分析与发展设想], *Journal of the Academy of Equipment Command & Technology* [装备指挥技术学院学报], October 2004, 44–48. *http://d.wanfangdata.com.cn/periodical_zhjsxy200405011.aspx.*The author is affiliated with the Shanghai Institute of Satellite Engineering, or SAST 509th Research Institute. Also see Gao Fei et al., "An Analysis on the Influence of Military Satellite Information Systems on Missile Operations" [军事卫星信息系统对导弹作战的影响分析], *National Defense Science and Technology* [国防科技]29:4 (2008); Hu Xujie et al., "An Analysis on the Effectiveness of Space-Based Information to Support Missile Offense and Defense Operations" [天基信息支援对导弹攻防作战的效用分析], *Spacecraft Engineering* [航空器工程]18:1 (2009); Huang Xuan et al., "Graph Modeling Influence of Space-Based Information Supporting Aerospace Force Anti-Ship Missile Assault" [天基信息支援下航空兵对海导弹攻击的影响图模型], *Tactical Missile Technology* [战术导弹技术], Vol. 2 (2007).

[115] Wang Huilin et al., "Design and Implementation of Area-Covering Electronic Reconnaissance Satellite Planning System" [面向区域的电子侦察卫星规划系统设计与实现], *Computer Engineering and Applications* [计算机工程与应用]46:26 (2010): 209. The authors are affiliated with the National University of Defense Technology's National Key C4ISR Technology Laboratory in Changsha. Their research was conducted as part of the 973 Program.

[116] Dong Qiaozhong and Zhu Weiqiang, "Research on ELINT Satellite Techniques in GSO" [静止轨道电子侦察卫星技术研究], *Electronic Warfare* [电子对抗],July 30, 2009, 13.The authors are affiliated with the CASIC 8511 Research Institute in Nanjing; Lu An'nan, "Thoughts on Developmental Problems of ELINT Satellite Passive Geo-location Techniques" [对电子侦察卫星无源定位技术发展问题的思考], *Communications Countermeasures* [通信对抗], March 2008, 19–20. The author is affiliated with the 36th Research Institute of CETC in Jiaxing, Zhejiang; Li Hengnian et al. "The Strategies and Algorithm Study for Multi-GEO Satellite Collocation" [地球静止轨道共位控制策略研究], *Journal of Astronautics* [宇航学报]30:3 (2009).Also see Dong Qiaozhong and Zhu Weiqiang, "Study on Electronic Reconnaissance Satellites in Geostationary Orbit" [静止轨道电子侦察卫星技术研究], *Electronic Countermeasures*, June 2009. *http://www.cqvip.com/qk/91679x/200906/32557007.html.* The authors are from the CASIC 8511 Research Institute in Nanjing. A cluster of three Yaogan-9 satellites were launched from China's Jiuquan Satellite Launch Center on March 5, 2010. The formation orbits in a 1080 km x 1100 km x 63.4 degree position, strikingly reminiscent of earlier generations of the U.S. "White Cloud" Naval Ocean Surveillance System (NOSS) satellite triplets described in detail by Chinese writings. Among various sources, see *Jane's Defense Weekly*, "China's Yaogan-9 May Be Ocean Surveillance Satellite," March 11, 2010. *http://www.janes.com/articles/Janes-Defence-Weekly-2010/China-s-Yaogan-9-may-be-ocean-surveillance-*

constellation would offer the PLA the ability to geolocate U.S. and allied naval ship activity. The latest Yaogan-30 satellite was launched in July 2019.[117]

In short, increasingly greater spatial resolution and an ability to monitor U.S. activity in the Indo-Pacific region (including the locations of U.S. aircraft carrier battle groups) in all weather conditions is likely to enhance China's ability to conduct military operations farther from shore. Space-based sensors also provide the data necessary for mission planning functions, such as terminal guidance for ballistic and land attack cruise missiles.

Survey, Mapping, and Navigation

The PLASSF also is responsible for space-based military survey, mapping, and navigation operations. Survey, mapping, and navigation systems facilitate force movement and logistics, and are used for ballistic and cruise missile targeting and precision-guided munitions. A corps leader-grade base command, probably designated as Base 35, is headquartered in Wuhan and may have integrated a range of survey, mapping, and navigation missions previously carried out by the GSD Operations Department and Military Regions. Division leader-grade "battlefield environment support" (战场环境保障) units previously under GSD include the Beidou GNSS ground segment, which previously was managed by the GSD Operations Department Survey and Mapping Bureau.[118] Base 35 appears to have a working relationship with Wuhan University's Collaborative

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satellite.html. The initial indication that the Yaogan-9 may be a NOSS system came from a number of amateur astronomers who reported that the Yaogan-9 mission saw the launch of not one, but rather a constellation of three satellites that are now orbiting together in a highly choreographed triangular formation. For example, see *Gunter's Space Page*, "Yaogan 9A, 9B, 9C." http://space.skyrocket.de/doc_sdat/yaogan-9.htm; NASA Spaceflight.com, "Yaogan Weixing-9 CZ-4C Launch March 5, 2010," March 5, 2010. *http://forum.nasaspaceflight.com/index.php?topic=20567.30*; Robert Christy, "Space Events of 2010," *Zarya*. *http://www.zarya.info/Diaries/2010.php*; *Jonathan's Space Report*, "Yaogan Weixing 9," No. 625, April 6, 2010. *http://planet4589.org/space/jsr/back/news.625.*

[117] Rui C. Barbosa, "Long March 2C Lofts Yaogan-30 Group 05 Satellites," *NASA Spaceflight.com*, July 25, 2019. *https://www.nasaspaceflight.com/2019/07/long-march-2c-yaogan-30-group-05-satellites/.*

[118] Base 35 may carry an external designation of 32020 部队. For reference to Unit 32020 on Wuhan's Donghu East Road (武汉市武昌区东湖东路), see (32020 部队 54#楼整修工程招标公告) at *http://cn.jixiexinxi5.com/supply/201710/17/492280.html*. For reference to PLASSF Base 35 (战略支援部队 35 基) and Base 35 Staff Department division directors Liu Chenglai and Li Hengyuan (35 基地参谋部处长刘成来、处长李鹤元)—the latter was previously with the Survey and Mapping Technology Command (测绘信息技术总站; Unit 61363) in Xian—see (蔡列飞), "Joining Hands with the Wuhan Donghu New Technology Development Zone" (与武汉东湖新技术开发区携手共进), *State Key Lab for Engineering in Survey, Mapping, and Remote Sensing* (测绘遥感信息工程国家重点实验室) website, September 22, 2017. *http://www.lmars.whu.edu.cn/index.php/kydt/2029.html*. Among other sources, see Zou Weirong (邹维荣) and Zong Zhaodun (宗兆盾), "Commemorating Tan Shusen of Beidou Satellite Navigation Command" (记投身北斗事业的某卫星导航定位总站高级工程师谭述森院士), *PLA Daily*, February 27, 2016. *http://cpc.people.com.cn/n1/2016/0227/c64104-28155004.html*. The Beidou satellite navigation and positioning command carries an external designation of 61081 部队. Also see Marcus Clay, "Supporting the Infinitive Battlefield," *China Aerospace Studies Institute*, 2019, 38–41.

Innovation Center of Geospatial Technology.[119]

Three generations of Beidou satellites have been in operation since 2000. China's first-generation navigation satellite system, the Beidou-1, consisted of two geosynchronous satellites (plus spares) for civilian and military purposes and was limited to coverage within the Asia-Pacific region. This was an active location system, with a signal from a handheld unit transmitted to the two geosynchronous satellites, which then transmitted the signal to an earth station. The earth station measured the differential in the two signals (one per satellite), determined the location that fit, and then transmitted that data back to the handheld unit.

Planning for a second generation of navigation satellites, Beidou-2 (Compass), began in April 1999 under the sponsorship of the former GSD First Department and with participation from civilian entities. The eighth Beidou-2 satellite was launched from Xichang Satellite Launch Center in April 2011, with another 24 satellites expected. An emphasis was placed on system survivability, division of military and civilian bandwidth usage, laser ranging, and integration of micro-electro-mechanical system (MEMS) technology.[120] The first launch of a third-generation Beidou satellite took place in 2017 from Xichang Satellite Launch Center. The Tianhui mapping satellites augment the Beidou system. The PLA-managed China Tianhui Satellite Center directs operations and is located in Beijing's Xibeiwang township.[121]

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[119] For example, Unit 32020 appears to have cooperated with Wuhan University on the Luojia-1 satellite program. The satellite is a prototype for a future 60-80 earth observation satellite constellation. Luojia 1 features an imager with 100-meter ground resolution. See *Xintiandi*, "Luojia-1-01 On-Orbit Evaluation Meeting and Night Illumination Remote Sensing Application Research Meeting Convene" (珞珈一号 01 星在轨测试评审会暨夜光遥感应用研讨会召开), July 10, 2018. *http://www.sohu.com/a/240202947_650579*. For reference to Unit 32030 cooperation with Wuhan University and responsibility for "Space Information Support" (空天信息保障), see "Academicians and Experts Collaborate to Construct the Military-Civil Fusion Laboratory of Aerospace Information" (院士专家共谋空天信息军民融合实验室建设), *Wuhan University Collaborative Innovation Center of Geospatial Technology*(地球空间信息技术协同创新中心) website, December 6, 2017. *http://innogst.whu.edu.cn/newsnoticedetail.jsp?id=y0jfrlvv5j* (link no longer active).

[120] Key engineers included Liu Jiyu, a leading engineer from the Wuhan University of Survey and Mapping Technology. See University Network, "Liu Jiyu" [刘基余], November 2009. *http://www.daxue1g.cn/fengyunrenwu/200911/4570.html.*

[121] The Tianhui Satellite Center (中国天绘卫星中心) carries a military unit cover designation of 61618. For reference to Tianhui and the PLA, see 梁蓬飞, 张能华, and 张振威, "Crack Surveying Team Matures and Walks the "Green Road," Resolving the Whole Military's Problems" (测绘奇才部队成长走"绿色通道" 破解全军难题), *PLA Daily*, June 22, 2016. *http://www.81.cn/jwgz/2016-06/22/content_7112522.htm*. For reference to Ren Shujun (任树军) as Tianhui Satellite Center director, see "Focus on the Frontier, Practice Grand Strategy: Wang Yuxiang, Chairman of Aerospace Hongtu, Leads a Delegation to Attend the Songshan Remote Sensing Forum" (聚焦最前沿，实践大战略——航天宏图董事长王宇翔博士率团参加嵩山遥感论坛), Piesat website, April 28, 2018. *http://www.piesat.cn/portal/article/1524904480648.html*. For affiliation of Ren Shuwang with Unit 61618, see "2017 Internal Evaluation and Assessment Meeting of National Special Environmental and Special Function Observation Research Station Shared Service Platform Convenes" (国家特殊环境、特殊功能观测研究台站共享服务平台 2017 年内部评价考核工作会议召开). *http://www.crensed.ac.cn/portal/news/detail/fba029e9-74cc-4bae-aa26-ce2515db09d0.*

Satellite Communications and Data Relay

Satellite communications (SATCOM) enable beyond-line-of-sight connectivity between joint commanders and subordinate units, and between operational units. SATCOM will become particularly important as the PLA operates farther from China's borders. Since the launch of China's first experimental communications satellite in January 1984 and the first operational system in March 1988, the country's SATCOM capacity has grown in sophistication. Before the development and launch of dedicated military communications satellites, the PLA most likely leased civilian transponders operating in the C- and Ku-bands, such as SinoSat and ChinaSat. The PLA likely continues to lease transponder space, but this cannot be confirmed at the current time.

The PLASSF Space Systems Department develops operational and technical requirements for dedicated military communications satellites, such as the Fenghuo and Shentong systems. Fenghuo-1 (ChinaSat-22) was launched in January 2000 and functioned as the PLA's first dedicated military communications satellite. Weighing 2,300 kilograms (kg) and designed to operate for eight years, Fenghuo-2 (ChinaSat-22A) was launched in September 2006. Shentong-1 (ChinaSat-20), was launched in November 2003, and is said to incorporate steerable spot beams operating in the Ku-band. Follow-on satellites were launched from Xichang in 2010, 2015, and January 2018.[122] Since 2017, China also has carried out verification testing of a wideband (Ka-band) communications satellite. The SJ-20 satellite was launched from Wenchang on an LM-5 in December 2019, and validated a new-generation communications satellite bus, the DFH-5. The DFH-5 is China's heaviest satellite to date. The same platforms have been used for testing of laser communications and electronic propulsion.[123]

The PLASSF Space Systems Department manages the PLA's SATCOM network. A new base command, notionally designated Base 37, was established in 2017 in the Beijing suburb of Mentougou.[124] To expand the scope of its communications satellite architecture, China has fielded

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[122] Sun Jiadong is said to have played a leading role in the Fenghuo satellite. The chief designer of the Fenghuo is said to be Peng Shoucheng [彭守诚]. Peng has a background in the 504thResearch Institute and has a background in electronic reconnaissance. The chief designer of the Shentong-1 was Wang Jiasheng [王家胜]. Born in 1953, Wang served as deputy chief designer of the DFH-3 COMSAT and chief designer of the Tianlian-1 data relay satellite. For reference to the January 2018 launch, see *https://www.nasaspaceflight.com/2019/01/long-march-3b-lofts-chinasat-2d/*.

[123]The SJ-13 was launched from Xichang in April 2017 using a DFH-3 satellite bus. See CASC Fifth Academy ,*CASC Fifth Academy-Developed SJ-13 Successfully Launched*(我院研制的实践十三号卫星成功发射), April 12, 2017. *http://news.sciencenet.cn/htmlnews/2017/4/373300.shtm.* The SJ-18, launched on an LM-5 in June 2017, failed to reach proper orbit. For reference to the SJ-20, see *S&T Daily*, "SJ-20 Satellite Launched, First Flight of DFH-5 Platform" (实践二十号卫星上岗东五平台首飞成功), January 6, 2020. *http://www.xinhuanet.com/tech/2020-01/06/c_1125424476.htm*.

[124] Base 37 may carry a military unit cover designation of 32039. The base headquarters appears to be located in the compound housing of the former GSD Satellite Communications Command (Unit 61096). In 2017 reporting, Huang Huiming (黄惠明) was cited as director and Lu Guiqi is political commissar (鲁贵齐). Huang Huiming previously directed the GAD Data Relay Control and Management Center (总装备部中继卫星控制管理中心) in the 2012 timeframe. Among various sources, see "Mentougou District and Troops Stationed in the District Discuss Promoting The Common Development of Both" (门头沟区与驻区部队座谈促进双方共同发展), (京西时报), June 6, 2017.

a data relay capability. Operations are directed by the PLASSF Data Relay Satellite Control Center. While the exact hierarchy is unclear, the Data Relay Control Center may be subordinate to the Space Control Center.[125] China's first-generation data relay satellite, the Tianlian-1, was launched in April 2008 and a second was launched in July 2011. Theoretically, the satellites, using a basic DFH-3 bus, support the crewed space program. The satellites also could allow sensors to operate beyond line of sight of ground stations in China.[126]

Meteorology, Oceanography, and Space Weather

The PLASSF also manages military meteorological satellite data and oversees a specialized unit responsible for space weather analysis and forecasting.[127] These conditions can influence the performance and reliability of space-borne and ground-based systems and can endanger human life or health. These conditions can cause disruptions of satellite operations, communications, radar, navigation, high-altitude crewed flight, and electrical power distribution. Since its inception in 1988, China's Fengyun (FY) weather satellite program began with Chinese Premier Zhou Enlai's 1970 approval of a CMC proposal to initiate R&D on meteorological satellites.[128] With the launch of the first FY-1A in 1988, China became the third country to launch its own meteorological satellites. Nominally administrated by the China Meteorological Administration (CMA), the FY series appear to be roughly analogous to those associated with the U.S Defense Meteorological Satellite Program. The FY-4, equipped with space weather sensors, is China's most advanced space asset providing meteorological support to PLA and other users. As a dual-use asset, FY satellite requirements appear to have been developed by both the PLASSF and CMA, although their respective responsibilities remain unknown. The system also could provide measurement and signature intelligence data for PLA targeting.[129] The PLASSF has launched at least 16 FY satellites.

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http://www.bjmtg.gov.cn/jrmtg/yw/201706/t20170606_66168.html. Also see Marcus Clay, "Supporting the Infinitive Battlefield," *China Aerospace Studies Institute*, 2019, 44–45.

[125] The Data Relay Satellite Control Center probably carried an external designation of 63999 部队.

[126] *Xinhua*, "China Blasts Off First Data Relay Satellite," April 26, 2008; *Xinhua*, "China Successfully Launches First Data Relay Satellite, the Tianlian-1 (01)" [中国首颗数据中继卫星"天链一号 01 星"发射成功], April 26, 2008. *http://news.xinhuanet.com/mil/2008-04/26/content_8053374.htm*. Also see *Xinhua*, "China Launches New Data Relay Satellite," July 12, 2011. *http://news.xinhuanet.com/english2010/sci/2011-07/12/c_13978690.htm*.For an example of the data relay satellite being used for missile guidance, see Chen Lihu, Wang Shilian, and Zhang Eryang, "Modeling and Simulation of Missile Satellite-Missile Link Channel in Flying-Control Data-Link" [基于卫星中继的导弹飞控数据链链路分析],*Systems Engineering and Electronics*29:6 (2007). The chief designer of the satellite was Ye Peijian [叶培建].

[127] See *Renminwang*, "GSD Weather and Oceanographic Space Weather Command Supports Shenzhou-8 Launch" [总参某气象水文空间天气总站保障"神八"发射], November 1, 2011. *http://military.people.com.cn/GB/172467/16087308.html*. The former GSD Meteorological, Hydrological, and Space Weather Command (总参气象水文空间天气总站) was a division leader-grade unit and carried a designation of 61741 部队.

[128] *China Meteorological Newspaper* [中国气象报社],"Premier Zhou En-lai: We Shall Establish Our Own Weather Satellites" [周恩来总理提出"要搞我们自己的气象卫星"], March 15, 2011. *http://www.cma.gov.cn/ztbd/20110104/20110314/2011031405/201103/t20110315_88685.html.*

[129] See *Sina News*, "Delivery of Four FY-3 Payloads and Satellite Testing" [风云三号气象卫星 4 项有效载荷交付总体装星测试], August 8, 2006. *http://tech.sina.com.cn/d/2006-08-08/15291076129.shtml.*

Oceanographic satellites, like meteorological satellites, support military operations. Oceanographic satellites are useful for disaster warning, recovery, and response, support for fishing, and exploitation of maritime resources, as well as for military operations. Multispectral sensors may be able to detect ships at sea. The Haiyang (HY) series of satellites was first launched in 2002. An initial follow-on variant, the HY-2, was launched in 2009, with subsequent launches expected in 2012, 2015, and 2019. Requirements were developed by the State Oceanic Administration, presumably with PLA input. HY satellites, integrating EO and other sensors, are mainly used for monitoring watercolor, water environment, and temperatures.[130] HY-2 integrates microwave technology to detect sea surface wind field, sea surface height, and sea surface temperature. R&D on a more advanced ocean monitoring system incorporating SAR technology, the HY-3, is well underway.[131] One study noted that the FY-3 includes a prototype package intended to support other sensors, such as OTH radar systems, to compensate for sea clutter when tracking aircraft carriers and other moving targets at sea. Greater resolution enables more precise targeting.[132]

In short, Fengyun and Haiyang satellites collect and provide strategic weather and oceanographic data for civilian and military purposes. An accurate assessment of current and future weather conditions, such as cloud cover, atmospheric moisture, winds, temperature, and ocean currents, is critical for a range of military operations. Weather satellites can measure electromagnetic conditions in the ionosphere that could affect OTH radar and communication systems. They also can provide militarily useful data associated with complex maritime environments and terrains, including observation of targets under camouflage or perhaps even underground. Meteorological and hydrographic satellites would facilitate PLA operations at sea at increasingly long ranges.

Deep Space Operations

The PLA and its civilian counterparts are moving beyond Earth's orbit and into deep space. PLA ambitions in deep space are intimately linked with China's lunar program. The China National Space Administration (CNSA) administers China's lunar exploration program. The former PLA Commission of Science, Technology, and Industry for National Defense began detailed planning in 1998. By 2004, the State Council and CCP Central Committee directed the formation of a Lunar Exploration Project Leading Small Group to coordinate efforts across the bureaucracy. In 2013, China became the first space power to land on the moon since the Soviet Union's mission in 1976. China's various motivations include mining of helium-3 as a replacement for fossil fuels and solar

[130] Oceanographic monitoring is a focus area within the 863 Program, specifically the maritime area [海洋领域]. Also see China Great Wall Industry Corporation, "China's Three-Dimensional Oceanographic System." *http://www.cgwic.com/In-OrbitDelivery/RemoteSensingSatellite/SEA.html.*

[131] Jiang Xingwei, Lin Mingsen, and Tang Junwu, "The Programs of China Ocean Observation Satellites and Applications," National Satellite Ocean Application Service briefing, February 26, 2008 (in English).

[132] Fudan University Project Overview, "Theory and Application of Collection and Fusion of Information Regarding Complex Natural Environments" [复杂自然环境时空定量信息获取与融合处理的理论与应用], June 2004. *http://www.guochengzhi.com/gx/Print.asp?ArticleID=371.*

power. Four lunar exploration spacecraft—designated Chang'e—have been launched to date.[133] In December 2018, the Chang'e-4 mission deployed an initial lunar rover that explored the far side of the moon. The mission also entered a "parking orbit" at Lagrangian Point-2 on the moon's far side.[134] China seeks to lead internationally in lunar research, also investing in Mars and asteroid exploration. By 2020, China intends to launch its first Mars exploration vehicle that will land on the surface of the planet. A future mission will bring back samples from Mars.[135]

The direct benefits to the PLA of the lunar exploration program, including activities on the far side of the moon, are unclear. However, the PLA manages significant components, including space launch, tracking and control, and benefits from the scientific research stemming from investments into the program. The CMC Equipment Development Department oversees an expert working group for validating a manned lunar landing program.[136] As part of its lunar exploration program, China has demonstrated critical military capabilities in space, such as proximity operations and loitering.

In support of the lunar exploration and other programs, the PLA maintains a dedicated deep space tracking and communications network. Deep space tracking and communications stations are located in Kashgar, Kunming, Beijing, Qingdao, and Jiamusi. Overseas stations are in Namibia and Argentina.[137] The PLA's deep space surveillance system is augmented by very-long-baseline

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[133] Leading advocates included Ouyang Ziyuan and Chu Guibo. For an excellent overview of the lunar program policy, see Patrick Besha, "Policy Making in China's Space Program: A History and Analysis of the Chang'e Lunar Orbiter Project," *Space Policy* 26 (2010). *http://www.gwu.edu/~spi/assets/docs/Besha_article_2010.pdf.*Also see *Xinhua*, "China to Launch 2nd Lunar Probe before End of 2011," November 12, 2008. *http://www.chinadaily.com.cn/china/2008-11/12/content_7199005.htm.* For reference to potential of Helium-3, see John Lasker, "Race to the Moon for Nuclear Fuel," *Wired*, December 15, 2006. *http://www.wired.com/science/space/news/2006/12/72276.* Also see Namrata Goswami, "China Has a Head Start in the New Space Race," *Diplomat*, May 29, 2019. *https://thediplomat.com/2019/05/china-has-a-head-start-in-the-new-space-race/.*

[134] Patrick Tucker, "China's Moon Missions Could Threaten US Satellites: Pentagon," *Defense One*, October 16, 2018. *https://www.defenseone.com/technology/2018/10/chinas-moon-missions-could-threaten-us-satellites-pentagon/152084/.*

[135] For background on China's lunar program, see the CNSA China Lunar Exploration Program website at *http://www.cnsa.gov.cn/n6758823/n6758844/n6760026/index.html.* Also see National Air and Space Intelligence Center, *Competing in Space*, December 2018. *https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF.*

[136] For reference to the CMC/EDD Manned Lunar Landing Program Validation Expert Working Group (载人登月综合论证专家组), see Xian Jiaotong University, "Professor Yang Yikang" (杨宜康教授), November 20, 2018. *http://mail.sei.xjtu.edu.cn/html/tt/dmt/p/2018/1120/10.html.* Also see *Renminwang*, "Manned Lunar Landing Expert Meeting Convenes in Beijing" (载人登月专题研讨会议在京召开), May 11, 2010. *http://scitech.people.com.cn/GB/11567265.html*.

[137] For a detailed examination of China's deep space tracking and control system, see Dong Guangliang (董光亮) et al., "Construction and Technical Development of Chinese Deep Space Exploration Systems" (中国深空测控系统建设与技术发展), *Journal of Deep Space Exploration*, December 30, 2017. *http://jdse.bit.edu.cn/html/sktcxbcn/2018/2/20180201.htm.* The authors are from the Beijing Institute of Tracking and Telecommunications Technology (BITTT; 北京跟踪与通信技术研究所). A precursor of the PLASSF Space Systems Department—China Launch and Tracking Control General (CLTC; 中国卫星发射测控系统部)—manages

interferometry sites controlled by the China Academy of Sciences.[138] Little if any information is available regarding jamming capabilities in deep space.

Current and Future Kinetic and Non-Kinetic Counterspace Operations

China has an operational counterspace capability that will evolve through 2020 and out to 2035. These capabilities include antisatellite KKV and space electronic countermeasures. The former GAD and China Aerospace Science and Industry Corporation (CASIC) demonstrated a space intercept KKV in January 2007. According to U.S. government reporting, China allegedly has military units that have begun training with antisatellite missiles. While speculative, one possibility is that the PLA Rocket Force, given its synergistic relationship with the PLASSF, has been assigned space intercept as a secondary mission.

On the non-kinetic side, the PLA has an operational ground-based satellite electronic countermeasures (ECM) capability designed to disrupt adversary use of SATCOM, navigation, SAR, missile early warning, and other satellites through use of jamming.[139] The PLA initially acquired ground-based satellite jammers from Ukraine in the late 1990s and has indigenously developed satellite ECM since then. The PLA is capable of carrying out ECM to disrupt, deny, deceive, or degrade space services. Jamming prevents users from receiving intended signals and can be accomplished by attacking uplinks and downlinks. The PLA and defense industry are developing and deploying jammers capable of targeting satellite communications over a large range of frequencies, including dedicated military communication bands. The PLASSF also has advanced cyber capabilities that could be applied in parallel with counterspace operations. While the PLA capabilities have improved, the U.S. is assumed to maintain a lead in counterspace.

China also is carrying out R&D and testing on potential space-based counterspace systems. The PLASSF and defense industry have carried out advanced satellite maneuvers and are likely testing orbital technologies that could be applied to counterspace operations. For example, in 2013, the Shiyan-7 (SY-7) released an object that performed maneuvers and tested a telerobotic arm. In June 2016, the PLASSF launched the Aolong-1 spacecraft—which included a robotic arm—on a space

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the deep space tracking site in Argentina. Among various sources, see "Argentina Allies with China in Moon Plan" (阿根廷加盟中国探月计划), August 28, 2012. *http://news.china.com.cn/space/2012-08/28/content_26352388.htm*; Victor Robert Lee, "China Builds Space-Monitoring Base in the Americas," *Diplomat*, May 24, 2016. *https://thediplomat.com/2016/05/china-builds-space-monitoring-base-in-the-americas/.*

[138] For discussion of China's VLBI (甚长基线干涉) network see *Space Daily*, "China Building Large Radio Telescope for Space Observation," January 4, 2010. *http://www.spacedaily.com/reports/China_Building_Large_Radio_Telescope_For_Space_Observation_999.html.* Also see International Space Science Institute Beijing, "Space Very Long Baseline Interferometry (VLBI) Forum." *http://www.issibj.ac.cn/Program/Forums/SVLBI/201403/t20140321_118148.html.*

[139] For a good early theoretical discussion of "space information countermeasures," see 周家波, 杨凯, and 吴贤良, "Primary Study of Information Resistance in Space" (空间信息对抗初探), *Radar and Electronic Warfare* 1 (2007). *http://www.defence.org.cn/aspnet/vip-usa/UploadFiles/2008-01/20080120152549б093.pdf.* Also see 汤泽滢, 孙希刚, 程静, "Study of Information Resistance Equipment Systems in Space" (空间信息对抗装备体系研究), *Space Electronic Countermeasures* (航天电子对抗), 2014 年 03 期, at *http://www.cnki.com.cn/Article/CJFDTOTAL-HTDZ201403005.htm*.

debris-related mission. Between November 2016 and August 2018, the Shijian-17 carried out rendezvous and proximity operations with Chinese satellites in geostationary orbit, ostensibly for the purposes of monitoring space debris. Satellites also could serve as platforms for space-based ECM.[140]

The PLASSF Network Systems Department probably oversees satellite jamming operations, though this cannot be confirmed at the current time. At a minimum, the PLASSF Network Systems Department appears to support the PLA space mission.[141] The Network Systems Department integrated PLA technical reconnaissance and probably ECM missions previously under the former GSD Technical Reconnaissance Department (Third Department or 3PLA) and ECM and Radar Department (Fourth Department, or 4PLA).[142] The Network Systems Department probably has integrated the former GSD Third Department 12th Bureau, which is responsible for the intercept of foreign satellite communications from sites throughout China and possibly from space-based collection assets.[143] It appears to maintain a close linkage with the PLASSF's Beijing Institute of Remote Sensing Information.[144] Subordinate offices under the 12thBureau operate satellite

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[140] For reference to the SJ-17 (实践十七号) and space debris monitoring (空间碎片观测), see China Academy of Space Technology, "SJ-17, Developed by CAST, Achieves Launch" (我院研制的实践十七号卫星成功发射), November 4, 2016. *http://www.cast.cn/3g/show.asp?m=1&d=5369.* Also see Todd Harrison, Kaitlyn Johnson, and Thomas Roberts, "Space Threat Assessment 2019," *Center for Strategic and International Studies*. *https://aerospace.csis.org/space-threat-assessment-2019/*; David D. Chen, "China's Advanced Weapons," testimony before the U.S.-China Economic and Security Review Commission, 23 February 2017. *https://www.uscc.gov/sites/default/files/Chen_Testimony.pdf*.

[141] The Network Systems Department is led by a commander and a political commissar. Both carry TC deputy leader grades. Deputy commanders and deputy political commissar of the Network Systems Department (and/or chief of staff and director of the Political Work Department) presumably carry corps leader grades. Senior PLASSF Network Systems Department officers presumably exercise at least administrative authority over corps leader, corps deputy leader, division leader, and division deputy leader-grade units previously subordinate to the former GSD Third and Fourth Departments. Selected divisions under former Military Region, PLAN, and PLAAF technical reconnaissance bureaus may have been integrated into at least six corps leader or corps deputy leader-grade base commands. Corps leader-grade base leaders would report to officers at the next-higher grade, in this case directly to the PLASSF chief of staff and/or PLAASF deputy commander overseeing the Network Systems Department. While administratively subordinate to the PLASSF, five of these base commands could provide national-level ISR support to TCs during peacetime. They could be formally assigned to TC operational control during a contingency.

[142] As a corps leader-grade organization, the GSD Third Department consisted of administrative third-level departments, 12 operational bureaus, a computing center, and three research institutes. GSD Third Department operational bureaus carried a division leader grade (or possibly corps deputy leader grade in some cases) and were separate and distinct from technical reconnaissance bureaus under the PLA's then seven military regions, the PLAN, and PLAAF.

[143] The 12th Bureau carries a cover designator of the 61486 Unit. For linkage of the 12th Bureau with the MUCD, see *http://www.kshr.cn/ksasp/unit/SHOWEMPL.ASP?employee_id=660550.*The Third Department 12th Bureau Headquarters appears to be located on 46 Yuexiu Road in Shanghai's Zhabei District [闸北区粤秀路 46 号].See *http://www.isee.zju.edu.cn/attachments/2011-04/01-1302228510-41734.xls.* The Jiangnan Institute of Remote Sensing Applications [江南遥感应用研究所]shares the same address. The 12th Bureau's former designation was the 57394 Unit.

[144] The 61486 Unit Commander, Senior Colonel Ju Qiansheng [巨乾生], has been affiliated with both the GSD Second Department Remote Sensing Institute and the GSD Third Department's 12th Bureau. See "District Standing Committee, Deputy Mayor Yan Jianping Visits 61486 Unit for a Social Visit" [区委常委、副区长颜建平率队赴驻区 61486 部队开展军地互动联谊活动], February 8, 2010. *http://www.shmzj.gov.cn/gb/mzzbq/mzxw/zxxw/userobject1ai486.html.*

monitoring facilities in Changchun (Jilin Province), Fuzhou and Xiamen (Fujian Province), Hangzhou (Zhejiang Province), Guangzhou (Guangdong Province), Kunming (Yunnan Province), and in Xinjiang.[145]

The PLASSF absorbed at least two strategic ECM brigades and a satellite ECM command previously subordinate to the GSD Fourth Department. The satellite ECM command likely oversees the development and operation of capabilities designed to disrupt adversary use of SATCOM, navigation, SAR, and other satellites. The satellite ECM command is headquartered on Beiqing Road in Beijing's northern suburbs.[146] A possible new base command consolidating strategic ECM units may have been established in Henan's Kaifeng City. The PLASSF also incorporated a unit previously subordinate to the GAD that is responsible for directed energy testing.[147]

Today, the PLA can carry out both kinetic and non-kinetic counterspace activities. Few details are known about operational infrastructure for ground-based kinetic counterspace operations. However, looking out to 2035, and as the effects of the ongoing reform and reorganization bear fruit, PLASSF capacity for counterspace operations is likely to advance significantly with the consolidation of RD&A, training, and operations under a single integrated command. PLASSF-managed defense industrial development of key technologies over the next 15 years—such as active millimeter-wave and imaging infrared sensors, artificial intelligence, and automated target recognition—are likely to provide a further boost to the PLA's operational capabilities. Such advances may erode traditional advantages the United States has enjoyed in space.

Training

The PLASSF has emphasized education and training, although little information is available regarding integration into the PLA's annual training cycle. Force-wide training plans likely are managed by the PLASSF Staff Department Training Bureau or perhaps a similar bureau within the Space Systems Department. For example, the PLASSF has carried out joint reconnaissance and counter-reconnaissance training and mobility training, and it has participated in command

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[145] See Mark A. Stokes, Jenny Lin, and L.C. Russell Hsiao**,** "The Chinese People's Liberation Army Signals Intelligence and Cyber Reconnaissance Infrastructure," *Project 2049 Institute*, November 11, 2011, 11. *http://project2049.net/documents/pla_third_department_sigint_cyber_stokes_lin_hsiao.pdf.*

[146] Military cover designations associated with the Satellite ECM Command (电子对抗卫星总站) include 61276, 61651, 61541, 61764 (Hainan), and more recently 32032.

[147] Among various sources, see Marcus Clay, "Supporting the Infinitive Battlefield," *China Aerospace Studies Institute*, 2019, 42–43. The satellite ECM command may carry a designation of 61276 部队, 61541 部队, or 32032 部队. A subordinate unit is located on Hainan Island and appears to have either operational or experimental satellite jamming responsibilities. One indication of the unit having satellite jamming responsibilities is the number of articles published by its members. See, for example, Li Bin and Jin Guodong, "Analysis on GPS Jamming" [浅析 GPS 干扰技术], *Electronic Countermeasures*, January 2009, 39–42; Jin Guodong and Li Suoku, "On Broadband Communications Satellites [宽带卫星通信探析], *Electro-Optical Systems*, April 2008, 16–31; Zhang Ming and Li Suoku, "Space Information Warfare and International Space Law [空间信息作战与国际空间法], *Armament Command and Technology Academy Journal*, February 2003; Xiang Hanfei, Li Suoku, and Han Honglin, "Analysis of GPS System Countermeasures," [GPS 系统对抗若干分析], *Tracking and Communications*, October 2008.

center exercises.[148] PLASSF units also have carried out training in contingency response and integrating into a TC joint command and control structure.[149] A three-day field training exercise included integrated command and control, execution of contingency combat operations, wartime political work, and maintaining communications support.[150] During Stride-2017 exercises, the PLASSF is noted to have provided joint reconnaissance support during field training.[151] In March 2019, the PLASSF completed an unnamed exercise that focused on enemy combat methods and countermeasures.[152] The U.S. Air Force indicates that "China has military units that have begun training with anti-satellite missiles," although no details are offered.[153] At least one PLASSF test and training base has increased emphasis on combat training.[154] PLASSF units also have trained in restoring command communications that have been cut off.[155] The PLA Space Engineering University and Information Engineering University are both military training institutions directly subordinate to the PLASSF.[156] The PLA Space Engineering University

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[148] For discussion of general PLASSF training, see *PLA Daily*, "PLA Daily Takes You to See Strategic Support Force Troops" (军报带你走进战略支援部队看一看), June 5, 2017. *http://www.81.cn/jwsj/2017-06/05/content_7628476_3.htm.* Also see Hu Ruizhi (胡瑞智) and Xia Wei (夏昊), "Cross-Service Joint Training: PLA Army and PLASSF Conduct Confrontation Exercise" (跨军种联合训练:陆军与战略支援部队开展对抗演练), *PLA Daily*, October 15, 2018. *http://www.xinhuanet.com/mil/2018-10/14/c_129970955.htm.* For reference to mobility training, see 徐雅静 and 蒋玥, "A Certain Strategic Support Force Department: A Strong Military First Strengthens the 'Chinese Military Account'" (战略支援部队某部 -- 强军先强"中军帐"), *PLA Daily,* April 29, 2019. *http://www.81.cn/jfjbmap/content/2019-04/29/content_232741.htm*.

[149] See Ma Wei (马璟) and Wang Bin (王斌), "PLASSF Base Prepares for Battle: A Look at Your Expedition" (战略支援部队某基地练兵备战：望着你出征的背影), *PLA Daily*, February 20, 2018. *http://www.xinhuanet.com/mil/2018-02/20/c_129814052.htm.*

[150] *Xinhua*, "A Certain Department of the Strategic Support Force Begins Open Country Joint Exercises" (战略支援部队某部开展野外联合演训), May 4, 2018. *http://www.xinhuanet.com/mil/2018-05/04/c_129864636.htm.*

[151] 杨庆民 and 吴科儒, "Stride-2017 Zhurihe: The New Changes in Training after the Reconstruction of the Army System from the Action of the Red Army Brigade("跨越－2017·朱日和"：从红军旅动作看陆军体制编制重塑后演训新变化). *http://www.xinhuanet.com//politics/2017-09/07/c_1121625327.htm.* Also see Elsa Kania, "China's Strategic Support Force at 3," *Diplomat*, December 29, 2018. *https://thediplomat.com/2018/12/chinas-strategic-support-force-at-3/.*

[152] "A Certain Strategic Support Force Department: A Strong Military First Strengthens the 'Chinese Military Account'" (战略支援部队某部强军先强'中军帐), *PRC Ministry of National Defense*, April 29, 2019. *http://mod.gov.cn/power/2019-04/29/content_4840768.htm/.* The PLASSF also conducted an unnamed simulated exercise in mid-July 2019. See "Nearly 80% of Key Technical Posts in a Certain Strategic Support Force Department Are Held by Young Cadres" (战略支援部队某部近八成关键技术岗位由年轻干部担纲,) *China Military*, August 9, 2019. *http://www.81.cn/zlzy/2019-08/09/content_9584300.htm.*

[153] See National Air and Space Intelligence Center, *Competing in Space*, December 2018. *https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF.*

[154] Zou Weirong (邹维荣)and Cheng Zilong (成子龙),"PLASSF Base Integrates Testing and Combat Training" (战略支援部队某基地战试训一体联动融合推进), *PLA Daily*, February 9, 2018. *http://www.mod.gov.cn/power/2018-02/09/content_4804534.htm.*

[155] Lu Jun (路俊), "PLASSF Communications Support Training in Complex Environment" (战略支援部队某部—复杂环境演练通信保障), *PLA Daily*, January 5, 2018. *http://www.81.cn/jfjbmap/content/2018-01/05/content_196236.htm.*

[156] PRC Ministry of National Defense, *Ministry of National Defense Announces Names of Post-Reform Military Academies* (国防部公布调整改革后军队院校名称),June 29, 2017. *http://www.mod.gov.cn/shouye/2017-06/29/content_4783975.htm.*

houses facilities, including a space simulation center, space testing center, and space measure and control station, and functions as the PLASSF's command college and noncommissioned officer academy.[157] PLASSF space-related participation in military exercises with international partners has not been noted.

[157] PRC Ministry of National Defense,(2017 军校巡礼第二十五站：航天工程大学（附报考指南）,June 15, 2017. *http://www.mod.gov.cn/services/2017-06/15/content_4783023.htm*; Wang Yajun (王亚军), "A New Generation in Aerospace Engineering University Space Science and Technology Emerges" (航天工程大学航天科技"新生代"崭露头角), *PLA Daily*, June 14, 2018. *http://military.people.com.cn/n1/2018/0614/c1011-30057365.html*; *PRC Ministry of National Defense*(2017 军校巡礼第二十五站：航天工程大学), June 15, 2017. *http://www.mod.gov.cn/services/2017-06/15/content_4783023.htm*; Marcus Clay, "Supporting the Infinitive Battlefield," *China Aerospace Studies Institute*, 2019, 16–18.

SECTION THREE
SPACE/COUNTERSPACE FORCE MODERNIZATION

The CMC oversees a well-established structure and process for PLA weapons and space systems RD&A. The CMC/EDD and CMC S&T Committee develop and oversee broad RD&A policies and regulations, advise on technical solutions to satisfy operational requirements, and oversee formal coordination mechanisms between the PLA and the defense industrial system. Based on CMC-approved mid- to long-term strategic guidelines, the CMC/EDD, like its predecessor, the GAD, coordinates the drafting of a PLA Equipment Development Strategy. The strategy establishes PLA-wide priorities for long-term (e.g., 20–30 years), mid-term (e.g., 10 years), and short-term (e.g., five years) force modernization investments. The strategy is reviewed every five years. Within this process, the PLA Army, Navy, Air Force, Rocket Force, and Strategic Support Force likely compete within a set budget. The CMC S&T Committee, which functions as the senior-level defense technology advisory group, is supported by at least 20 national-level technology working groups that advise on defense technology policy and priorities.[158] Civilian space organizations, such as SASTIND and defense industrial enterprises, support the PLA in the development of technical requirements and engineering R&D.

Research, Development, and Acquisition System

Under CMC/EDD and CMC S&T Committee guidelines, end users, such as the PLA Army (PLAA), PLA Navy (PLAN), PLA Air Force (PLAAF), PLA Rocket Force (PLARF), and PLA Strategic Support Force (PLASSF) manage weapons and space systems RD&A programs. More specifically, PLAA, PLAN, PLAAF, and PLARF equipment departments manage RD&A programs in close coordination with the civilian defense S&T and defense industry community.[159] The consolidation of space-related RD&A management under a single end user—the PLASSF—probably has improved the efficiency of the requirements development process, program validation, engineering R&D, and integration of military space systems.

As a reflection of China's military-civil fusion policy, PLA end users work closely with SASTIND and defense industrial enterprises in managing space systems RD&A. RD&A generally consists of five phases: (1) preliminary research,(2) program validation,(3) concept design,(4) engineering

[158] For reference to the *Equipment Development Strategy* (装备发展战略), *Ten-Year Equipment Development Plan* (装备建设十年规划), *Five-Year Equipment R&D Plan* (军装备研制五年计划), and other force modernization documentation, see Tu Hengzhang (屠恒章), "Military Equipment Development" (军事装备发展), *China Encyclopedia Publishing*, 2008, 31–35. Another term for five- and ten-year force modernization plans is 装备建设规划计划. For a brief discussion on the Strategic Planning Department, see Tai Ming Cheung, *Forging China's Military Might: A New Framework for Assessing Innovation*, Johns Hopkins University Press, 2014, 52–53.
[159] For the PLASSF, RD&A is handled by two second-level departments: The Space Systems Department and the Network Systems Department. For the PLA Navy, Air Force, and Rocket Force, RD&A is managed by their respective equipment departments with support from dedicated research academies.

R&D,(5) design finalization, and (6) low-rate/full production. Each phase presumably requires individual contracts between the end user and civilian service provider.[160]

Preliminary Research: PLA-funded preliminary research (预先研究) invests resources into the development of advanced technologies that could be applied to multiple weapons system programs or to overcome a bottleneck on a specific program. In addition to national-level initiatives, such as the 863 Program, end users such as the PLASSF Systems Department probably oversee a dedicated office responsible for preliminary research planning, awarding grants for studies, and disseminating research results. PLA research institutes and universities, defense industrial research centers, and civilian universities can compete for preliminary research projects.[161]

Concept/Program Validation: During the concept program validation (方案论证) phase, end users develop detailed operational and technical requirement documentation for CMC/State Council approval. Validation involves the development of mockups and assessment of alternatives, along with cost and operational effectiveness assessments. Operational and technical requirements for major weapons systems are validated by a special committee consisting of representatives of the CMC and State Council. It is unclear is this committee evaluates military programs, civilian programs, or both. If approved, new programs are included in the five-year plan (FYP). In some cases, a program may be approved but not included in the FYP. In this case, an end user would be expected to fund R&D from its own budget. PLA Navy, Air Force, and Rocket Force Equipment Research Academies, as well as the PLASSF counterparts, presumably are responsible for overseeing program validation. The civilian defense industry contributes to the process through detailed feasibility studies. The validation process also includes the development of a program budget. The validation phase concludes with a CMC/State Council committee approval of operational and technical requirements, referred to as a Tactical Technology Index.

Engineering R&D: Engineering R&D involves the management of a complex supply chain overseen by a dual command system that divides technical and administrative aspects of a program. SASTIND functions as a coordinating body for defense industrial enterprises supporting military R&D, manufacturing, and follow-on support. Among the 97 central state-owned enterprises (SOEs) listed on the State-Owned Assets Supervision and Administration Commission (SASAC, 国有资产监督管理委员会) website, the first ten are considered defense industrial enterprises. However,

[160] For a general overview of satellite engineering R&D, see PRC State Council Information Office, *Civilian Satellite Engineering Management Guidelines* (民用卫星工程管理暂行办法), November 29, 2016. *http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/35861/36552/xgzc36558/Document/1549898/1549898.htm.* Also see Guo Baozhu (郭宝柱), "Process for Space Program R&D" (空间项目的研制程序), *Spacecraft Engineering* 23:2 (April 2011). *http://www.ccose.org/static/files/gbz5.pdf.* Guo Baozhu (b. 1945) was the engineering chief designer (工程总设计师) of the SJ-9 (实践九号) satellite.

[161] Before the reorganization, the GAD Comprehensive Planning Department oversaw a Preliminary Research Bureau (总装综合计划部预研局). GAD also managed a Preliminary Research Management Center (总装备部预研管理中心).

most engineering R&D programs are assigned to one of ten central defense industrial enterprises administered by SASAC.

A central defense industrial enterprise, a specific business division, or a research academy is assigned systems integration responsibilities. Research academies function as second-tier units under defense industrial enterprises. In the case of large national-level projects that cut across two or more central defense industrial enterprises, such as the lunar exploration program, SASTIND may host an engineering office that exercises dual command responsibilities.

Technical aspects of a space program are the responsibility of the chief designer and his/her design team. The chief designer, deputy chief designers, and directing designers bridge a complex network of research institutes and manufacturers. Deputy chief designers and directing designers are responsible for subsystems, assemblies, and manufacturing/final assembly. A chief designer may be housed within an academy's design department. The department hosts the chief designer, who oversees a dedicated office to coordinate with research institutes, other academies, and program managers. Deputy chief designers are often selected from research institutes or factories, rather than within a design department. Engineering R&D includes a test prototype phase (试样阶段). Design and program management teams work closely together with end user acquisition offices to ensure an economy of effort, timely production, and cost-effective use of resources. PLA end users manage industrial representative offices to monitor aspects of engineering R&D to ensure quality control.[162]

Design Finalization: During the design finalization phase, the CMC, State Council, end users, and industrial program managers evaluate whether or not a satellite or launch vehicle meets operational and technical requirements. Testing is carried out and evaluated in accordance with operational and technical requirements, including the Tactical Technology Index and R&D Mission Document. End user Equipment Research Academies appear to play a role in the design finalization process. After successfully completing testing, the system is reviewed by two certification boards. The program management team produces a systems R&D report for review by a senior end user committee. If approved, the system is reviewed by a first-level Design Finalization Committee comprising members of the State Council (Premier or Vice Premier) and CMC.[163]

[162] See 花兴来 and 刘庆华,eds., *Equipment Management Engineering* (装备管理工程), Defense Industry Publishing, 2002, 9.

[163] Among various sources outlining the design finalization process, see *Military Products Design Finalization Process and Requirements* (军工产品定型程序和要求), PLA Directive GJB-1362A (2007). Until 1979, the committee was known as the Military Product Design Finalization Leading Small Group (国务院、中央军委军工产品定型工作领导小组). The first-level design finalization committee, which maintains a standing office, may also be known as the Central Special Committee. Senior PLA Navy authorities comprise a second-level design finalization committee (二级定委). According to one corporate source, the certification process proceeds through a series of reviews: (1) Second-Level Design Finalization Review Committee (二级定委会审查会); (2) Second-Level

Space Requirements Development and Program Management

The PLASSF supports the CMC in the development of technical and operational requirements for space systems. The requirements development process likely is informed by the CMC Office for Strategic Planning (former GSD Strategic Planning Department), which may conduct a long-term analysis of the international security environment and space-related trends. The office also appears responsible for organizational transformation, strategic resource allocation, and departmental and "domain" coordination (e.g., between GSD and GAD). Although speculative, the office may play a central role in force planning for future space operations.[164]

The process for how the PLASSF develops operational requirements remains opaque. The PLASSF Space Systems Department develops requirements for and manages joint military use of ISR, communications, navigation, mapping, metrological, and oceanographic space systems. The Space Systems Department Equipment Department Program Management Center most likely oversees key PLASSF space-related RD&A initiatives.[165] Other organizations likely supporting requirements development and RD&A management include the PLASSF Space Equipment Integrated Technology R&D Center, Space Engineering Research Institute (航天系统部航天工程研究所), Beijing Institute of Systems Engineering, Beijing Institute of Remote Sensing Information, and the Beijing Institute of Tracking and Telecommunications Technology. The Beijing Institute of Remote Sensing Information, previously subordinate to the GSD Intelligence Department Space Reconnaissance Bureau, appears to be primarily focused on developing EO and SAR remote sensing requirements. The Beijing Institute of Tracking and Telecommunications Technology is a critical player in the design of tracking and control stations, and has been involved in international projects in Venezuela and Nigeria.[166]

Design Finalization Committee (二级定委会); (3) First-Level Design Finalization Committee Expert Advisory Committee (一级定委会专家咨询会); and (4) First-Level Product Design Finalization Committee (一级定委会产品定型会). See (东风"猛士"通过定型审查), *Dongfeng Vehicle Company*, June 26, 2007. *www.dfmc.com.cn/news/show.aspx?ID=10003237.*

[164] *Xinhua*, "Ceremony Held for Establishment of the PLA Strategic Planning Department, Chairman Guo Boxiong Speaks" [解放军战略规划部成立大会举行郭伯雄出席并讲话], November 22, 2011. *http://news.xinhuanet.com/mil/2011-11/22/c_111187194.htm.*

[165] For reference to the PLASSF Space Systems Department Equipment Department Program Management Center (航天系统部装备部项目管理中心), see *http://my.yingjiesheng.com/xjh-003-057-033.html.*

[166] The military unit cover designator of the Beijing Institute of Remote Sensing Information may be 61646. Its former GSD alter ego, the GSD Space Reconnaissance Bureau (总参航天侦察局) managed an R&D center directed by Zhou Zhixin [周志鑫]. For reference to Zhou, see [杜善义院士、曲久辉、栾恩杰和周志鑫校友获 2009 年度何梁何利奖], *Harbin Institute of Technology Today*. *http://today.hit.edu.cn/articles/2009/11-11/1115372591.htm.*For reference to Zhou with the Second Department's Space Remote Sensing, see *http://www.ciomp.cas.cn/jgsz/kyxt/klomt/sysgk_klomt/xswyh_klomt/.*For reference to Zhou as 61646 Unit Deputy Bureau Director, see [胡锦涛签署通令给军队 1 个单位 22 名个人记功] at *http://www.wpeu.net/html/china/2010/1225/18703.html.* For reference to the 61646 Unit ground station (presumably an imagery downlink site), see [2007 年度首都文明单位候选名单(1908 个)], at *http://jbhg.bjwmb.gov.cn/public/info_selinfo.asp?Info_ID=27680&Bar_ID=123.* For discussion of the BITTT and

Defense Industry and Space Systems Engineering

The CMC and PLASSF rely upon state-owned defense industrial establishments for research, development, and manufacturing of space systems. Administrative oversight of China's defense industry is exercised by the Ministry of Industry and Information Technology (MIIT) and SASTIND. Formed in summer 2008, SASTIND is administratively in charge of defense industrial enterprises that support military-related R&D, manufacturing, and follow-on support. SASTIND seeks to foster greater competition within the defense industry to better meet the requirements of the PLA, as well as encourage greater military-civil fusion. SASTIND provides policy guidance to at least ten state-owned defense industrial enterprise groups responsible for space and missiles, electronics, aviation, nuclear-related products, shipbuilding, and other sectors.

The two large SOEs that make up the space and missile industry include CASC and CASIC. CASC and CASIC receive government subsidies, although efforts have been made to introduce market-based incentives. The aerospace industry enjoys a historical legacy with a proven record of success, well-established channels and methods for overcoming technological bottlenecks, and the prestige needed to recruit some of China's best and brightest.

Both CASC and CASIC are organized in a manner similar to U.S. defense corporations, with a corporate-level structure and various business divisions, referred to as academies. Like U.S. defense industrial business divisions, each academy focuses on a core competency, such as medium-range ballistic missiles, short-range ballistic missiles, intercontinental-range ballistic missiles and satellite launch vehicles, cruise missiles, and satellites. While U.S. defense companies tend to specialize further within a business division, CASC/CASIC academies are organized into R&D and/or design departments; research institutes focusing on specific subsystems, subassemblies, components, or materials; and then testing and manufacturing facilities. Each academy is accountable for profit and loss and includes an information collection and dissemination institute that diffuses technical information.[167]

China Aerospace Science and Technology Corporation

CASC develops and manufactures space launch vehicles, strategic ballistic missiles, satellites, and other space flight vehicles.[168] CASC employs more than 100,000 engineers, technicians, and workers. Its functional business divisions specialize in ballistic missiles and space launch vehicles, large solid-rocket motors, liquid-fueled engines, satellites, and related subassemblies and components. Anew division was established in 2008 that consolidated CASC institutes and

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involvement in Nigeria and Venezuela, see State Administration for Science, Technology and Industry for National Defense, (北京跟踪与通信技术研究所), September 30, 2013. *http://www.sastind.gov.cn/n132/n230/n18113/c42724/content.html.*

[167] See, for example, Mark Stokes, "Appendix One and Appendix Two: China's Evolving Conventional Strategic Strike Capability: The Anti-Ship Ballistic Missile Challenge to U.S. Maritime Operations in the Western Pacific and Beyond," *Project 2049 Occasional Paper*, September 2009. *http://project2049.net/documents/chinese_anti_ship_ballistic_missile_asbm.pdf.*

[168] See "Company Profile" on CASC's official website at *http://english.spacechina.com/n16421/n17138/n17229/index.html*.

factories specializing in inertial measurement units, telemetry, and missile-related microelectronics, such as the high-performance digital signal processors and field programmable gate arrays that are needed for long-range precision strikes at high speeds and extreme temperature conditions. The CASC S&T Committee advises the State Council, CMC, and CASC leadership on space technology issues. CASC's dedicated export management and international contracting entity is China Great Wall Industry Corporation (CGWIC).

China Aerospace Science and Industry Corporation

The second major industrial enterprise engaged in space-related R&D and production is CASIC. CASIC employs more than 100,000 engineers, technicians, and workers within its headquarters, academies or business divisions, subordinate design departments, research institutes, factories, and commercial enterprises. CASIC specializes in conventional defense and aerospace systems, including tactical ballistic missiles, antiship and land attack cruise missiles, air defense missile systems, direct ascent ASAT interceptors, operationally responsive tactical microsatellites, and associated tactical satellite launch vehicles. While academies and subordinate institutes appear to conduct independent international business transactions, CASIC's principle export management enterprise is the China Precision Machinery Import-Export Company (CPMIEC).[169]

Launch Vehicle RD&A

The PLASSF's space launch infrastructure depends upon a well-established and increasingly reliable family of launch systems to deploy payloads into space for military and civilian users. The CASC First Academy and CASC Eighth Academy are leading suppliers of liquid-fueled launch vehicles. To date, seven basic series of Long March (LM) liquid-fueled launch vehicles deliver payloads to orbits at varying altitudes and inclinations around the earth.[170] The CASC First Academy, also known as the China Academy of Launch Technology (CALT), is China's largest entity involved in the development and manufacturing of space launch vehicles and related ballistic missile systems. CALT is also a leading organization in China's crewed space program. Launch vehicle systems engineering responsibilities reside within the First Academy First Design Department. Various research institutes specialize in guidance, navigation, and control subsystems, reentry vehicles, and launch systems. The 211 Factory in Nanyuan is the academy's primary

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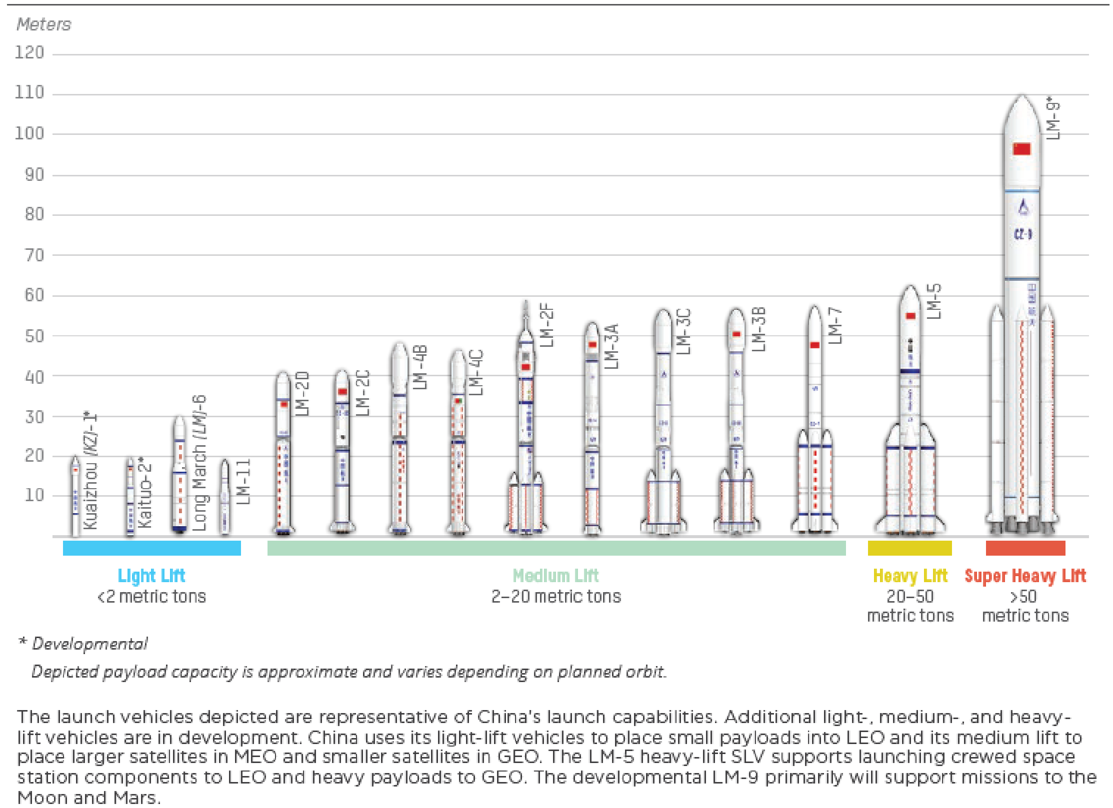
[169] For background on CASIC, see *http://www.casic.com/n189298/n189314/index.html*. The CEO/president/director of CASIC (航天科工集团) is Gao Hongwei(b. 1956). He was assigned in 2013. He previously directed the CASIC Third Academy, served as CASIC deputy director, and directed the former 066 Base (Sanjiang) in Hubei. He has roots in the Hongfeng Factory. Gao Hongwei is supported by six vice presidents.

[170] For the most comprehensive background on China's ballistic missile program, see John Lewis Wilson and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goals*," International Security* 17:2 (Fall 1992). The LM launch vehicle family has roots in the country's ballistic missile program, specifically the Dongfeng-4 (DF-4) and Dongfeng-5 (DF-5) ICBM systems. Based on a March 1965 CMC decision, formal design work on the two missile systems commenced in May 1966. By 1970, initial technical designs were completed. The first DF-5 prototype was assembled in May 1971, and tested from Base 20 on September 10, 1971. Its design was certified in 1973.Both the 211 and 7102 factories in Sichuan assembled prototypes for testing. The warhead design, however, was not completed until July 1986.

launch vehicle assembly plant. The Long March Machinery Factory (7102 Factory) in Sichuan may augment the 211 Factory in assembling launch vehicles.

Figure 2: Chinese Space Launch Vehicles



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

The CASC Eighth Academy, also known as the Shanghai Academy of Space Technology (SAST), also designs, develops, and assemblesliquid-fueledLM-4 launch vehicles. SAST's Eighth Design Department is responsible for overall design and systems engineering.

CALT and SAST rely upon a vast supply chain for subsystems and components. The CASC Sixth Academy, also known as the Academy of Space Propellant Technology (or 067 Base), is China's primary organization engaged in research, development, and production of liquid-fueled engine systems. Among its more recent products are the YF-77 and YF-100, currently China's most powerful liquid oxygen and kerosene rocket engines. The CASC Sixth Academy is also a key organization involved in the development of LM-5 engines.[171]

The LM-2 series has been used for delivering both remote sensing and communications satellites from Jiuquan and Xichang Satellite Launch Centers. The LM-2F is China's most powerful launch

[171] Originally centered in the Qinling mountain range west of Xian, the CASC Sixth Academy employs around 10,000 people in four research institutes and one factory, and is now headquartered in Xian. For background on the CASC Sixth Academy, see China Aerospace Science and Technology Corporation,(航天推进技术研究院), September 26, 2011. *http://www.spacechina.com/n25/n142/n152/n12989/n13957/c25220/content.html.*

vehicle to date, able to boost more than 8,000 kg into LEO. Sharing the same first and second stages as the LM-2C, the LM-3 series integrates a cryogenic third stage that has been used for boosting heavier payloads into space from Xichang Satellite Launch Center.

Other launch vehicles include the LM-2D and LM-4 series, which have transported remote sensing, weather, and other payloads to SSO from Taiyuan Satellite Launch Center. The LM-2D has launched more than 40 payloads into both LEO and SSO from the Jiuquan Satellite Launch Center.[172]

Since 2008, China has been investing resources into a new generation of launch vehicles, including the LM-5, LM-6, LM-7, LM-8, and LM-9. The LM-5, first launched in November 2016, is designed to lift a 23+ ton payload to LEO, or a 14-ton payload into geosynchronous transfer orbit. The second LM-5 launch in July 2017 failed due to a first-stage engine problem. A CGWIC official noted that a follow-on launch is slated for late 2019.[173] With R&D beginning in September 2009, SAST's LM-6 is a smaller launch vehicle capable of boosting 500–1000 kg into orbit. The LM-7, first launched in 2016, is designed to place a 5.5-ton payload into SSO at an altitude of 700 km. The LM-8 is intended to be China's first reusable launch vehicle.[174]

Solid-Fueled Propulsion Systems

Over the last 20 years, CASIC and CASC have invested resources into R&D and production of operationally responsive solid-fueled satellite launch systems. The CASIC Fourth Academy has designed and produced another family of other tactical solid-fueled launch vehicles. Established in 2002, the CASIC Fourth Academy specializes in design, development, and manufacturing of the DF-21 medium-range ballistic missile and associated variants, including the PLA's first-generation antiship ballistic missile.[175]

The CASIC Fourth Academy developed the Kaituozhe (KT) small launch vehicle to serve the domestic and foreign market for boosting small and microsatellites with weights less than 100 kg into low-earth or sun-synchronous orbit. The developmental program is said to have begun in June 2000, with the third-stage motor successfully tested on February 25, 2001.[176] Aerospace industry

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[172] China Great Wall Industry Corporation "The LM-2D," April 1, 2010. *http://www.cgwic.com/LaunchServices/LaunchVehicle/LM2D.html.*

[173] *Xinhua*, (长征五号飞行故障原因查明), March 3, 2018. *http://www.xinhuanet.com/tech/2018-03/03/c_1122480716.htm.* Also see Debra Werner and Andrew Jones, "China Could Launch Another Long March 5 by Year's End," *Space News*, September 11, 2019. *https://spacenews.com/china-great-wall-wsbw-2019/.*

[174] *Xinhua*, "High Altitude Simulation Testing of the LM-8 Launch Vehicle, First Flight Scheduled for Next Year" (长征八号运载火箭芯二级氢氧发动机高空模拟试验成功预计明年), December 2, 2019. *http://www.xinhuanet.com/tech/2019-12/02/c_1125299157.htm.*

[175] The Fourth Design Department was formerly subordinate to the Second Academy, one of the few academies that has managed more than one subordinate design department.

[176] Shi Fashu, "Kaituozhe-1 Solid Launch Vehicle Development Planning and Implementation," *China Aerospace* (*zhongguohangtian*), August 2003, 13–16.

reporting indicated that an initial test of the 1.4-meter diameter first-stage motor on September 15, 2002, failed to achieve the anticipated outcome.[177]

Development of a follow-on Kaituozhe launch vehicle centered upon a new 1.7-meter solid rocket motor. The KT-2was a three- or four-stage launch vehicle designed for geosynchronous transfer orbit and polar orbit missions with an estimated payload capacity of 300 kg. Plans for a KT-2 were based upon the CASIC Sixth Academy's ability to develop and produce a larger 1.7-meter diameter motor, presumably based on the foundation of the SpaB-17 perigee kick motor for communication satellite programs. The KT-2A planned to add external motors for lifting over 400 kg into polar orbit. The ultimate requirement appeared to be the deployment of a 500-kg payload to a 700-km orbit. The KT program appears to have been discontinued and succeeded by the Kuaizhou program, also designed and developed by the CASIC Fourth Academy's Ninth Design Department. The Kaituozhe's first flight took place in 2013 from Jiuquan.[178] Subsequent launches took place in 2019 and 2020.[179]

The CASC First Academy designed a larger solid-fueled launch vehicle, the LM-11 launch vehicle. The main supplier of solid rocket motors is the CASC Fourth Academy. The CASC Fourth Academy is developing large high-thrust solid rocket motors for delivering large payloads. Initial ground tests were conducted in 2009.[180] A two-stage solid motor was successfully flight tested on September 25, 2010. While unconfirmed, a large high-thrust solid rocket motor with a diameter greater than two meters could serve as the basis for a new mobile intercontinental ballistic missile. Its first flight took place in 2015, and the first LM-11 sea launch took place in June 2019.[181]

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[177] The test involved the launch of the 35.8-kg KT-1PS microsatellite, manufactured by CASIC First Academy, from Taiyuan Satellite Launch Center into an intended 300-km altitude orbit. Tian Zhiqiang, [小型固体运载火箭], *Space Exploration* [太空探索], October 2003.For background on the microsatellite payloads, see CASIC Satellite Technology Company,"KT-1PS/PS2/PS3 载荷星."*http://www.casic-sat.com.cn/operation5.asp.*The satellite passed its final factory certification on August 24, 2002, approximately five weeks before launch. Gu Ti, "Kaituozhe: New Choice for Small Satellite Launches," *Aerospace China*, November 2002, 2. There are indications the KT-2 has been redesignated as the KT-1B.

[178] Liang Jiqiu (梁纪秋; b. 1974) is with the CASIC Ninth Design Department and recruited by Hu Shengyun in August 2002 to serve as directing designer, and subsequently deputy chief designer, of a user interface program. Liang Jiqiu is cited in 2014 reporting as chief designer of the Kuaizhou small solid-fueled launch vehicle (快舟小型固体运载火箭). The Kuaizhou-2 was launched on November 21, 2014.

[179] Rui C. Barbosa, "China Conducts Double Kuaizhou-1A Launch from Taiyuan," *NASA Spaceflight.com*, December 7, 2019. *https://www.nasaspaceflight.com/2019/12/china-double-kuaizhou-1a-launch-taiyuan/*.

[180] *China Space News*, "China Aerospace Entities Actively Develop Heavy Solid Launch Vehicle [中国航天部门将积极发展重型固体运载火箭], June 12, 2010. *http://news.ifeng.com/mil/2/detail_2010_06/12/1616757_0.shtml*; Shaanxi Defense Industry Information Network, "Gan Xiaosong: 'Forrest Gump's' Run on the Innovation Road" [甘晓松：奔跑在创新路上的"阿甘"], May 4, 2009. *http://www.jungong.net/_info/content/con-ren_12982.htm.*

[181] *China Space News*, "CASC Fourth Academy Achieves Four Breakthroughs within Two Years in New Motor R&D" [航天科技四院某新型发动机研制两年攻坚实现四大新突破], December 27, 2010. *http://www.spacechina.com/xwzx_jcdt_Details.shtml?recno=72512.*The program manager was Fourth Academy Deputy Director Wang Jinglin [王景林] and the chief designer was Gao Bo [高波], director of the CASC Fourth Academy's Design Department. Also see Lu Jun (路俊) and Zou Weirong (邹维荣), "Commemorating Taiyuan

New-Generation Aerospace Flight Vehicles/Reusable Launch Vehicles

China's defense industry is investing considerable resources into new modes of space launch, including transatmospheric and reusable launch vehicles. Theoretically, both would be capable of delivering payloads to LEO and returning to earth at less cost than single-use launch vehicles.[182] Basic research and an assessment of alternative reusable launch vehicles was initiated in 1987 under the 863 Program in parallel with technical assessments of the crewed space program. In July 1989, the 863-204 Expert Group (863-204 专家组) completed a feasibility assessment for a large reusable launch vehicle (大型运载火箭及天地往返运输系统).[183] Among the various options was a space shuttle design.[184] China allegedly is targeting 2030 for a two-stage-to-orbit reusable launch vehicle.[185] A transatmospheric vehicle appears to be in the preliminary stage of R&D, including ground testing of propulsion systems, and notionally would leverage advanced propulsion technologies, such as a supersonic combustion ramjet (scramjet) or combined-cycle engines. The CASIC Third Academy 301st Research Institute (Beijing Institute of Aerospace Technology; 北京空天技术研究所) appears to be one of the leading design departments engaged in transatmospheric R&D. Established in 2012, the CASIC 301st Institute's principle effort is the Tengyun Engineering (腾云工程) program.[186] CASC also has reported intent to develop a nuclear-propelled space vehicle by 2040.[187] As a final note, little information is available regarding RD&A of space-to-air vehicles, or space-to-ground weapons capable of directly engaging, defeating, or destroying a target.

Space Launch Center's Maritime Launch Mission Team" (记太原卫星发射中心海上发射任务团队), *PLA Daily*, June 11, 2019. *http://www.81.cn/jfjbmap/content/2019-06/11/content_235682.htm.*

[182] For general discussion of reusable launch vehicle R&D, see (我国将加强可重复天地往返运输系统研发), *S&T Daily*, September 24, 2013. *http://www.nsfc.gov.cn/publish/portal0/tab446/info65565.htm.*

[183] Among various sources, see *http://www.csaspace.org.cn/n2505504/n2505531/c2524224/content.html*.

[184] See *Legal Evening News* (法制晚报), (秘而不宣的"921"工程), October 28, 2013. *http://www.ldyx.org/html/2013/lectureHall_1028/7626.html.* For explicit linkage between Tengyun and the 301st Institute, see Ren Zhiwei (任志伟), (打造满载人类梦想的空天飞行器), *China Space News* (中国航天报), May 22, 2018. *https://new.qq.com/omn/20180522/20180522A19YBF.html.*

[185] See (航天专家提出中国发展重复使用航天运输系统路线图) at *http://www.chinanews.com/gn/2018/04-25/8499746.shtml.*

[186] Among various sources, see *CCTV*, "New Generation of Reusable Space Flight Vehicle in R&D" (新一代天地往返飞行器"空天飞机"正在研制), March 6, 2018. *http://m.news.cctv.com/2018/03/06/ARTIpsmrJVGPEsI1WxHA0ADL180306.shtml.* For reference to ground testing of propulsion systems, see 付毅飞, (我国正研发可重复使用天地往返飞行器), *Xinhua*, June 7, 2017. *http://www.xinhuanet.com//science/2017-06/07/c_136830662.htm.*As of 2018, Guan Chengqi (关成启) directed the CASIC 301st Institute. He previously served as deputy director of the Third Academy Third Design Department.

[187] See (中国旨在 2040 年建造一艘核动力航天飞机), 核能研究展望 NPRV), at *http://www.sgcio.com/eduinfo/hd/2017/1208/38513.html.* Another key 301st Institute engineer is Luo Jinling (罗金玲). Reference to Luo Jinling and CASC 11th Academy support for testing, see (建院十周年空气动力学术研讨会圆满结束) at *http://www.caaa-spacechina.com/n301/c2101/content.html.* Also see Gabe Collins and Andrew Erickson, "Spaceplane Development Becomes a New Dimension of Emerging U.S.-China Space Competition," *China Signpost*, August 17, 2012. *http://www.chinasignpost.com/2012/08/17/spaceplane-development-becomes-a-new-dimension-of-emerging-u-s-china-space-competition/.*

Satellite Systems RD&A

The CASC Fifth Academy, CASC Eighth Academy, and CASIC First Academy are lead systems integrators for satellite systems. Established in February 1968, the CASC Fifth Academy, or China Academy of Space Technology (CAST), is China's primary organization engaged in satellite design, development, and manufacturing. Based in Beijing's northwestern suburbs, CAST institutes, factories, and other enterprises are centered upon the 501st Design Department, which functions as CAST's overall systems engineering organization.[188] Established in 1975, the 502nd Research Institute (also known as Beijing Institute of Control Engineering) designs, researches, and develops satellite attitude and orbit control systems, including jet propulsion and various guidance, navigation, and control subsystems. The 508th Research Institute designs and develops EO and other satellite sensors. The principle assembly facility is the 529 Factory. Other institutes specialize in vacuum and cryogenic technologies, antenna systems, and modeling and simulation.[189] A subsidiary in Shenzhen is expected to develop and produce a number of navigation satellites on behalf of the CASC Fifth Academy.[190] The CASC Fifth Academy is the industrial lead systems integrator for major communications satellite programs. CAST has a number of international cooperation programs, including with entities from the Netherlands, Germany, and Pakistan, to name a few.[191]

The CASC Eighth Academy, also known as the Shanghai Academy of Space Technology (SAST), designs, develops, and manufactures satellites, along with specialized launch vehicles and other aerospace systems. SAST oversees a dedicated design department—the 509thResearch Institute—that focuses on weather, SAR, and electronic reconnaissance satellites. Established in August 1961,

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[188] Established in 1968, the 501st Research Institute is also known as the China Spacecraft Integrated Design Department [中国空间技术研究院总体部].

[189] CAST's Dongfanghong Satellite Company [航天东方红卫星公司] appears to be a significant commercial entity. It was established in August 2001 as a wholly owned satellite research and production subsidiary of China Spacesat. The enterprise is a publicly traded company that offers satellite-related solutions to military and civil users. Its activities include manufacturing of satellite ground equipment, and satellite services, such as satellite integrated applications, satellite navigation, satellite remote sensing and image transmission, satellite communication, television broadcasting, etc. It has eight subsidiaries, including ones in Xiamen, Yungang, and Xian. Dongfanghong lays claim to the CAST968 platform as a common bus for small and microsatellites.

[190] Established in 2000, Shenzhen Academy of Aerospace Technology is a joint venture between CASC, the Shenzhen City government, and Harbin Institute of Technology. It specializes in radio frequency identification (RFID), digital trunking communication systems, GPS vehicle location, radio frequency monitoring systems, and systems integration services. It has a relationship with a number of organizations, including the Bauman Institute in Russia, Samara State Aerospace University (SSAU), Russian Academy of Sciences (Far East Branch), Far East Technical University, Novosibirsk State Technical University, National Technical University of Ukraine, and Saint Petersburg Electrotechnical University.

[191] DSTI.net, "CASC Fifth Academy and Netherlands Measurements Systems Company Sign Cooperative Agreement" (航天科技五院总体部与荷兰测量系统公司签署合作协议), April 8, 2019. *http://www.dsti.net/Information/Viewpoint/79156*; China Aerospace Science and Technology Corporation, "CASC Fifth Academy and Germany's Pfeiffer Vacuum Cooperate on Development" (航天科技五院 510 所与德国普发真空公司共谋合作发展), February 16, 2017. *http://www.sasac.gov.cn/n2588025/n2588124/c3837825/content.html.* For Pakistan, see State-Owned Assets Supervision and Administration Commission,(开启中巴航天合作新篇章——中巴两国研制资源一号 04A 卫星纪实), February 14, 2020. *http://www.sasac.gov.cn/n2588025/n2641616/c13766817/content.html.*

the CASC Eight Academy is the aerospace industry's largest and most diverse business division. Employing around 16,800 people, the institution was in large part formed through the consolidation of several defense industry research institutes in the mid-1960s.

CASIC's First Academy, also known as the Academy of Information Technology, has designed and fielded microsatellites. Working with the academic community, the CASIC First Academy is one of a number of entities within China focused on operationally responsive tactical microsatellites that ostensibly could be launched on solid-fueled launch vehicles. It also is engaged in R&D satellite applications and Beidou and GPS/inertial guidance units. Serving as a test bed for MEMS-based guidance and navigation systems, its most prominent products are the Hangtian-Tsinghua-1 (HT-1) 50-kg microsatellite that operates in SSO, and the 25-kg NS-1 microsatellite. One institute under the Academy of Information Technology specializes in space-based and missile-borne ECM research and development.[192]

Microsatellite Programs

In a crisis situation, China may have the option of augmenting existing space-based assets with microsatellites launched on solid-fueled launch vehicles. Weighing between 10 and 100 kg, past microsatellite programs appeared experimental in nature, but competency and experience could translate into a lower cost, operationally responsive space capability.[193] Microsatellites also serve as experimental technology test beds for MEMS and formational flight as an integrated constellation that could offer greater survivability due to their numbers and potentially reduced radar cross section. While speculative, microsatellites may function in part as technology demonstrations for counterspace operations, including ASAT KKVs. A number of R&D organizations in China have entered the microsatellite field, including CAS, CASIC First Academy, CASC Fifth Academy, CASC Eighth Academy, Nanjing University of Aeronautics and Astronautics, Harbin Institute of Technology, and Tsinghua and Zhejiang Universities.[194]

Initial technology demonstration programs include the Tsinghua-1 satellite, an ostensibly privately funded program carried out in conjunction with the United Kingdom's (UK) University of Surrey. Launched in June 2000, the Tsinghua-1 weighed 50 kg and conducted experiments on satellite-

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[192] Formed in 1978 in Nanjing, the 8511 Institute is the aerospace industry's main electronic and infrared countermeasures entity. It manages an integrated test and manufacturing facility in Nanjing's Jiangning Science Park.

[193] For an overview of CASC microsatellite development, see China Space Network, [集团公司组织召开微小卫星关键技术研讨会], May 6, 2011. *http://www.space.cetin.net.cn/index.asp?modelname=new_space%2Fnews_nr&FractionNo=&titleno=XWEN0000&recno=75869.*

[194] The China Academy of Sciences opened a microsatellite lab [中国科学院微小卫星重点实验室] in 2011. China Academy of Sciences, "CAS Microsatellite Key Laboratory Holds Inaugural Session of Academic Council" [中国科学院微小卫星重点实验室举行揭牌仪式暨学术委员会第一届第一次会议], December 23, 2010. *http://www.cas.cn/hy/xshd/201012/t20101231_3052884.shtml.*The NUAA project is the Tianxun-1 [天巡一号] intelligent network microsatellite system. See *http://www.nuaa.edu.cn/nhb/997/b1.htm.*

borne navigation, multispectral remote sensing, and store and dump downlink communications.[195] The program appears to have been jointly managed by Tsinghua University and the CASIC First Academy.[196] A subsequent Tsinghua/CASIC microsatellite program was the Naxing-1, launched on April 18, 2004, as a piggyback to the Shiyan-1. Naxing served as a MEMS test bed for an onboard miniature inertial measurement unit and complementary metal-oxide-semiconductor digital imagery.[197] Shiyan-1, developed by the Harbin Institute of Technology, was also launched on April 18, 2004, and followed by the Shiyan-3. Other organizations involved include CAST, CAS Changchun Institute of Opto-Electronics, and Xian Institute of Survey and Mapping.[198]

Another microsatellite is Pixing-1, a state-funded completed program developed by Zhejiang University, which has been involved in defense-related basic research.[199] The initial Pixing satellite was launched from Jiuquan in conjunction with the Yaogan-2 on May 25, 2007. Two additional Pixing microsatellites were launched as piggyback payloads on the Yaogan-11 in September 22, 2010, from Jiuquan. The satellite was intended to function as a test platform for digital imagery, data storage, and management; downlink communications; attitude control; MEMS inertial measurement unit; thermal control; and other missions.[200]

Other programs include Banxing-1 (BX-1), a payload of less than 40 kg that deployed from the Shenzhou-7 orbital module in September 2008 to test data relay and other payloads associated with Shenzhou-8. The BX-1 satellite was designed and manufactured by CAS's Satellite Engineering Center. Another system, the 88-kg Chuangxin-1 (CX-1) satellite, was a prototype LEO telecommunication satellite launched in October 2003.A second was launched in November

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195 See "Aerospace Tsinghua 1 Satellite," ["航天清华"一号卫星] on the CASIC Satellite Technology Ltd. official website [航天科工卫星技术有限公司]at *http://www.casic-sat.com.cn/operation4.asp.*

196 For background on the CASIC role, see the CASIC Satellite Technology Ltd. official website [航天科工卫星技术有限公司]at *http://www.casic-sat.com.cn/abouts.asp.*

197 See *China News* [中新网], "Small Satellite R&D Receives Breakthrough: China Successfully Launched "One Rocket, Two Stars," [中国成功发射"一箭双星" 小卫星研制取得突破], April 9, 2004. *http://news.tsinghua.edu.cn/publish/news/6661/2011/20110225231431312562162/20110225231431312562162_.html.* See *S&T Daily*, "The First Indigenously Made Nano-1 Satellite Has Been Launched Successfully" [第一颗自主研制的纳星一号发射成功], April 18, 2004. *http://www.stdaily.com/oldweb/gb/kjzg/2004-09/28/content_305818.htm.*Also see *http://www.smallsat.org/proceedings/13/tech-ix/ts-ix-3.pdf.*

198 Harbin Institute of Technology, [我国首颗高校自主研制的微小卫星"试验卫星一号"发射成功], July 7, 2008. *http://news.hit.edu.cn/articles/2008/07-07/07140722.htm.*For background on the Shiyan-3, see Harbin Institute of Technology, [揭秘哈工大"试验卫星三号"], November 11, 2008. *http://news.hit.edu.cn/articles/2008/11-11/11101604.htm*.

199 Zhejiang University has been actively involved in research associated with strike technology, including the 863-801 and 863-805 programs.

200 See Zhejiang University, "Zhejiang University's Successful Launch of "Pixing-1A Satellite, Challenging Microsatellites" [浙江大学成功发射"皮星一号 A"卫星挑战微型小卫星], October 7, 2010. *http://mememama.cn/2010/1007/1334.html.* Also see *Xinhua*, "Nation's First Kilogram-Level Micro-Satellite Operating Smoothly for Eight Days and Nights"[我国首颗公斤级微小卫星平稳运行八天八夜], September 30, 2010. *http://news.sina.com.cn/c/2010-09-30/222621204836.shtml*. Also see *http://www.most.gov.cn/eng/newsletters/2010/201010/t20101011_82540.htm.*

2008.[201] Yet another program was the Beijing-1, a miniature satellite designed and manufactured by Surrey Satellite Technology Ltd (SSTL) for the Disaster Monitoring Constellation of the International Charter on Space and Major Disasters.Beijing-1 was delivered into polar orbit on a Russian launch vehicle from Plesetsk in October 2005. SSTL concluded an agreement for three additional satellites with one-meter resolution to be launched in 2014.[202] Now an Airbus subsidiary, SSTL oversees a space debris removal satellite system.[203]

Counterspace RD&A

The CASIC First Academy (Academy of Aerospace Information Technology) is likely central to engineering R&D of space-based ECM systems. The First Academy's R&D Center and 8511 Institute are responsible for space ECM, with the latter publishing a leading journal entitled *Aerospace Electronic Warfare* (航天电子对抗). China Electronics Technology Group Corporation (CETC) appears to be a prominent player in ground-based satellite ECM systems.[204]

CASIC's Second Academy is the principal enterprise responsible for kinetic kill counterspace systems and is China's largest producer of air defense missile systems. Established in 1961, and with a growing emphasis on integrated air and space defense, the Second Academy consists of a design department, ten specialized research institutes, a simulation center, three factories, and nine commercial enterprises. The extent of the academy's formal relationships with foreign enterprises remains unclear. With the PLAAF serving as a core customer, the Second Academy's most prominent defense products include the Hongqi series of surface-to-air missile systems, including the missile, radar, and associated ground equipment. The Second Academy also likely designed the space intercept systems that were tested in January 2007 and January 2010.[205] CASIC

[201] For overview of the BX-1, see David Wright and Gregory Kulacki, "Chinese Shenzhou 7 'Companion Satellite' (BX-1),"*Union of Concerned Scientists*, October 21, 2008. *http://www.ucsusa.org/assets/documents/nwgs/UCS-Shenzhou7-CompanionSat-10-21-08.pdf*;Brian Weeden, "China's BX-1 Microsatellite: A Litmus Test for Space Weaponization," *Space Review*, October 20, 2008. *http://www.thespacereview.com/article/1235/1*. The chief designer of the BX-1 was Zhu Zhencai.

[202] Among various sources, see Peter B. de Selding,"Surrey to Build Three Optical Imaging Satellites for Chinese Firm," *Space News*, June 29, 2011. *http://www.spacenews.com/contracts/110629chinese-firm-orders-three-optical-imaging-satellites-from-surrey.html.*The Chinese company is Twenty-First Century Aerospace Technology Co. Ltd. A ground station affiliated with the Beijing-1 satellite is collocated with a GSD Third Department Seventh Bureau facility in the northern Beijing suburb of Shangzhuang [上庄].

[203] Airbus, "Testing Technology to Clear Out Space Junk." *https://www.airbus.com/space/space-infrastructures/removedebris.html.*

[204] The key R&D organization is probably the CETC 54th Research Institute (石家庄通信测控技术研究所). See (通信子集团 54 所 2019-2020 年度招聘简章). *http://ccst.jlu.edu.cn/info/1094/9809.htm*.

[205] Zhang Yiqun, assigned to the CASIC Second Academy Second Design Department, is a possible subsystem designer for the ASAT/missile defense KKV. Cited as a deputy chief designer of an unnamed system, Zhang was granted a national "model worker" award in April 2010. For one account, see Chinese Military Network, "Preliminary Analysis on China's Ground-Based Mid-Course Missile Defense Intercept Technology" [中国"陆基中段反导拦截技术试验"初步分析], January 13, 2010. *http://military.china.com/zh_cn/critical3/27/20100113/15774945.html.*

conducted successful tests of a KKV in January 2007 and January 2010.[206] In doing so, they demonstrated an ability to intercept polar orbiting satellites and rudimentary medium-range ballistic missiles during the mid-course of flight. Subsequent tests may have taken place in 2013, 2014, and 2018. At least one KKV funding source during the late 1990s and earlier this decade appears to be the 863-409 program (and possibly the 863-706 program).[207] These technologies include active millimeter wave and possible passive imaging infrared terminal guidance and automated target recognition software.[208] These technologies likely also have applications for increasingly accurate and lethal ballistic, hypersonic, and cruise missile systems.

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[206] Zhang Yiqun, assigned to the CASIC Second Academy Second Design Department, is a possible subsystem designer for the ASAT/missile defense KKV. Cited as a deputy chief designer of an unnamed system, Zhang was granted a national "model worker" award in April 2010. For one account, see Chinese Military Network, "Preliminary Analysis on China's Ground-Based Mid-Course Missile Defense Intercept Technology" [中国"陆基中段反导拦截技术试验"初步分析], January 13, 2010. *http://military.china.com/zh_cn/critical3/27/20100113/15774945.html.*

[207] For an excellent and reasonable analysis of the January 2010 missile defense interceptor test by a well-regarded independent Chinese military-technical analyst, see KKTT, "A Preliminary Analysis of China's Ground-Based Mid-Course Missile Defense Interceptor Technology Test" [我国"陆基中段反导拦截技术试验"初步分析], *KKTT blog*, January 12, 2010, at *http://liuqiankktt.blog.163.com/blog/static/12126421120100129195498/.* Also see Mark A. Stokes, "China's Strategic Modernization: Implications for U.S. National Security," *Army War College*, 1999, 115; Ian Easton, "The Great Game in Space: China's Evolving ASAT Weapons Programs and Their Implications for Future U.S. Strategy," *Project 2049 Institute Occasional Paper*, June 24, 2009.

[208] For an excellent and reasonable analysis of the January 2010 missile defense interceptor test by a well-regarded independent Chinese military-technical analyst, see KKTT, "A Preliminary Analysis of China's Ground-Based Mid-Course Missile Defense Interceptor Technology Test" [我国"陆基中段反导拦截技术试验"初步分析], *KKTT blog*, January 12, 2010. *http://liuqiankktt.blog.163.com/blog/static/12126421120100129195498/.*Also see Mark A. Stokes, "China's Strategic Modernization: Implications for U.S. National Security," *Army War College*, 1999, 115; Ian Easton, "The Great Game in Space: China's Evolving ASAT Weapons Programs and Their Implications for Future U.S. Strategy," *Project 2049 Institute Occasional Paper*, June 24, 2009.

SECTION FOUR
MILITARY-CIVIL FUSION POLICIES AND INTERNATIONAL COOPERATION

Under General Secretary of the CCP Xi Jinping, the advancement of China's domestic civilian space program is a central theme woven throughout many key PRC policies since the 18th Party Congress in 2012. In particular, the PRC's military-civil fusion (MCF; 军民融合) strategy seeks to more effectively and efficiently integrate the use of both civilian and military-industrial economic resources to benefit the PLA. MCF builds on the well-established principles of civil-military integration, which sought to combine the defense and civilian industrial bases to meet military and commercial demands.[209]

Military-Civil Fusion and the PRC's Space Program

The PRC State Council's 2017 *Opinions on Promoting the Deep Development of Military-Civil Fusion in the National Defense Science and Technology Industry* states a need to "accelerate the overall planning of space infrastructure according to the needs of the military and civilian sectors" as well as increase the number of MCF projects in the realms of launch vehicles, deep space exploration, nuclear-powered space equipment, remote sensing satellites, and others.[210] The recent influx of PRC non-state-owned "commercial" launch vehicle and satellite companies into China's domestic market since 2015 suggests the PRC is successfully advancing MCF efforts, blurring the lines between civilian and military entities and obfuscating the ultimate end users of acquired foreign technology and knowhow, which in turn presents export control challenges for the United States.

China's civilian space program is stewarded by PRC government organs under MIIT, including SASTIND and the CNSA (国家航天局). Some SASTIND leadership concurrently serve in the CNSA (see Tables 1 and 2 below), demonstrating that space is a critical aspect of MCF; SASTIND plays a central role in MCF implementation.[211] According to the PRC State Council, SASTIND is tasked with serving the needs of national defense, military forces, the national economy, and military-related organizations in the fields of nuclear weapons, aerospace, aviation, and others.[212] The CNSA is the primary PRC government agency in charge of civil space management and

[209] Greg Levesque and Mark Stokes, "Blurred Lines: Military-Civil Fusion and the 'Going Out' of China's Defense Industry," *Pointe Bello*, December 2016.
[210] State Council of the People's Republic of China, *Opinions of the General Office of the State Council on Promoting the Deep Development of Military-Civil Fusion in the National Defense Science and Technology Industry* [国务院办公厅关于推动国防科技工业军民融合深度发展的意见], December 2017. *http://www.gov.cn/zhengce/content/2017-12/04/content_5244373.htm.*
[211] Greg Levesque and Mark Stokes, "Blurred Lines: Military-Civil Fusion and the 'Going Out' of China's Defense Industry," *Pointe Bello*, December 2016.
[212] State Council of the People's Republic of China, *State Administration for Science, Technology and Industry for National Defense*, October 6, 2014. *http://english.gov.cn/state_council/2014/10/06/content_281474992893468.htm.*

international space cooperation, according to its official website.[213] Subordinate CNSA departments hold a range of responsibilities and specialties, including earth observation, remote sensing, space debris monitoring, satellite research, and space law.[214]

Table 2: SASTIND Leadership

Name	Position
Zhang Kejian(张克俭)	Director
Zhang Jianhua (张建华)	Deputy Director
Wu Yanhua(吴艳华)	Deputy Director
Xu Zhanbin(徐占斌)	Deputy Director
Tian Yulong (田玉龙)	Deputy Director

Source: SASTIND official website.[215]

Table 2: CNSA Leadership

Name	Position
Zhang Kejian(张克俭)	Director
Wu Yanhua(吴艳华)	Deputy Director
Li Guoping(李国平)	Secretary-General

Source: CNSA official website.[216]

SASTIND and the CNSA often collaborate with PLA institutions to further MCF development in the aerospace field, as demonstrated by the June 2019 release of the *Notice on Promoting the Orderly Development of Commercial Launch Vehicles* by SASTIND and the CMC/EDD on CNSA's official website. This document states that commercial rocket companies engaged in launch vehicle research and production must report to SASTIND and the EDD before launching any products.[217]

In addition, to launch vehicles, the PRC is actively pushing for MCF development in other "emerging fields" (新兴领域) in the civilian space industry, according to reporting from the China Electronics and Information Industry Development Research Institute's (中国电子信息产业发展研究院) CCID Think Tank (赛迪智库), which is under MIIT.[218] For instance, the CCID's

[213] China National Space Administration [国家航天局], *Institutional Function* [机构职能], *http://www.cnsa.gov.cn/n6758821/index.html#w_two.*

[214] China National Space Administration [国家航天局], *Subordinate Units* [直属单位]. *http://www.cnsa.gov.cn/n6758821/index.html#w_two.*

[215] State Administration for Science, Technology and Industry for National Defense. *Leadership Resumes* [领导简历]. *http://www.sastind.gov.cn/n254046/n6115882/index.html.*

[216] China National Space Administration [国家航天局], *Leadership Introduction* [领导简介]. *http://www.cnsa.gov.cn/n6758821/index.html#w_two.*

[217] China National Space Administration [国家航天局], *Notice of SASTIND and the CMC Equipment Development Department on Promoting the Orderly Development of Commercial Launch Vehicles* [国家国防科技工业局中央军委装备发展部关于促进商业运载火箭规范有序发展的通知], June 10, 2019. *http://www.cnsa.gov.cn/n6758823/n6758838/c6806484/content.html.*

[218] CCID Think Tank [赛迪智库], "About Us" [关于我们]. *http://www.ccidwise.com/plus/list.php?tid=2.*

Prospects for the Development of China's Military-Civil Fusion in 2019(2019年中国军民融合发展形势展望) highlights progress on Beidou (北斗)—China's indigenous GNSS—within the context of advancements in civilian space and launch activities.[219] The CCID report stipulates that PRC breakthroughs in GNSS follow the *mincanjun* (民参军) model,[220] a concept that refers to civilian participation in the defense industry.[221]

China's Beidou program is a key example of MCF at work, demonstrating not only the indistinctness between civilian and military/defense entities but also the significance of civilian contributions to military and defense assets. Beidou is a PLA-coordinated program, which is made evident in the numerous CASIC entities that play a role in its development, including CASIC's First,[222] Second,[223] Third,[224] and Tenth[225] academies, all of which provide unique contributions to Beidou development. CASIC touts itself as "adhering to the road of military-civil fusion with Chinese characteristics" ("…中国航天科工坚持走中国特色的军民融合发展之路…").[226] Although collaboration between CASIC/CASC and the United States in space are prohibited by U.S. export regulations, both PRC entities have collaborated on space topics with U.S. allies, including Japan and the EU. For instance, CALT organized the International Academy of Astronautics (IAA) Academy Day in Beijing in November 2018, which was attended by former European Space Agency (ESA) administrator Jean-Jacques Dordain and Japan IHI Aerospace

219 CCID Think Tank [赛迪智库], "Prospects for the Development of China's Military-Civil Fusion in 2019" [2019年中国军民融合发展形势展望], 2019. *http://www.ccidwise.com/uploads/soft/181220/1-1Q220153F5.pdf.*

220 CCID Think Tank [赛迪智库], "Prospects for the Development of China's Military-Civil Fusion in 2019" [2019年中国军民融合发展形势展望], 2019. *http://www.ccidwise.com/uploads/soft/181220/1-1Q220153F5.pdf.*

221 State Council Information Office of the PRC [中华人民共和国国务院新闻办公室], *SASTIND Holds Press Conference on the Situation of Military-Civil Fusion in the National Defense Science and Technology Industry* [国防科工局举行国防科技工业军民融合发展情况发布会], December 6, 2017. *https://www.scio.gov.cn/xwfbh/gbwxwfbh/xwfbh/hfkgw/Document/1612885/1612885.htm.*

222 China Aerospace Science and Industry Corporation First Institute, "First Institute Beidou Navigation Products Achieve Usage in the Tourism Industry" [一院北斗导航产品实现在旅游行业规模应用], July 3, 2014. *http://www.casic.com.cn/n103/n135/c1870136/content.html.*

223 China Aerospace Science and Industry Corporation, "Our 'Chinese Heart' for Global Time and Positioning -- The Development Story of the Beidou Guided Navigation Satellite Atomic Clock Produced by Second Institute 203 Institute" [我们的"中国心"为世界时间定位——二院203所北斗导航星载原子钟研制发展记], February 23,2018. *http://www.casic.com.cn/n103/n135/c6873806/content.html.*

224 *China Daily Net* [中国日报网],"CASIC Third Institute 304 Institute Beidou Mission Software Evaluation Team Assists the Beidou Satellite Network" [航天科工三院304所北斗任务软件评测团队助力北斗卫星组网], May 25, 2018. *https://baijiahao.baidu.com/s?id=1601424168891451161&wfr=spider&for=pc.*

225 China Aerospace Science and Industry Corporation, "CASIC's Comprehensive Support Efforts for the 42nd and 43rd Beidou Navigation Satellite Launches Meet with Complete Success"[中国航天科工全力保障第四十二、四十三颗北斗导航卫星发射任务圆满成功], November 19, 2018. *http://www.casic.com.cn/n3053244/n3053530/n3053532/c10090392/content.html*; Sun Zifa [孙自法], "China's Newest Beidou Payload Is a New Generation Atomic Clock That Will Assist Precision Positioning" [中国最新北斗双星装载新一代原子钟助力精准定位], *China News Network* [中国新闻网], November 19, 2018. *http://china.eastday.com/c/20181119/u1a14391653.html.*

226 China Aerospace Science and Industry Corporation, "Group Introduction" [集团简介], April 21, 2014. *http://www.casic.cn/n101/n119/c34628/content.html.*

Corporation President Shigeki Kinai.[227] Known PLA affiliates such as Northwestern Polytechnical University also attended the event.[228]

In addition to more traditional defense enterprises, ostensibly civilian-owned entities such as Beijing Unistrong Science and Technology (北京合众思壮科技股份有限公司) claim to play a leading role in Beidou development.[229] Representatives from Unistrong appear throughout various aspects of Beidou development. For instance, Unistrong Independent Director Zhang Yongsheng(张永生) previously served as the director of the Institute of Remote Sensing and Aerial Survey Engineering of the PLA Institute of Surveying and Mapping,[230] and Unistrong seems to have led the development of the first Beidou Overseas Center in Tunisia, which opened in April 2018.[231] This center, also referred to as the China-Arab Beidou/GNSS Center (中阿北斗/GNSS 中心), will bring together participants from Oman, Algeria, Nigeria, Kuwait, Sudan, Iraq, Tunisia, and others to partake in PRC-led training and R&D cooperation on global navigation satellite systems.[232]

Established by the Politburo Standing Committee in 1992, the China Manned Space Engineering Program (CMSP; 中国载人航天工程) is tasked with implementing a "three-step development policy" (三步走) for human spaceflight. These steps include:(1) launching crewed spacecraft and improving experimental civilian space engineering, (2) making technological breakthroughs in extravehicular activities (EVA) and launching a space laboratory, and (3) building a space station.[233] MCF is most evident in CMSP leadership, which contains both high-level military personnel as well as leaders from some of China's top civilian S&T organizations. According to CMSP's official website, the positions of chief commander and deputy chief commander are filled by CMC/EDD, MIIT, CAS, CETC, and CASC leadership.[234] Notably, PLA personnel hold the top

[227] International Academy of Astronautics, "Academy Day Held in Beijing," November 16, 2018. *https://iaaweb.org/content/view/757/995/.*
[228] International Academy of Astronautics, "Academy Day Held in Beijing," November 16, 2018. *https://iaaweb.org/content/view/757/995/.*
[229] Beijing Unistrong Science and Technology Corporation [北京合众思壮科技股份有限公司], "About Us" [关于我们]. *http://www.unistrong.com/AboutUs/AboutUsShow_220.aspx.*
[230] Sina Finance, "Zhang Yongsheng Introduction" [个人简介：张永生],*http://vip.stock.finance.sina.com.cn/corp/view/vCI_CorpManager-Info.php?stockid=002383&Name=%D5%C5%D3%C0%C9 %FA*.
[231] Beijing Unistrong, "Beijing Unistrong Fully Supports the Construction of the First Overseas Beidou Center to Help Beidou Go to the World" [合众思壮权力支持首个海外北斗中心建设助力北斗走向世界],April 13, 2018. *http://www.unistrong.com/ news/NewsShow_2700.aspx*.
[232] Beijing Unistrong, "Beijing Unistrong Fully Supports the Construction of the First Overseas Beidou Center to Help Beidou Go to the World" [合众思壮权力支持首个海外北斗中心建设助力北斗走向世界], April 13, 2018. *http://www.unistrong.com/ news/NewsShow_2700.aspx*.
[233] China Manned Space Program, *Introduction to China's Manned Spaceflight Project* [中国载人航天工程简介], [中国载人航天工程], April 23, 2011. *http://www.cmse.gov.cn/art/2011/4/23/art_24_1054.html.*
[234] China Manned Space Program, *Management*. *http://en.cmse.gov.cn/col/col71/index.html.*

two positions within CMSP (see Table 3), once again demonstrating the importance of the military in China's space program.

Table 3: CMSP Leadership

Name (Chinese)	Title	CMSP Position
Li Shangfu(李尚福)	Director, CMC EDD	Chief Commander
Qian Weiping(钱卫平)	Deputy Director, CMC EDD	Deputy Chief Commander
Zhang Kejian(张克俭)	SASTIND	Deputy Chief Commander
Shang Hong (尚宏)	Commander, PLASSF Space Systems Department	Deputy Chief Commander
Xiang Libin(相里斌)	Vice President, CAS	Deputy Chief Commander
Wu Yansheng(吴燕生)	Chairman, CASC	Deputy Chief Commander
Gao Hongwei (高红卫)	Chairman, CASIC	Deputy Chief Commander
Xiong Qunli(熊群力)	Chairman, CETC	Deputy Chief Commander
Zhou Jianping(周建平)	Chinese Academy of Engineering	Chief Designer
Chen Shanguang(陈善广)	International Academy of Astronautics	Deputy Chief Designer
Zhou Yanfei(周雁飞)	N/A	Deputy Chief Designer

Source: China Manned Space Program official website.[235]

MCF also dovetails with other PRC national-level policies such as Made in China 2025 (中国制造 2025). This 2015 leading industrial policy aims to promote the development of key strategic emerging industries as China seeks to end its reliance on international technology and upgrade its own domestic industrial capability. Made in China 2025 lays out ten "key areas" (重点领域) for targeted rapid development—including aerospace equipment (航空航天装备)—which are reiterated in the 13th Five-Year Plan (2016–2020). The 13th Five-Year Plan highlights a need to develop next-generation and heavy-lift launch vehicles as well as new types of satellites and other space platforms and payloads.[236]

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[235] China Manned Space Program [中国载人航天工程],*Program Introduction* [工程简介]. *http://www.cmse.gov.cn/cmsp/.*

[236] National Development and Reform Commission (NDRC), *The 13th Five-Year Plan for Economic and Social Development of the People's Republic of China*, March 2016. *http://en.ndrc.gov.cn/newsrelease/201612/P020161207645765233498.pdf.*

Academia and Universities’ Role in Space-Related Basic Research and RD&A

China’s university system plays an important role in space-related R&D. State academic organizations such as the Chinese Academy of Sciences (CAS) house units dedicated to various aspects of civilian space research. CAS is different from other traditional universities in China, functioning more like a think tank and academic governing institution directly under the supervision of the State Council. CAS’s link to the State Council means it develops policies and recommendations around state priorities and communicates them to academic institutions.[237]

CAS institutes such as the National Space Science Center (NSSC; 国家空间科学中心) and the Technology and Engineering Center for Space Utilization (CSU; 空间应用工程与技术中心) lead the institution in space-related research and development. The NSSC claims to be the primary PRC institution responsible for planning and developing space research in the fields of space physics, satellites, remote sensing, engineering technology, deep space exploration, and others.[238] It has also made significant contributions to several key aspects of China’s aerospace industry, including its applied satellite, human spaceflight, and lunar exploration programs.[239] In 2011, CAS approved the Strategic Priority Program on Space Science, making the NSSC a CAS pilot project.[240]

Select Projects from the NSSC Strategic Priority Program

Hard X-Ray Modulation Telescope (HXMT): Proposed by CAS academician Li Tibei(李惕碚), HXMT allegedly has the ability to survey black holes and other high-energy objects in space,[241] where traditional telescopes would be blind to brighter energy sources. The first HXMT, dubbed Insight, was launched into an orbit of 550km above earth in June 2017.[242] Chinese media reports note that the telescope will allow scientists to study how to use pulsars for spacecraft navigation.[243]

Quantum Experiments at Space Scale (QUESS):QUESS aims to implement long-distance quantum communication networks based on high-speed quantum key

[237] Chinese Academy of Sciences [中国科学院], “Introduction to Chinese Academy of Sciences” [中国科学院简介]. *http://www.cas.cn/zz/yk/201410/t20141016_4225142.shtml.*
[238] National Space Science Center, Chinese Academy of Sciences, “A Snapshot of NSSC.” *http://english.nssc.cas.cn/au/ac/.*
[239] National Space Science Center [国家空间科学中心], Chinese Academy of Science [中国科学院], “History.” *http://english.nssc.cas.cn/au/histroy/.*
[240] National Space Science Center [国家空间科学中心], Chinese Academy of Science [中国科学院], “Historical Evolution” [历史沿革]. *http://www.nssc.cas.cn/zxgk2015/lsyg2015/.*
[241] National Space Science Center, Chinese Academy of Sciences, “Strategic Priority Program on Space Science.” *http://english.nssc.cas.cn/missions/FM/.*
[242] *Xinhua*, “China Launches Space Telescope to Search for Black Holes, Pulsars,” June 15, 2017. *http://www.xinhuanet.com//english/2017-06/15/c_136367916.htm.*
[243] *Xinhua*, “China Launches Space Telescope to Search for Black Holes, Pulsars,” June 15, 2017. *http://www.xinhuanet.com//english/2017-06/15/c_136367916.htm.*

distribution between satellites and ground stations.[244] Cited as a major breakthrough by CAS academician Pan Jianwei (潘建伟), QUESS is designed to establish "hack-proof" quantum communications by transmitting uncrackable keys from space to the ground.[245] China is currently collaborating with Austria and other nations to establish the first-ever "global quantum communication network" by 2030.[246] In February 2019, QUESS was awarded the Newcomb Cleveland Prize from the American Association for the Advancement of Science for "laying the groundwork for ultra-secure communication networks of the future."[247]

The CSU also has played a major role in human spaceflight engineering R&D. The CSU conducts research on payloads, electronic information technology, electromagnetic technology, space manufacturing, deep space exploration, space software, space simulation technology, and other areas.[248] It houses China's Key Laboratory of Space Utilization (LSU; 太空应用重点实验室), a CAS-directed lab focused on finding new applications for advanced technologies in space, particularly in the field of human spaceflight engineering.[249] Notably, the LSU has historically utilized plans and research from the National Aeronautics and Space Administration (NASA) and other international space programs as the basis for its research. For instance, in 2016 the LSU released a report titled *NASA Technology Roadmap* that analyzes potential development pathways over the next 20 years for key technologies such as remote sensing instruments and lasers, noting that this plan was adapted from the 2015 *NASA Technology Roadmaps*.[250] In this instance, the LSU appears to only be copying NASA, as Individual Technology Roadmaps are publicly available; there were no observable cases of formal collaboration between NASA and the LSU. However, more broadly this signals that PRC entities are paying close attention to U.S. space goals and policies in an attempt to replicate them. The CSU also collaborates with other space R&D academic institutions. It directs joint laboratories with Beihang University as well as China's

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244 National Space Science Center, Chinese Academy of Sciences, "Strategic Priority Program on Space Science." *http://english.nssc.cas.cn/missions/FM/.*

245 Yu Fei and Xu Haitao, "China Focus: China's Quantum Satellite Achieves 'Spooky Action' at Record Distance," *Xinhua*, June 16, 2017. *http://www.xinhuanet.com//english/2017-06/16/c_136371668.htm*; Mike Wall, "China Launches Pioneering 'Hack-Proof' Quantum-Communications Satellite," *Space.com. https://www.space.com/33760-china-launches-quantum-communications-satellite.html.*

246 *Xinhua*, "China Focus: China's Space Satellites Make Quantum Leap," *PLA Daily*, August 16, 2016. *http://english.chinamil.com.cn/news-channels/today-headlines/2016-08/16/content_7210313.htm.*

247 Chinese Academy of Science, "Chinese Study on Quantum Communications Wins Newcomb Cleveland Prize," February 1, 2019. *http://english.cas.cn/newsroom/news/201902/t20190201_205271.shtml.*

248 Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences, "Research Departments" [科研部门]. *http://www.csu.cas.cn/gb/jggk/kybm/xtsjyjs/.*

249 Key Laboratory of Space Utilization, Chinese Academy of Sciences [中国科学院太空应用重点实验室], "Laboratory Introduction" [实验室简介], *http://lsu.csu.cas.cn/sysgk/jj/.*

250 Key Laboratory of Space Utilization, Chinese Academy of Sciences [中国科学院太空应用重点实验室], "NASA Technology Roadmap – Scientific Instruments" [NASA 技术路线图 – 科学仪器], September 14, 2019. *http://lsu.csu.cas.cn/kxyylyjz/yxzhjsyj/201609/t20160914_348338.html*; National Aeronautics and Space Administration (NASA), *2015 NASA Technology Roadmaps*,2015. *https://www.nasa.gov/offices/oct/home/roadmaps/index.html.*

National University of Defense Technology, the latter being the PLA's military engineering university.[251]

CAS units are actively participating in international cooperation initiatives with foreign universities and institutions. In 2009, the NSSC collaborated on a Sino-Russian Joint Mars Exploration Program known as Firefly No. 1(萤火一号), the first Chinese vessel to conduct an interplanetary mission, according to the NSSC.[252] CAS has also set up joint overseas laboratories like the CAS South America Center for Astronomy (CASSACA; 中国科学院南美天文研究中心), also referred to as the China-Chile Joint Center for Astronomy (CCJCA). According to the center's overview in vernacular Chinese, CASSACA's main purpose is to "meet the strategic needs of the internationalization of S&T innovation and promote the 'going out' of CAS."[253] Through CASSACA, CAS seeks to exploit South America's astronomical observation resources and its strategic location to achieve breakthroughs in space research.[254] The program is housed by the University of Chile[255] in Santiago and has received support from both the PRC and Chilean governments through high-level visits.[256]

In October 2017, CAS's National Astronomical Observatory of China (NAOC; 中国科学院国家天文台) announced a strategic cooperation agreement with the California Institute of Technology at a ceremony that included nearly 50 scholars from NAOC, CalTech, Peking University, Tsinghua University, China's University of Science and Technology, Nanjing University, and others.[257] According to NOAC, the agreement renewed NAOC's ability to use CalTech's telescopes at the

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[251] Center for Space Utilization, Chinese Academy of Sciences [中国科学院空间应用工程与技术中心], "Unit Overview" [单位概况]. *http://www.csu.cas.cn/gb/jggk/dwgk/*; National University of Defense Technology [国防科技大学], "School Profile" [学校概况]. *https://www.nudt.edu.cn/xxgk/index.htm.*

[252] National Space Science Center, Chinese Academy of Sciences, "Firefly One Mars Exploration Program" [萤火一号火星探测计划]. *http://www.cssar.cas.cn/zdkyhd/yh1h/.*

[253] Chinese Academy of Sciences South America Center for Astronomy [中国科学院南美天文研究中心], "Center Introduction" [中心简介]. *http://www.cassaca.org/zh/%e4%b8%ad%e5%bf%83%e7%ae%80%e4%bb%8b/.*

[254] Chinese Academy of Sciences South America Center for Astronomy [中国科学院南美天文研究中心], "Center Introduction" [中心简介]. *http://www.cassaca.org/zh/%e4%b8%ad%e5%bf%83%e7%ae%80%e4%bb%8b/.*

[255] Chinese Academy of Sciences South America Center for Astronomy [中国科学院南美天文研究中心], "Center Introduction" [中心简介]. *http://www.cassaca.org/zh/%e4%b8%ad%e5%bf%83%e7%ae%80%e4%bb%8b/.*

[256] CASSACA, "Chinese Ambassador to Chile Xu Bu Unveiled the Office of CASSACA" [中国驻智利大使徐步为中智联合文特峰天文项目办公室揭牌] August 14, 2018. *http://www.cassaca.org/zh/%E6%96%B0%E9%97%BB%E7%AE%80%E8%AE%AF/2018/08/%E4%B8%AD%E5%9B%BD%E9%A9%BB%E6%99%BA%E5%88%A9%E5%A4%A7%E4%BD%BF%E5%BE%90%E6%AD%A5%E4%B8%BA%E4%B8%AD%E6%99%BA%E8%81%94%E5%90%88%E6%96%87%E7%89%B9%E5%B3%B0%E5%A4%A9%E6%96%87%E9%A1%B9%E7%9B%AE%E5%8A%9E/.*

[257] National Astronomical Observatory of China, "The First National Astronomical Observatory – California Institute of Technology Cooperation Seminar Held and Cooperation Agreement Signed" [第一届国家天文台 – 美国加州理工学院合作研讨会举办并签署合作协议], October 27, 2017. *http://www.bao.ac.cn/xwzx/kydt/201710/t20171027_4879495.html.*

Palomar Observatory in San Diego.[258] In addition, representatives from the institutions agreed at the ceremony to pursue academic exchange programs.[259]

Beyond CAS, PRC universities play a prominent role in China's space-related R&D. Many, including Harbin Institute of Technology and Beihang University (北京航天航空大学), claim to conduct research in support of the PLA and the state. Harbin Institute of Technology's School of Astronautics (哈尔滨工业大学航天学院) states on its official website that it established its first two aerospace majors in satellite engineering and aircraft engineering in 1990 with assistance from the Ministry of Space (now the China National Space Administration) and the China Academy of Space Technology, a subordinate CASC institution.[260] Beijing University of Aeronautics and Astronautics (BUAA) portrays itself as the "leader and backbone" of China's national defense and aerospace industry and also claims to have trained various PLA military leaders throughout its history.[261]

PRC universities conduct "party building work" (党建工作) in their various aerospace-oriented schools to ensure that research is conducted in accordance with Party guidelines. For instance, in October 2018 the Party Branch of the Spacecraft Technology Department at BUAA's School of Astronautics held a meeting focused on "promoting the Party's theoretical knowledge, propaganda, and practice in daily teaching and scientific research."[262]

Space-oriented departments within universities also manage provincial, ministerial, and national-level R&D units. Northwestern Polytechnical University (NWPU; 西北工业大学) claims to oversee two national-level state key laboratories—the State Key Laboratory of Combustion, Thermal Structure and Internal Flow Fields (燃烧、热结构与内流场国家级重点实验室) and the State Key Laboratory of Aerospace Flight Dynamics Technology (陕西省微笑卫星工程实验室)—as well as provincial-level organs like the Shaanxi Provincial Microsatellite Engineering Laboratory. NWPU also appears to conduct space-related R&D for the PLA; NWPU's School of

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[258] National Astronomical Observatory of China, "The First National Astronomical Observatory – California Institute of Technology Cooperation Seminar Held and Cooperation Agreement Signed" [第一届国家天文台 – 美国加州理工学院合作研讨会举办并签署合作协议], October 27, 2017. *http://www.bao.ac.cn/xwzx/kydt/201710/t20171027_4879495.html.*

[259] National Astronomical Observatory of China, "The First National Astronomical Observatory – California Institute of Technology Cooperation Seminar Held and Cooperation Agreement Signed" [第一届国家天文台 – 美国加州理工学院合作研讨会举办并签署合作协议], October 27, 2017. *http://www.bao.ac.cn/xwzx/kydt/201710/t20171027_4879495.html.*

[260] Harbin Institute of Technology School of Astronautics [哈尔滨工业大学航天学院], "College Introduction" [学院简介]. *http://sa.hit.edu.cn/xygk/list.htm.*

[261]Beijing University of Aeronautics and Astronautics [北京航空航天大学], "Today's Aerospace" [今日宇航]. *http://www.sa.buaa.edu.cn/xygk/jryh.htm.*

[262] Beijing University of Aeronautics and Astronautics [北京航空航天大学], "The Party Branch of the Spacecraft Technology Department Held a Branch Party Assembly" [航天飞行器技术系党支部召开支部党员大会], October 18, 2018. *http://www.sa.buaa.edu.cn/info/1043/5536.htm.*

Astronautics directs the Space Attack and Defense Technology Research Center (空间攻对抗技术研究中心).[263]

Cooperation with U.S. Institutions

PRC universities working on space issues also have numerous cooperation agreements, joint programs, and partnerships with foreign universities, organizations, and firms, including in the United States. These partnerships may be leveraged to transfer technology or important knowhow back to the PRC, providing insight into how Beijing circumvents U.S. exclusionary space policies like the Wolf Amendment, including by collaborating with firms that maintain close relationships with NASA. The Wolf Amendment states the following:

> *None of the funds made available by this (House Appropriations) Act may be used for the National Aeronautics and Space Administration (NASA), the Office of Science and Technology (OSTP), or the National Space Council (NSC) to develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company.*[264]

The Wolf Amendment also prohibits the use of appropriations funding for hosting official Chinese visitors at NASA facilities. Limitations imposed by the Wolf Amendment do not apply to activities in which NASA, OSTP, or NSC have consulted with the U.S. Federal Bureau of Investigation (FBI) and ensured that the activities pose no risk of technology, data, or information transfer, and will not involve knowing interactions with officials "determined by the United States to have direct involvement with violations of human rights."[265]

These collaborations and partnerships also allow PRC entities to gain access to and transfer key technology back to China, as well as broadcast PRC policies and standards to worldwide audiences. For example, the Institute of Remote Sensing and Geographic Information Systems (遥感与地理信息系统研究所) at Peking University's School of Earth and Space Sciences (北京大学地球与空间科学学院) has international exchange and cooperation programs with the University of California, Santa Barbara; the University of Maryland; Columbia University; and Clark University; as well as other institutions in the UK and Canada.[266] Nanjing University of Aeronautics and Astronautics (NUAA; 南京航空航天大学) also offers three joint degree programs in avionics,

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[263] Northwestern Polytechnical University School of Astronautics, "Research Institutions" [科研机构], *http://hangtian.nwpu.edu.cn/kyysys/kyjg.htm.*

[264] House Appropriations Bill 2019-2020, 116th Congress, May 2019. *https://appropriations.house.gov/sites/democrats.appropriations.house.gov/files/FY2020%20CJS%20Sub%20Markup%20Draft.pdf.*

[265] House Appropriations Bill 2019-2020, 116th Congress, May 2019. *https://appropriations.house.gov/sites/democrats.appropriations.house.gov/files/FY2020%20CJS%20Sub%20Markup%20Draft.pdf.*

[266] Peking University's School of Earth and Space Sciences [北京大学地球与空间科学学院], "Institute of Remote Sensing and Geographic Information Systems" [遥感与地理信息系统研究所]. *https://sess.pku.edu.cn/xszx/ygydlxxxtyjs/index.htm.*

aviation manufacturing, and aeronautical engineering with City University of London (established in 2011), Australia's Royal Melbourne Institute of Technology (established in 2012), and the UK's Cranfield University (established in 2018).[267]

Additionally, all PRC universities almost certainly participate in MCF research and projects. For instance, in June 2017 the Sichuan Academy of Safety Science and Technology (SCASST; 四川省安全科学技术研究院) published an article stating that representatives from the Sichuan Provincial Defense S&T Industry Office, the CETC 29th Research Institute, CAS' Institute of Remote Sensing and Digital Earth, and Peking University's Institute of Remote Sensing and Geographic Information Systems visited SCASST to conduct a research exchange on the military-civil fusion safety supervision applications. According to the report, SCASST had previously "applied more than 4000 high-resolution satellite images of Sichuan Province, processed 2950 scenes of effective images, and obtained 850 high-resolution image fusion maps" used in several MCF arenas, including "non-coal mines, chemical parks, cultural relics protection, urban security, airports, and highways."[268] SCASST Party Secretary Shi Fuqiang also proposed that in the future, SCASST could apply its imagery technology to 3D laser scanning technology and ground observation technology to create "seamless coverage of multi-source data for risk warning."[269]

Beijing Institute of Technology Partnership with George Washington University: Beijing Institute of Technology's (BIT) Institute of International Law (北京理工大学国家法研究所) is actively working to shape research and promote PRC standards in international space law with George Washington University's (GWU) Elliott School of International Affairs. The two organizations signed a cooperation agreement in September 2013,[270] and GWU currently lists BIT's Institute of Space Law as one of its "proud affiliates," according to the university's official website.[271]

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[267] Nanjing University of Aeronautics and Astronautics, "Sino-Foreign Cooperative Education" [中外合作办学]. *http://iced.nuaa.edu.cn/2019/0619/c10486a160251/page.htm.*

[268] Sichuan Academy of Safety Science and Technology [四川省安全科学技术研究院],"The Provincial Defense Science and Technology Industry Office and Four Departments Jointly Went to the Provincial Academy of Science and Technology Safety to Investigate the High-Scoring SpecialMilitary-CivilFusionSafetySupervisionApplicationDemonstration" [省国防科工办联合部门到省安科院调研高分专项军民融合安监应用示范], June 9, 2017. *http://www.scasst.com/News/Detail/c8ecd4d6-9864-499b-9004-e88becbb45f9.*

[269] Sichuan Academy of Safety Science and Technology [四川省安全科学技术研究院],"The Provincial Defense Science and Technology Industry Office and Four Departments Jointly Went to the Provincial Academy of Science and Technology Safety to Investigate the High-Scoring SpecialMilitary-CivilFusionSafetySupervisionApplicationDemonstration" [省国防科工办联合部门到省安科院调研高分专项军民融合安监应用示范], June 9, 2017. *http://www.scasst.com/News/Detail/c8ecd4d6-9864-499b-9004-e88becbb45f9.*

[270] Beijing Institute of Technology School of Law [北京理工大学法学院], "Our Institute of Space Law and the George Washington University Institute for Space Policy Signed a Cooperation Agreement and Held the US Space Law and Policy Forum" [我校空间法研究所乔治华盛顿大学空间政策研究所签署合作协议举行美国空间法律与政策论坛], January 23, 2016. *http://law.bit.edu.cn/xzzx/gjjl/74698.htm.*

[271] George Washington University Space Policy Institute. "About Us." *https://spi.elliott.gwu.edu/about-us/.*

Through their cooperation agreement, the two universities conduct faculty exchanges and visits and host conferences and symposiums on international space policy and law. In June 2016, the two institutions held a symposium at the University of Vienna titled "Looking to the Future: Changing International Relations and Legal Issues Facing Space Activities." According to BIT, a delegation from the PRC's Ministry of Foreign Affairs (MOFA; 外交部) attended the symposium along with representatives from the UN Office for Outer Space Affairs. BIT Institute of Space Law Secretary-General Zhang Zhenjun gave a keynote speech titled "New Developments in Sino-U.S. Space Legal Relations."[272] Notably, GWU's Space Policy Institute claims to be sponsored by a number of important U.S. defense contractors and federally funded R&D centers, including Aerojet Rocketdyne, Aerospace Corporation, Boeing, L3Harris Technologies, Lockheed Martin, Northrup Grumman, Raytheon, and others.[273]

BIT Partnership with NanoRacks, Connection to Kuang Chi-Duke University Case: U.S.-based NanoRacks has previously collaborated with BIT to deploy PRC technology into space, despite its connections to the U.S. government and access to proprietary space-related information. NanoRacks is located in Houston near NASA's Johnson Space Center.[274] The company was founded in 2009 to provide commercial hardware and services for the International Space Station's (ISS) U.S. National Laboratory as part of the Space Act Agreement with NASA.[275] The company has since grown, having deployed over 700 payloads as of June 2018.[276] In June 2017, NanoRacks announced it had launched and deployed the first-ever Chinese experiment to be brought aboard the ISS, despite regulations limiting Sino-U.S. collaboration in space. According to the official report from NanoRacks, the Chinese experiment came from BIT and was led by Deng Yulin, professor at Georgia Tech's School of Chemical and Biomolecular Engineering(邓玉林).[277] The company claims the project was launched only after approval from the U.S. government, and the BIT NanoLab will remain confined to the NanoRacks platform on the ISS to ensure it can "in no way interface with the ISS or NASA's IT infrastructure and systems."[278]

NanoRacks has collaborated with additional Chinese entities on space-related R&D. In March 2018, the company announced a partnership with Shenzhen-based Kuang-Chi Science Limited (光

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[272] Beijing Institute of Technology School of Law [北京理工大学法学院], "The Institute of Space Law of Our School and the Institute of Space Policy of the George Washington University Jointly Held an International Conference in Vienna" [我校空间法研究所与乔治华盛顿大学空间政策研究所在维也纳联合举办国际会议], June 20, 2016. *http://law.bit.edu.cn/xzzx/gjjl/83855.htm.*

[273] George Washington University Space Policy Institute, "Our Supporters."*https://spi.elliott.gwu.edu/about-us/our-supporters/.*

[274] NanoRacks, "Our Story." *http://nanoracks.com/our-story/.*

[275] NanoRacks, "Our Story." *http://nanoracks.com/our-story/.*

[276] Crunchbase, "NanoRacks." *https://www.crunchbase.com/organization/nanoracks#section-overview.*

[277] NanoRacks, "NanoRacks Prepares Activation of Historic Chinese Research, 25+ Experiments Onboard International Space Station," June 6, 2017. *http://nanoracks.com/nanoracks-launches-historic-chinese-research-25-experiments-to-international-space-station/.*

[278] NanoRacks, "NanoRacks Prepares Activation of Historic Chinese Research, 25+ Experiments Onboard International Space Station," June 6, 2017. *http://nanoracks.com/nanoracks-launches-historic-chinese-research-25-experiments-to-international-space-station/.*

启) to cooperate on Kuang-Chi's Traveler program—the PRC's first near-space commercial platform. Kuang-Chi's Traveler program is likely a dual-use effort in support of not only commercial but also PRC government and PLA priorities. In February 2015, Kuang-Chi entered into a strategic cooperation agreement with the Hunan Space Bureau (068 Base) and CASIC's 7801 Research Institute to collaborate on aerostat R&D and production in near space.[279] This collaboration, in conjunction with Kuang-Chi's commercial "space tourism" platforms, may serve as a vehicle for collecting foreign technology and knowhow, as demonstrated by the company's collaboration with NanoRacks. Specifically, the partnership will focus on the development of Traveler outside of China by leveraging Kuang-Chi's near-space technology and NanoRacks' expertise in in-space business development and customer marketing.[280] In March 2018, Kuang-Chi president and cofounder Liu Ruopeng noted that the Traveler program is being developed to create a "space vehicle that can be used both for scientific research and [to] provide commercial travel to near space."[281]

Established in 2010, Kuang-Chi is regarded highly by the PRC government, as made evident by General Secretary Xi's December 2012 visit to the company's headquarters—his first official visit to a company as leader of China's ruling party.[282] Kuang-Chi is also involved in key PRC strategic initiatives thanks to its position as host and overseer of the State Key Laboratory of Metamaterial Electromagnetic Modulation Technology.[283] The company notes on its website that "state key" denotes "funding or support by the Chinese government."[284]

Separate from its connection to NanoRacks, Kuang-Chi is yet another example of PRC transfer of critical technology and knowhow from the United States to China via PRC recruitment programs. Kuang-Chi was founded by five Chinese scientists who returned to China after receiving advanced degrees from elite institutions in the United States and Europe.[285] The company's origins trace back to a Duke University research lab focused on cutting-edge stealth applications of metamaterials. Liu Ruopeng, often referred to as "China's Elon Musk" in PRC official media,[286]

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[279] 068 Base [068 基地], "068 Base and 7801 Institute Sign Strategic Framework Agreement with Shenzhen KuangChi Space Technology Co., Ltd." [068 基地 7801 所余深圳光启空间技术有限公司签订战略合作框架协议], February 28, 2015. *http://guba.eastmoney.com/news,002625,179107736.html*.

[280] NanoRacks, "Kuang-Chi and NanoRacks Announce Agreement on Near Space 'Traveler' Program," March 22, 2018. *http://nanoracks.com/near-space-traveler-program/*.

[281] NanoRacks, "Kuang-Chi and NanoRacks Announce Agreement on Near Space 'Traveler' Program," March 22, 2018. *http://nanoracks.com/near-space-traveler-program/*.

[282] Kuang-Chi official website, "President Xi Jinping Visits Kuang-Chi," June 3, 2016. *http://www.kuang-chi.com/en/index.php?ac=article&at=read&did=1080.*

[283] Kuang-Chi official website, "The State Key Laboratory of Metamaterial Electromagnetic Modulation Technology," 2016. *http://www.kuang-chi.com/en/index.php?ac=article&at=list&tid=289.*

[284] Kuang-Chi official website, "The State Key Laboratory of Metamaterial Electromagnetic Modulation Technology," 2016. *http://www.kuang-chi.com/en/index.php?ac=article&at=list&tid=289.*

[285] Daniel Golden, *Spy Schools: How the CIA, FBI, and Foreign Intelligence Secretly Exploit America's Universities,* Henry Holt and Company, 2017.

[286] Deng Zhangyu, "Innovator Liu Ruopeng Surges on with Dreams of the Future," *China Daily USA*, July 8, 2016. *http://usa.chinadaily.com.cn/epaper/2016-07/08/content_26016060.htm.*

allegedly arranged meetings with Chinese officials associated with Plan 111—a key PRC talent recruitment program—as a means to transfer the lab's critical technological research back to China.[287]

International Recruitment Programs

The Thousand Talents Program (千人计划) encourages Chinese citizens working in high-tech strategic sectors overseas to return to China and boost the country's S&T innovation capabilities. It has implemented subprograms for both young and non-ethnic Chinese experts (see Figure 3 for an example of a recruited individual).[288] The program is directed by several high-level PRC government and CCP Party organizations, including the PRC Ministry of Education (MOE), the CCP Central Organization Department, the Ministry of Science and Technology (MOST), the State-Owned Assets Supervision and Administration Commission (SASAC), MIIT, the United Front Work Department (UFWD), MOFA, the Ministry of Public Security (MPS), and others, according to the program's official website.[289] The website also states that Thousand Talents awardees receive special benefits, including the title of "National Distinguished Expert" and a guaranteed position at a university, R&D institute, or central state-owned enterprise.[290] Awardees also receive a one-time monetary package of $140,000 (renminbi [RMB] 1 million) "from China's central budget" as well as permanent residence status for them and their families, insurance, housing subsidies, guaranteed admission to schools for their children, job offers for spouses, and other perks.[291] To qualify, individuals must meet the following criteria, according to declassified U.S. intelligence reporting:

- Expert or scholar with full professorship in a prestigious foreign university or research and development institute;
- Technical managerial professional in a senior position at an internationally known company or financial institution; or
- Entrepreneur holding intellectual property rights or key technologies and processes, as well as overseas experience.[292]

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[287] Federal Bureau of Investigation, *Counterintelligence Strategic Partnership Intelligence Note: Chinese Talent Programs*, September 2015. *https://info.publicintelligence.net/FBI-ChineseTalentPrograms.pdf.*
[288] Federal Bureau of Investigation, *Counterintelligence Strategic Partnership Intelligence Note: Chinese Talent Programs*, September 2015. *https://info.publicintelligence.net/FBI-ChineseTalentPrograms.pdf.*
[289] Thousand Talents Program official website, "Thousand Talents Program Introduction" [千人计划介绍]. *http://www.1000plan.org.cn/qrjh/section/2?m=rcrd.*
[290] Thousand Talents Program official website, "The Recruitment Program for Innovative Talents (Long Term)." *http://www.1000plan.org.cn/en/.*
[291] Thousand Talents Program official website, "The Recruitment Program for Innovative Talents (Long Term)." *http://www.1000plan.org.cn/en/.*
[292] Federal Bureau of Investigation, *Counterintelligence Strategic Partnership Intelligence Note: Chinese Talent Programs*, September 2015. *https://info.publicintelligence.net/FBI-ChineseTalentPrograms.pdf.*

Figure 3: Example of Thousand Talents Recruitment

German scientist Sebastian Wandelt[小赛] was recruited by the PRC's Young Thousand Talents Program [青年千人计划] in 2017, according to his biography on his official website. He was a postdoc at Humboldt University of Berlin from 2011 until he was recruited to work at Beihang University, focusing on efficient multimodal transportation engineering. He also works at the State Key Laboratory of Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM), which is housed at Beihang University.

Source: Various.[293]

The 2006 Plan 111 aims to recruit foreign S&T experts and bring them to China to support the enhancement of China's domestic innovation and S&T capabilities. The plan was jointly initiated by the MOE and the State Administration of Foreign Experts.[294] In addition to acquiring overseas talent, Plan 111 also seeks to utilize overseas talent to build world-class universities and S&T disciplines within China's domestic higher education. In line with this plan, the MOE selects domestic Chinese universities to participate based on achievements in specific disciplines; in 2018, MOE selected 62 universities to participate in Plan 111 (see Appendix for a detailed list).[295]

China's Hundred Talents Program (百人计划) is touted as China's first overseas-oriented program for recruiting high-level S&T talent. This program appears to be a more specific precursor to the Thousand Talents Program in that it was exclusively designed for cultivating S&T talent for CAS and focuses on attracting younger individuals.[296] Programs like China's National High-Tech Research and Development Plan (国家高技术研究发展计划) (hereinafter referred to as Plan 863; 863 项目) offer an institutionalized extrabudgetary source of funding for PLA strategic advanced technology initiatives.[297]

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[293] Multi-Modal Mobility Networks (M3Nets) at Beihang University, "Sebastian Wandelt." *http://m3nets.de/group/sw.html*; Research Gate, "Sebastian Wandelt." *https://www.researchgate.net/profile/Sebastian_Wandelt.*

[294] Phoenix Media [凤凰新媒体], "2018 National '111 Plan' Project List Announced, 25 Colleges Selected" [2018 国家 "111 计划" 立项名单公布 25 高校入选], August 8, 2018. *http://tech.ifeng.com/a/20180808/45108928_0.shtml.*

[295] Sina, "62 Colleges and Universities Nationwide Were Selected for the National 111 Plan in 2018" [62 所高校入选 2019 年国家 111 计划], January 23, 2018. *http://edu.sina.com.cn/gaokao/2018-01-23/doc-ifyquptv8808208.shtml.*

[296] Federal Bureau of Investigation, *Counterintelligence Strategic Partnership Intelligence Note: Chinese Talent Programs*, September 2015. *https://info.publicintelligence.net/FBI-ChineseTalentPrograms.pdf.* University of Chinese Academy of Sciences, "The Hundred Talents Program." *http://english.ucas.ac.cn/index.php/join/job-vacancy/2133-the-hundred-talents-program.*

[297] Mark A. Stokes with Dean Cheng, "China's Evolving Space Capabilities: Implications for U.S. Interests," prepared by the Project 2049 Institute for the U.S.-China Economic and Security Review Commission, April 26, 2012.

Table 4: Overview of Chinese Talent Recruitment Programs

Program Name	Date Enacted	Associated Party/Government Body	Description
Plan 863 (863 计划)	1986	MOST	Provides funding to leverage talent within China's domestic university/research system.
Hundred Talents Program(百人计划)	1994	CAS	Aimed at transferring to China U.S. technology embodied in foreign scientists/experts working in foreign universities and businesses.
Plan 111 (111 计划)	2006	MOE	Aimed at recruiting "foreign high-level talents and intelligence" from world-class universities to "serve China's strategic needs."
Thousand Talents Program (千人计划)	2008	MOE	Aimed at recruiting ethnic Chinese experts from foreign universities, research centers, and private companies to enhance China's national capabilities in critical S&T fields.

Source: Various.[298]

PRC Non-State-Owned Space Business

Financing and Investment Vehicles

Beijing utilizes State-Industry Innovation Alliances (SIIAs; 产业创新联盟) as financing and investment vehicles to support its domestic civilian space industry. SIIAs are smaller groups within target sectors that provide a platform for PRC government departments, domestic and international scientific research institutes, academia, Chinese defense industries, SOEs, and private enterprises to interface within China. They also help to facilitate overseas collaboration to promote the rapid development of targeted technological sectors and MCF applications, putting foreign companies at risk of sharing or having key knowhow taken that contributes to PRC strategic—including military—priorities.[299]

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[298] State Administration of Foreign Experts [国家外国专家局] of the Ministry of Education [教育部],*Notice of the State Administration of Foreign Experts of the Ministry of Education on Printing and Distributing the Measures for the Implementation and Management of Disciplinary Innovation and Incentives in Colleges and Universities* [教育部国家外国专家局关于印发《高等学校学科创新引智计划实施与管理办法》的通知], November 9, 2016. *http://www.moe.gov.cn/srcsite/A16/s3340/201611/t20161129_290299.html*; Ministry of Science and Technology of the People's Republic of China, *National High-Tech R&D Program (863 Program)*. *http://www.most.gov.cn/eng/programmes1/200610/t20061009_36225.htm*;University of Chinese Academy of Sciences," The Hundred Talents Program."*http://english.ucas.ac.cn/index.php/join/job-vacancy/2133-the-hundred-talents-program*;Federal Bureau of Investigation, *Counterintelligence Strategic Partnership Intelligence Note: Chinese Talent Programs*, September 2015. *https://info.publicintelligence.net/FBI-ChineseTalentPrograms.pdf*;Thousand Talents Program official website, "Thousand Talents Program Introduction" [千人计划介绍]. *http://www.1000plan.org.cn/qrjh/section/2?m=rcrd.*

[299] Greg Levesque and Mark Stokes, "Blurred Lines: Military-Civil Fusion and the 'Going Out' of China's Defense Industry," *Pointe Bello*, December 2016.

One such SIIA is the China Commercial Small Satellite Industry Innovation Alliance (中国商业小卫星产业创新联盟). This alliance is led by the Ministry of Commerce; Harbin Institute of Technology; several CASC entities, such as Beijing Institute of Space Science and Technology Information; China Space Sat Co.; Xi'an Institute of Space Radio Technology; and others.[300] The alliance claims to have more than 100 members and prioritizes projects in "One Belt, One Road" (OBOR 一带一路) regions.[301] According to official PRC media reporting, the alliance's purpose is to unite domestic and foreign commercial aerospace research institutes as well as private companies and SOEs to "jointly promote the rapid development of China's commercial aerospace and military-civil fusion applications."[302] It also aims to provide support and guidance for emerging players in China's aerospace industry by encouraging private financing companies to invest in newer companies in the aerospace and satellite business.[303] Notably, PLA official media states that the alliance will study and implement the policies, laws, and regulations of the CCP and the PRC government and guide its members—both domestic and foreign—to do so as well.[304] Because the alliance is still fairly young—it was established in July 2018—only limited information about it is available.

Non-CASC/CASIC Launch Vehicle Companies

The following are examples of what the PRC touts as the leaders in its domestic "civilian" or "commercial" launch vehicle industry.[305] Despite this claim, these three companies all have strong ties to the state and CCP. In addition, MIIT's CCID Think Tank claims CASC is China's sole supplier of launch vehicles,[306] suggesting CASC is the primary—if not the exclusive—supplier of materials to PRC commercial launch companies.

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[300] *China Daily*, "China Commercial Small Satellite Industry Innovation Alliance Was Established" [中国商业小卫星产业创新联盟成立], July 12, 2018. *http://cn.chinadaily.com.cn/2018-07/12/content_36562655.htm.*

[301] China Military Network, "China Commercial Small Satellite Industry Innovation Alliance Established" [中国商业小卫星产业创新联盟成立], January 19, 2019. *http://www.81.cn/jfjbmap/content/2018-07/13/content_210835.htm.*

[302] *China Daily*, "China Commercial Small Satellite Industry Innovation Alliance Was Established" [中国商业小卫星产业创新联盟成立], July 12, 2018. *http://cn.chinadaily.com.cn/2018-07/12/content_36562655.htm.*

[303] *China Daily*, "China Commercial Small Satellite Industry Innovation Alliance Was Established" [中国商业小卫星产业创新联盟成立], July 12, 2018. *http://cn.chinadaily.com.cn/2018-07/12/content_36562655.htm.*

[304] *PLA Daily*, "China Commercial Small Satellite Industry Innovation Alliance Was Established" [中国商业小卫星产业创新联盟成立], July 13, 2018. *http://www.81.cn/jfjbmap/content/2018-07/13/content_210835.htm.*

[305] These three companies were cited in a CCID Think Tank [赛迪智库] report entitled "Prospects for China's Commercial Aerospace Development in 2019" [2019 年中国商业航天发展形势展望]. For more information, see CCID Think Tank [赛迪智库], Ministry of Industry and Information Technology, "Prospects for China's Commercial Aerospace Development in 2019" [2019 年中国商业航天发展形势展望], 2019. *http://www.ccidwise.com/uploads/soft/181220/1-1Q220155A4.pdf.*

[306] CCID Think Tank [赛迪智库], Ministry of Industry and Information Technology, "Prospects for China's Commercial Aerospace Development in 2019" [2019 年中国商业航天发展形势展望], 2019. *http://www.ccidwise.com/uploads/soft/181220/1-1Q220155A4.pdf.*

Notably, relevant companies have completed launches at Jiuquan Satellite Launch Center,[307] which is overseen by the PLA. Many of the PRC's allegedly commercial launch vehicle companies operate out of the Beijing Economic Technological Development Zone[308] (hereinafter referred to as E-Town, also called Yizhuang; 亦庄卡还区). Yizhuang is a high-level economic and technological development zone in the city that oversees six smaller parks, including the Military-Civil Fusion Industrial Park.[309] The zone is owned and operated by the Beijing E-Town International Investment and Development Co. (北京亦庄国际投资发展有限公司),[310] which is wholly owned by the State-Owned Assets Supervision Office of the Beijing Economic and Technological Development Zone (北京经济技术开发区国有资产管理办公室).[311]

ExPace: PRC media portrays ExPace (航天科工火箭技术有限公司), also known as the CASIC Rocket Technology Company, as the country's first commercial rocket launch company.[312] The company is better known for its quick-reaction Kuaizhou family of orbital launch vehicles. Its products include smaller solid- and liquid-fueled rocket stages as well as larger versions that were first introduced in March 2018.[313] National People's Congress Deputy and Director of CASIC's Hubei Provincial Science and Technology Committee Hu Shengyun stated that the new Kuaizhou series "is representative of China's work to promote military-civil fusion and develop its commercial aerospace industry."[314] ExPace was jointly founded in February 2016 by CASIC and its subordinate, China Sanjiang Space Group.[315] CASIC is the majority-controlling shareholder.[316]

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[307] CCID Think Tank [赛迪智库], Ministry of Industry and Information Technology, "Prospects for China's Commercial Aerospace Development in 2019" [2019 年中国商业航天发展形势展望], 2019. *http://www.ccidwise.com/uploads/soft/181220/1-1Q220155A4.pdf.*
[308] One Space, "Begin to Pursue the Space Dream, the First Opening Day of One Space's Event Ended Successfully" [逐梦航天创响未来零壹空间首届开放日活动圆满收官], November 9, 2018. *http://www.onespacechina.com/news20181109/.*
[309] City of Beijing, "Beijing Economic Technological Development Area (BDA)," *China Daily*, December 8, 2018. *http://www.chinadaily.com.cn/beijing/2012-12/08/content_15998564.htm.*
[310] Beijing E-Town International Investment and Development Co. [北京亦庄国际投资发展有限公司], "Company Introduction" [公司简介]. *http://www.etowncapital.com/nav/9.html.*
[311] Qichacha [企查查], "Entry for "State-Owned Assets Management Office of the Beijing Economic and Technological Development Zone" [北京经济技术开发区国有资产管理办公室], 2019. *https://www.qichacha.com/firm_g8b11dab6681a21c6a62360640560683.html.*
[312] *Xinhua*, "China's First Commercial Rocket Launch Firm Raises 182 Mln USD," December 19, 2017. *http://www.xinhuanet.com//english/2017-12/19/c_136837164.htm.*
[313] *Xinhua*, "China's 'Kuaizhou No. 11' Rocket Plan Is the First Flight of the Year" [我国 "快舟十一号" 后见计划年内首飞], March 5, 2018. *http://www.xinhuanet.com/politics/2018lh/2018-03/05/c_1122489998.htm.*
[314] *Xinhua*, "China's 'Kuaizhou No. 11' Rocket Plan Is the First Flight of the Year" [我国 "快舟十一号" 后见计划年内首飞], March 5, 2018. *http://www.xinhuanet.com/politics/2018lh/2018-03/05/c_1122489998.htm.*
[315] *Xinhua*, "China's First Commercial Rocket Launch Firm Raises 182 Mln USD," December 19, 2017. *http://www.xinhuanet.com//english/2017-12/19/c_136837164.htm.*
[316] Qichacha [企查查], "Entry for ExPace" [航天科工火箭技术有限公司]. *https://www.qichacha.com/firm_26aa84759d854ac97338ef5660a5006d.html.*

China Sanjiang Space Group (中国三江航天集团) is primarily engaged in solid-fueled ballistic missiles and stealth/counterstealth technology R&D, according to a U.S. think tank report.[317]

One Space: Beijing One Space Technology Co. (hereinafter referred to as One Space; 零壹空间科技集团有限公司) was founded in 2015 by Beihang University alumnus Shu Chang (舒畅), who previously worked for Legend Holdings, the controlling shareholder of Lenovo Group.[318] One Space's business focuses mainly on three sectors: its M-series commercial launch vehicle, its X-series flight test platforms, and electrical and propellant products;[319] however, its products include missile control and measurement control communications, uncrewed aerial vehicle integrated avionics, ground monitoring and control communications, and satellite and microsatellite measurement and control communications.[320] It also aims to enter the commercial small and microsatellite business over the next few years. News outlets within China often tout One Space as China's answer to SpaceX.[321]

Despite its claims to be privately owned, One Space maintains strong connections to both the PRC government and the CCP. In June 2019, One Space established a Communist Party committee, according to official reporting on One Space's website.[322] In 2018, the company also received $46.3 million in Series B financing led by China International Capital Corporation (CICC) Jiatai Equity Fund, a CICC subsidiary whose majority shareholder is the Central Huijin Investment Co. (中央汇金投资有限责任公司),[323] a wholly owned subsidiary of the State Council's China Investment Corporation (中国投资有限责任公司).[324]

LandSpace: LandSpace Technology Corporation (蓝箭航天空间科技股份有限公司), also referred to as Blue Arrow, was founded in 2015 by Tsinghua University MBA alumnus "Roger" Zhang Changwu (张昌武)and Wu Shufan, a former European Space Agency employee and

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317 Mark Stokes, "China's Evolving Conventional Strike Capability," *Project 2049 Institute*, September 14, 2009. *https://project2049.net/2009/09/14/chinas-evolving-conventional-strategic-strike-capability-the-anti-ship-ballistic-missile-challenge-to-u-s-maritime-operations-in-the-western-pacific-and-beyond/.*
318 Deyana Goh, "Interview: One Space CEO on Its Progress, Plans, and China's Space Industry," *Space Tech Asia*, November 7, 2018). *http://www.spacetechasia.com/interview-one-space-ceo-on-its-progress-plans-and-chinas-space-industry/.*
319 One Space, "Introduction to One Space." *http://www.onespacechina.com/en/about/.*
320 One Space, "Electronics." *http://www.onespacechina.com/en/electronics/.*
321 China Daily, "Entrepreneur's Rocket Dream Takes Off, "August 8, 2018. *http://www.chinadaily.com.cn/a/201808/08/WS5b6a305fa310add14f3847bc.html.*
322 One Space, "One Space Group Party Branch and General Branch Officially Established" [零壹空间集团党总支、团总支正式成立], 25 June 25, 2019. *http://www.onespacechina.com/news201900625/.*
323 China International Capital Corporation, "Shareholding Structure of China International Capital Corporation Limited," June 30, 2019. *http://www.cicc.com/portal/relations/stock/structure///156229379941878F16CFEA374EA689C7679982523EBD8.pdf.*
324 Qichacha [企查查], "Entry for Central Huijin Investment Co., Ltd." [中央汇金投资有限责任公司]. *https://www.qichacha.com/firm_210b64792e1e20d8b2cd21a65720e471.html.*

"expert of the National Thousand Talents Program," according to PRC official media.[325] The company's official website states that LandSpace is a "Chinese private aerospace enterprise engaged in the R&D and operation of launch vehicles"[326] and is focused on the development of liquid-fuel rocket engines and low-cost commercial launch vehicles with "independent intellectual property rights."[327]

Non-CASC/CASIC Satellite Companies

Chang Guang Satellite Technology Co: Chang Guang Satellite (CGSTL; 长光卫星技术有限公司), founded in December 2014, claims to be China's first commercial remote sensing satellite company. Its satellites are being used to track foreign military assets; a May 2016 Sina report shows pictures of high-definition (HD) satellite imagery of the Philadelphia Naval Yard taken by Chang Guang's Jilin 1A Satellite (吉林一号光学 A 星) in April of that year.[328]

CGSTL's official website states in vernacular Chinese that its ownership comprises seven shareholding units and 32 people, including CAS' Changchun Institute of Optics, Fine Mechanics, and Physics, in addition to Jilin provincial government small and medium enterprises;[329] however, the company's English-language site states that there are only five shareholding units.[330] CGSTL asserts that the company's main business scope comprises R&D and sales for satellite and UAV systems as well as their components, loading systems, monitoring and tracking systems, and other relevant services.[331] The company's official website also claims that the company maintains an internal CCP Party Committee in charge of "propagandizing and implementing the rules and resolutions of the CCP Central Committee" throughout the organization, according to the company's official Party "Working Rules" (工作规则).[332] CGSTL's Party Committee has also recently won honorary titles from the Changchun Municipal Government in April 2019 and 2017.[333] CGSTL is most well-known for developing the Jilin series of remote sensing satellites.

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[325] *Xinhua*, "Elon Musks of China" [亦庄的马斯克们], June 21, 2018. *http://www.xinhuanet.com/tech/2018-06/21/c_1123012838.htm.*
[326] LandSpace, "About Us." *http://www.landspace.com/site/about.*
[327] LandSpace, "About Us." *http://www.landspace.com/site/about.*
[328] Sina Military [新浪军事], "Chinese Commercial Satellites Captured the US Aircraft Carrier with Suspected Military-Level Precision" [中国商用卫星拍到美航母清晰图军用水平引猜想], May 26, 2016. *http://mil.news.sina.com.cn/china/2016-05-26/doc-ifxsqxxs7647821.shtml.*
[329] For background on CAS's Changchun Institute of Optics, Fine Mechanics, and Physics [中国科学院长春光学精密机械与物理研究所], see Chang Guang Satellite Technology Co., "Company Profile" [企业简介]. *http://charmingglobe.com/about_tw.aspx?id=9.*
[330] Chang Guang Satellite Technology Co., "Profile." *http://charmingglobe.com/EWeb/about_tw.aspx?id=9.*
[331] Chang Guang Satellite Technology Co., "Main Business Scope." *http://charmingglobe.com/EWeb/product1.aspx?id=20&tid=26.*
[332] Chang Guang Satellite Technology Co. official website, "Working Rules" [工作规则]. *http://charmingglobe.com/party1.aspx?id=42.*
[333] Chang Guang Satellite Technology Co., "The Company's Party Committee Won the Honorary Title of 2018 Changchun Non-Public Enterprise and Social Organization Advanced Party Organization" [公司单位荣获 2018 年长春市非公企业合社会组织先进党组织荣誉称号], April 28, 2019.

Jilin No. 1 (吉林一号) was first launched in October 2015 from the Jiuquan Satellite Launch Center.

CGSTL has worked closely with provincial and local governments on the Jilin project, and in 2018 jointly established the $70 million (RMB 500 million) "Jilin Aerospace Information Innovation Venture Capital Fund" (吉林省航天信息创新创业投资基金) with the Jilin provincial government and Changchun municipal government.[334]

A CGSTL media report states that in March 2019 the company provided disaster relief support as part of its China Group on Earth Observations (GEOSS) Disaster Data Response Mechanism, following the January 2019 dam collapse at the Córrego do Feijão iron mine. China GEOSS program coordinator Li Gouging claims that the system is "complementary to the International Charter Space and Major Disasters," and that the system is able to "mobilize high-resolution satellite resources operated by both government institutes and commercial sectors for international emergency response and make the data openly available to the public afterwards."[335] CAS' Institute of Remote Sensing and Digital Earth is also a contributor to this regional initiative.[336]

Beijing PieSat Information Technology Co: Beijing PieSat(北京航天宏图信息技术股份有限公司), founded in 2008, is a Chinese high-tech commercial firm that specializes in remote sensing and satellite technology.[337] The company website states that PieSat independently developed its Pixel Information Expert (PIE) software that can be used for analyzing remote sensing imagery and data using advanced information extraction techniques and artificial intelligence.[338] Its PIE-Map software provides map navigation and geographic information system (GIS) services for the government, army, enterprises, and other clients, according to PieSat's official website.[339] The company also claims that PIE-Map software is compatible with China's Beidou satellite system.[340]

Most notably, PieSat's website states that its "typical customers" (典型客户) include: the National Development and Reform Commission, the Ministry of State Security, the National Administration of State Secrets Protection (国家保密局), CASIC, CASC, the PLA General Staff Department, the PLA Logistics Department, the PLA Navy, the PLA Second Artillery Corps (now

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http://charmingglobe.com/party_view.aspx?id=1640; Chang Guang Satellite Technology Co., "July 2017 Changchun Satellite Technology Co. Ltd. Party Branch Award Notice" [2017 年 7 月长春卫星技术有限公司党支部获奖通知], November 10, 2017. *http://charmingglobe.com/party_view.aspx?id=252.*

334 Chang Guang Satellite Technology Co., "Company Profile" [企业简介]. *http://charmingglobe.com/about_tw.aspx?id=9.*

335 Chang Guang Satellite Technology Co., Ltd., "China GEO Supports Brazil Dam Collapse Disaster Response," March 13, 2019. *http://charmingglobe.com/EWeb/news_view.aspx?id=674.*

336 Chang Guang Satellite Technology Co., Ltd., "China GEO Supports Brazil Dam Collapse Disaster Response," March 13, 2019. *http://charmingglobe.com/EWeb/news_view.aspx?id=674.*

337 PieSat, "About Us." *http://www.piesat.cn/en/About%20us.html.*

338 PieSat, "PIE Product Overview." *http://www.piesat.cn/en/Pie.html.*

339 PieSat, "PIE-Map Product Introduction." *http://www.piesat.cn/en/Piemap.html.*

340 PieSat, PIE-Map Product Functions." *http://www.piesat.cn/en/Piemap.html.*

the PLA Rocket Force), and others.[341] The company's initial public offering (IPO) report states that the company derived part of its income from PLA Unit 61741 in 2016, PLA Unit 61646 in 2017, PLA Unit 61683 in 2017, and the PLA's Army Engineering University in 2018.[342]

PieSat also maintains relationships with U.S. entities. For example, in October 2018PieSat met with faculty from the University of Maryland's (UMD) Department of Geological Sciences to discuss strengthening cooperation with Wuhan University—which the UMD press release claims receives a large donation from PieSat—as well as ways to strengthen UMD's undergraduate study abroad program in China.[343] In addition, in August 2017 a blog run by the Laboratory of Remote Sensing and Hydrometeorology at Florida Atlantic University (FAU) claimed that FAU Geomatics started a partnership with PieSat to develop applications based on the company's PieSat 4.1 software package.[344]

PRC Provision of Satellite Infrastructure, Launch Services Overseas

China has provided launch services to several countries over the past decade. These satellites are launched from either the Xichang Satellite Launch Center in Sichuan Province, the Jiuquan Satellite Launch Center, or the Taiyuan Satellite Launch Center in Shanxi Province, all three of which various PLA units operate and oversee. Satellites are launched using CASC First Academy Long March launch vehicles. In addition to launch services, China has also assisted some countries with their domestic satellite development and manufacturing. Key players in China's aerospace industry—like CASC and its subordinate CGWIC—have contributed significantly to satellite programs in Venezuela, Sri Lanka, Pakistan, and elsewhere (see Table 5 for a more exhaustive list).In many cases, PRC entities appeared to have secured agreements giving them a key role in all phases of joint space programs, from design and financing to launch and subsequent operation of satellites and ground stations, so that they may use what they deem necessary to their own advantage.

Terms and conditions of contracts and agreements between China and other countries regarding ground stations and other space infrastructure appear to vastly benefit Chinese interests. For instance, the terms and conditions of the PRC's agreement with Namibia to set up a telemetry, tracking, and command station for China's Manned Space Program appear to benefit Beijing's interests despite also allegedly being intended to help Namibia develop its own space program. As of 2019, it is unclear whether or not Namibia's space program has benefited from its collaboration

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341 PieSat, "Typical Customers" [典型客户]. *http://www.piesat.cn/alticle/htht_dxkh.html.*
342 Guosen Securities Co., Ltd., "Regarding Beijing PieSat Information Technology Co., Ltd. Initial Public Offering of Shares and Listing on the Board, Reply to the Application Document Review Inquiry Letter" [关于北京航天宏图信息技术股份有限公司首次公开发行股票并在科创板上市，申请文件审核问询函的回复], May 2019. *http://qccdata.qichacha.com/Disclosure/8d405aac9f0a9a92dc236d2be3fc1f0a.pdf.*
343 University of Maryland Department of Geological Sciences, "GEOG Faculty Meet with Representatives from China PIESAT and EMDO US.," October 2018. *https://geog.umd.edu/news/geog-faculty-meet-representatives-china-piesat-and-emdo-us.*
344 Laboratory for Remote Sensing and Hydrometeorology at Florida Atlantic University, "Piesat 4.1 Software," August 29, 2017. *https://faculty.eng.fau.edu/suh/2017/08/29/piesat-4-1-software/.*

with China. Between 2000 and 2012, the Namibian government claimed the station had participated in six space launches run by the China Manned Space Program. However, it was not until 2012 that the two sides signed an additional agreement to facilitate the employment of Namibian citizens at the Swakopmund station, suggesting that assisting Namibia likely was a secondary priority.[345]

For instance, in August 2019 Chinese taikonauts traveled to Namibia at the invitation of Namibian President Hage Geingob for a five-day visit. Although official PRC media reporting from the event mentions the delegation was expected to pay a courtesy call to President Geingob, meet "local middle school learners" at the space tracking, telemetry, and control station, and communicate with students at Namibia University of Science and Technology, it makes no mention of any concrete collaborations that would benefit the Namibian space program.[346] The article also discusses President Geingob's 2018 visit to the Beijing Aerospace Control Center, although it does not specify any details of his visit except his interaction with three unnamed taikonauts.[347]

Sri Lanka's SupremeSat is owned in partnership with China Satellite Communications Co., a subsidiary of CASC, according to SupremeSat's official website.[348] This ownership structure strongly suggests the PRC maintains access to the satellite's data and bandwidth. In addition, at the first signing ceremony for SupremeSat in 2013, China and Sri Lanka also signed a Memorandum of Understanding to cooperate on Beidou expansion in the Indian Ocean region.[349] Specifically, SASTIND reporting claims Sri Lanka and China agreed to collaborate on improving Beidou's commercial operations in the region, including applications in fisheries and transportation.[350] The simultaneous signing of both the SupremeSat and Beidou agreements also suggests SupremeSat is meant to support Beidou's expansion, and, therefore, that the PRC most likely has access to the satellite's data at the very least.

Venezuela has collaborated with CGWIC since 2005. To date, the PRC has built and launched three satellites for Venezuela, with a fourth planned for 2022, according to an article by the China National Administration of GNSS and Applications (CNAGA; 中国卫星导航定位应用管理中

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[345] Republic of Namibia Ministry of Education, Arts and Culture, *Namibia and China Sign an Employment Agreement*, March 29, 2012. *http://www.moe.gov.na/news_article.php?id=60&title=Namibia%20and%20China%20sign%20an%20employment%20agreement.*

[346] *Xinhua*, "Chinese Astronauts Arrive in Namibia for Five-Day Visit," August 21, 2019. *http://www.xinhuanet.com/english/2019-08/21/c_138324264.htm.*

[347] *Xinhua*, "Chinese Astronauts Arrive in Namibia for Five-Day Visit," August 21, 2019. *http://www.xinhuanet.com/english/2019-08/21/c_138324264.htm.*

[348] SupremeSat, "SupremeSat-1." *http://www.supremesat.com/satellites/supremesat-i/.*

[349] *PLA Daily*, "China Will Deliver Communications Radio Satellite to Sri Lanka in Orbit" [中国将向斯里兰卡在轨交付通信广播卫星], October 9, 2013. *http://www.81.cn/jkhc/2013-10/09/content_5573657.htm*.

[350] State Administration of Science, Technology and Industry for National Defense, *Ma Xingrui Participated in the Talks and Signing Ceremony with the Heads of State of China and Sri Lanka* [马兴瑞参加中斯两国元首会谈合签约仪式], May 28, 2013. *http://www.sastind.gov.cn/n142/c11015/content.html*.

心).[351] Venesat-1 was CGWIC's first satellite in-orbit delivery contract signed with a Latin American customer, according to the company's official website.[352] Venezuela first signed a strategic cooperation agreement with CGWIC in November 2005 for Venezuela's communication satellite, Venesat-1. The signing ceremony was attended by former Venezuelan President Hugo Chavez, as well as other high-level officials from CGWIC, the Venezuelan Ministry of Science and Technology, the CNSA, the Chinese Embassy in Venezuela, CASC First Academy, CLTC, and others.[353]

According to the agreement, CGWIC would act as the general contractor for the project, which included undertaking the design, manufacturing, final assembly, testing, and launching tasks for the satellite with unnamed subcontractors.[354] The contract also stipulated that China would deliver relevant ground monitoring and control facilities.[355] Venezuela's VRSS-2 satellite was designed by CASC's China Academy of Space Technology, according to official PRC media reporting.[356] PRC media also states that the project was launched in October 2014 after the Venezuelan government signed an agreement with CGWIC.[357] General Secretary Xi and Venezuelan President Nicolas Maduro were both present at the signing ceremony for VRSS-2, according to official PRC reporting.[358] The Venezuelan government claimed in official reporting that it signed an agreement with the CNSA to exchange data and applications. Mariano Imbert, director of the Bolivarian Agency for Space Activities (ABAE; Agencia Bolivariana para Actividades Espaciales) also stated that, as per the agreement, Venezuela will have access to information from the PRC's GF1 and GF2 satellites, and China will have the ability to view Venezuelan satellite imagery from Chinese territory.[359]

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[351] China National Administration of GNSS and Applications, *Venezuela is Planning to Launch Its Satellites in 2022 with the Help of China's Technology*, September 3, 2019. *http://en.chinabeidou.gov.cn/c/1595.html.*

[352] China Great Wall Industry Corporation, "In-Orbit Delivery: VeneSat-1 Program." *http://www.cgwic.com/CommunicationsSatellite/project.html.*

[353] Embassy of the People's Republic of China in Venezuela, "China and Venezuela Sign Communications Satellite Project Contract" [中国合委内瑞拉签署通信卫星项目合同], 2005. *http://ve.china-embassy.org/chn/smwl/t219347.htm*.

[354] Embassy of the People's Republic of China in Venezuela, "China and Venezuela Sign Communications Satellite Project Contract" [中国合委内瑞拉签署通信卫星项目合同], 2005. *http://ve.china-embassy.org/chn/smwl/t219347.htm*.

[355] Embassy of the People's Republic of China in Venezuela, "China and Venezuela Sign Communications Satellite Project Contract" [中国合委内瑞拉签署通信卫星项目合同], 2005. *http://ve.china-embassy.org/chn/smwl/t219347.htm*.

[356] *China Daily*, "China Launches Second Remote-Sensing Satellite for Venezuela," *China Daily*, October 10, 2017. *http://www.chinadaily.com.cn/china/2017-10/10/content_33058430.htm.*

[357] *China Daily*, "China Launches Second Remote-Sensing Satellite for Venezuela," *China Daily*, October 10, 2017. *http://www.chinadaily.com.cn/china/2017-10/10/content_33058430.htm.*

[358] *People's Daily*, "Signing of the Venezuelan Remote Sensing Satellite Project No. 2" [委内瑞拉遥感卫星二号项目合同签署], October 10, 2014. *http://world.people.com.cn/n1/2016/1223/c409002-28973164.html*.

[359] National Telecommunications Commission [Comisión Nacional de Telecomunicaciones], *Venezuela Moves Towards Satellite Production* [Venezuela caminahacia la producción de satélites], January 12, 2017. *http://www.conatel.gob.ve/venezuela-camina-hacia-la-produccion-de-satelites/.*

China has also established programs with countries like Brazil to collaborate on satellite development and provide launch services. The China-Brazil Earth Resources Program (CBERS) dates back to 1988, and in October 1999 launched the first CBERS satellite, which it claims is utilized for observing and monitoring the earth's resources and environment.[360] CBERS is a joint initiative between CAST[361] and Brazil's National Institute for Space Research (INPE; Instituto Nacional de Pesquisas Espaciais).[362] For CBERS-1 and CBERS-2, China and Brazil agreed to split the over $300 million development costs 70-30, respectively. This agreement was revised in 2002 to have each country cover 50 percent of the costs.[363] In a presentation to the UN Office for Outer Space Affairs, Guo Jianning, director of the China Center for Resource Satellite Data and Application (CRESDA; 中国资源卫星应用中心) discussed his organization's role in the CBERS program.[364] CRESDA's responsibilities include: CBERS application development strategy; design, construction, and operation of CBERS application system; application fields; technologies related to CBERS data; and international cooperation related to CBERS data and applications.[365] In his presentation, Guo states that CRESDA is directed by the PRC's National Development and Reform Commission; CASC; and the Commission of Science, Technology and Industry for National Defense, which later became SASTIND.[366]

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[360] *Xinhua*, "30 Years of Space Cooperation for China and Brazil: Joint Development of 6 Earth Resource Satellites, Providing More than 500,000Units of Remote Sensing Satellite Data" [中国巴西航天合作 30 年：联合研制 6 颗地球资源卫星、提供 50 余万景遥感卫星数据], November 22, 2018. *http://www.xinhuanet.com/politics/2018-11/22/c_1123754544.htm*; European Space Agency's Earth Observation Portal (EO Portal), "CBERS-1 (China-Brazil Earth Resources Satellites) – 1st Generation Satellite Series." *https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cbers-1-2.*

[361] Guo Jianning, "CBERS and Applications, China Aerospace Science and Technology Corporation (CASC)," presentation prepared for United Nations Office of Outer Space Affairs, 2007. *http://www.unoosa.org/pdf/pres/stsc2007/tech-01.pdf.*

[362] European Space Agency, "CBERS: Mission Facts and Figures." *https://earth.esa.int/web/guest/missions/3rd-party-missions/potential-missions/cbers.*

[363]National Institute for Space Research: CBERS," Cooperation Background" [Antecedentes de Cooperação], February 5, 2018. *http://www.cbers.inpe.br/sobre/historia.php.*

[364] Guo Jianning, "CBERS and Applications," presentation for the United Nations Office for Outer Space Affairs, 2007. *http://www.unoosa.org/pdf/pres/stsc2007/tech-01.pdf.*

[365] Guo Jianning, "CBERS and Applications," presentation for the United Nations Office for Outer Space Affairs, 2007. *http://www.unoosa.org/pdf/pres/stsc2007/tech-01.pdf.*

[366] Guo Jianning, "CBERS and Applications," presentation for the United Nations Office for Outer Space Affairs, 2007. *http://www.unoosa.org/pdf/pres/stsc2007/tech-01.pdf.*

Figure 4: CBERS-4 Capabilities

- Power: 2300 W
- Orbit: Sun-synchronous
- Altitude: 778km
- Direct reception at appointed ground stations (Beijing, Guangzhou, Urumqi, Brazil)
- Near-real-time selected data from GEONetCast
- Off-line data distribution from INPE

Source: Various.[367]

In 2010, Argentina's Satellogic agreed to outsource it satellite launches to CGWIC, according to PRC official media.[368] The company also received financial support in 2017 from Chinese internet giant Tencent, which led Satellogic's Series B fundraising efforts.[369] The company claims to have clients in both the government sector as well as in industries such as forestry, agriculture, energy, finance and insurance, cartography, and critical infrastructure management.[370] Regarding government clients, in September 2019 Satellogic announced a partnership with PRC company ABDAS, headquartered in Henan Province. An official press release stated that the agreement will provide ABDAS with access to a fleet of multispectral imagery satellites.[371]

Although little information exists about ABDAS, Satellogic CEO Emiliano Kargieman stated that "the commitment of Henan government to embrace innovations in space technology, aid development, and propel forward the competitiveness of its industry serves as a source of inspiration," suggesting ABDAS is affiliated with the Henan government.[372] The company's products, which include affordable high-resolution satellites and microsatellites, have been

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[367] World Meteorological Organization's Observing Systems Capability Analysis and Review Tool (OSCAR),"Satellites: CBERS-4." *https://www.wmo-sat.info/oscar/satellites/view/29*; Guo Jianning, "CBERS and Applications," presentation for the United Nations Office for Outer Space Affairs, 2007. *http://www.unoosa.org/pdf/pres/stsc2007/tech-01.pdf.*

[368] Joel Richards, "Argentine Satellite Company Outsources Launches to China," *CGTN America*, June 25, 2019. *https://america.cgtn.com/2019/06/25/argentine-satellite-company-outsources-launches-to-china.*

[369] Darrell Etherington, "Satellogic Raises $27M for Affordable, High-Resolution Imaging Satellites," *TechCrunch*, June 23, 2017. *https://techcrunch.com/2017/06/23/satellogic-raises-27m-for-affordable-high-resolution-imaging-satellites/.*

[370] Satellogic, "Custom Solutions for Every Industry." *https://satellogic.com/industries/.*

[371] Satellogic, "Press Release: Satellogic Signs Agreement with ABDAS to Deliver Dedicated Satellite Constellation for Exclusive Geospatial Analytics in Henan Province, China," *PR Newswire*, September 9, 2019. https://markets.businessinsider.com/news/stocks/satellogic-signs-agreement-with-abdas-to-deliver-dedicated-satellite-constellation-for-exclusive-geospatial-analytics-in-henan-province-china-1028508453.

[372] Satellogic, "Press Release: Satellogic Signs Agreement with ABDAS to Deliver Dedicated Satellite Constellation for Exclusive Geospatial Analytics in Henan Province, China," *PR Newswire*, September 9, 2019. *https://markets.businessinsider.com/news/stocks/satellogic-signs-agreement-with-abdas-to-deliver-dedicated-satellite-constellation-for-exclusive-geospatial-analytics-in-henan-province-china-1028508453.*

launched from the Jiuquan Satellite Launch Center.[373] According to Satellogic's website, the company has seven global offices, including one in Beijing.[374]

In January 2019, the company signed an agreement with CGWIC to have it launch 90 satellites on its LM-6 carrier rocket, with the first 13 satellites reportedly being delivered in late 2019; it will be the first use case of anLM-6 rocket for an international customer.[375] Satellogic's founder and CEO noted that once in orbit, the 90 satellites would be able to capture a one-meter resolution image of the world every week. According to a 2019 U.S. Geological Survey report and a Satellogic presentation on the International Telecommunication Union's (ITU) website, Satellogic's Aleph-1 constellation consists of a total of eight multiresolution multispectral satellites that are all sun-synchronous. ÑuSat-1 to -5 satellites were launched between 2016 and early 2018. ÑuSat-6 to -8 were planned for 2018, but it is unclear whether these have already been launched.[376]

In addition, CGWIC's website claims it signed strategic cooperation agreements with the Nigerian government (2004 and 2009), the Pakistani government (2008), the Laotian government (2010), the Bolivian Space Agency (2010), the Belarusian government (2011), and the Algerian government (2013) to cooperate with these countries on satellite development.[377] Official PRC reporting notes that China Development Bank provided a preferential commercial loan to the Bolivian Space Agency to fund their satellite project.[378] CGWIC was chosen for the NigComSat program because Russian and Israeli companies failed to meet contract requirements and U.S. and European companies allegedly questioned the Nigerian government's ability to execute the contract.[379] In April 2019, China and Pakistan strengthened their cooperation in space, signing a cooperation agreement on crewed space missions between CNSA director Hao Chun and Pakistan

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373 Darrell Etherington, "Satellogic Raises $27M for Affordable, High-Resolution Imaging Satellites," *TechCrunch*, June 23, 2017. *https://techcrunch.com/2017/06/23/satellogic-raises-27m-for-affordable-high-resolution-imaging-satellites/.*

374 Satellogic, "Our Offices." *https://satellogic.com/about/.*

375 *Xinhua*, "90 Argentine Satellites to Be Launched in China," January 18, 2019. *http://www.xinhuanet.com/english/2019-01/18/c_137754750.htm*; China Great Wall Industry Corporation, "CGWIC and Argentina's Satellogic Company Signed a Telescope Constellation Launch Service Contract" [长城公司与阿根廷 Satellogic 公司签署遥感星座发射服务合同], January 15, 2019. *http://cn.cgwic.com/news/2019/20190115.html.*

376 Adrian Sinclair, "Commercial Grade Affordable Earth Observation in Real Time," Satellogic presentation to the International Telecommunication Union, 2017. *https://www.itu.int/en/ITU-R/space/workshops/2017-Bariloche/Presentations/30%20-%20Adrian%20Sinclair-%20Satellogic.pdf*; U.S. Geological Survey, *2019 Joint Agency Commercial Imagery Evaluation—Land Remote Sensing Satellite Compendium*,2019. *https://pubs.usgs.gov/circ/1455/cir1455.pdf.*

377 China Great Wall Industry Corporation, "In-Orbit delivery." *http://www.cgwic.com/CommunicationsSatellite/project.html.*

378 People's Republic of China, *China Has Helped Us Achieve the Satellite Dream* [中国帮我们圆了卫星梦],April 7, 2016. *http://www.gov.cn/xinwen/2016-04/07/content_5061830.htm.*

379 Ministry of Commerce of the People's Republic of China, *Nigerian Media Reports on the Launch of Communications Satellites* [尼日利亚媒体关于尼发射通讯卫星的有关报道], May 25, 2007. *http://www.mofcom.gov.cn/aarticle/i/jyjl/k/200705/20070504707894.html.*

Space and Upper Atmosphere Research Commission (SUPARCO) chairman Amer Nadeem.[380] CNSA and SUPARCO are expected to establish a China-Pakistan space committee chaired by top officials from both countries in order to address future collaborations and issues, according to PRC official media.[381]

Table 5: List of Countries That Have Had Satellites Launched in China

Country	Satellite Project Name	Launch Year	Launch Location	Status
Venezuela	Venesat-1*	2008	Xichang	Plan to launch fourth satellite (Guaicaipuro) in 2022.
	Venezuelan Remote Sensing Satellite-1 (VRSS-1)*	2012	Jiuquan	
	Venezuelan Remote Sensing Satellite-2 (VRSS-2)*	2017	Jiuquan	
Nigeria	Nigcomsat-1	2007	Xichang	Two new satellites under development by CGWIC as of Feb 2019.
	Nigcomsat-1R	2011	Xichang	
Bolivia	Tupac Katari (TKSat-1)*	2013	Xichang	Plan to launch second satellite in 2020–2021.
Ecuador	NEE-01 Pegaso	2013	Jiuquan	Last satellite launched by Russia in 2013.
Algeria	Alcomsat-1*	2017	Xichang	Considering launching second satellite under framework of 2020–2040 space program.
Sri Lanka	SupremeSAT-1*	2012	Xichang	Second satellite (SupremeSAT-2) delayed but expected to be launched imminently.
Pakistan	Badr-1	1990	Xichang	Last satellite launched in 2018.
	PakSat-1R*	2011	Xichang	
	Pakistan Remote Sensing Satellite-1 (PRSS-1)	2018	Jiuquan	
	PakTES-1A	2018	Jiuquan	
Indonesia	Palapa-D	2009	Xichang	Last satellite launched in 2017.
	Palapa-N1*	2017	Xichang	
Belarus	Belintersat-1*	2016	Xichang	Last satellite launched in 2016.
Laos	LaoSat-1*	2015	Xichang	Last satellite launched in 2015.
Brazil	CBERS-1*	1999	Taiyuan	Plan to launch CBER-4A during second half of 2019.
	CBERS-2*	2003	Taiyuan	
	CBERS-2B*	2007	Taiyuan	
	CBERS-3*	2013	Taiyuan	
	CBERS-4*	2014	Taiyuan	

* Satellite was developed either partially or fully by PRC entities.
Source: Various.[382]

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[380] *Global Times*, "China and Pakistan Sign Space Exploration Agreement," April 28, 2019. *http://www.globaltimes.cn/content/1147918.shtml.*
[381] *Global Times*, "China and Pakistan Sign Space Exploration Agreement," April 28, 2019. *http://www.globaltimes.cn/content/1147918.shtml.*
[382] China Science Communication [科普中国], China Association for Science and Technology [中国科协]"Successful Launch of the 'Venesat No. 1' Communication Satellite on October 30, 2008" [2008 年 10 月 30

日 ”委内瑞拉一号” 通信卫星成功发射], *Xinhua*, October 30, 2008. *http://www.xinhuanet.com//science/2017-10/30/c_136714183.htm*;Simon Garcia, “Venezuela and China Share Knowledge on Space Cooperation,” Ministerio del Poder Popular para Relaciones Exteriores, March 7, 2019. *http://mppre.gob.ve/en/2019/07/03/venezuela-china-space-cooperation/*;*Xinhua*,“China Launches Remote Sensing Satellite for Venezuela,” October 9, 2017. *http://www.xinhuanet.com/english/2017-10/09/c_136666885.htm*;State Administration of Science, Technology and Industry for National Defense (SASTIND),*China Delivered Venezuela's Satellite Project to Venezuela*[中访问委内瑞拉交付 “委遥二号” 卫星项目], March 23, 2018. *http://www.sastind.gov.cn/n142/c6800277/content.html*; *Xinhua*, “China Launches Remote Sensing Satellite for Venezuela,” October 9, 2017. *http://www.xinhuanet.com/english/2017-10/09/c_136666885.htm*;*People's Daily*, “Secret of ‘Nigcomsat-1'” [“尼日利亚卫星一号“ 密码], May 15, 2007. *http://scitech.people.com.cn/GB/5736151.html*;Adam White, “China Will Remain Main Contractor for Nigerian Satellites,” *Spaceflight News*, February 6, 2019. *https://newsspaceflight.com/china-will-remain-main-contractor-for-nigerian-satellites/*;*People's Daily*, “China Successfully Launched Nigeran Communication Satellite 1R” [我国成功发射尼日利亚通信卫星 1R], December 20, 2011. *http://scitech.people.com.cn/GB/16657000.html*; People's Republic of China, *China Delivers Communications Satellites to Bolivia* [中国向玻利维亚交付通信卫星], April 3, 2014. *http://www.gov.cn/xinwen/2014-04/03/content_2652647.htm*;China Aerospace Science and Technology Corporation (CASC),“China Successfully Developed a Communications Satellite for Bolivia” [中国为玻利维亚研制发射的通信卫星成功定点], January 2, 2014. *http://www.spacechina.com/N25/n2018089/n2018131/c2379819/content.html*;Agencia EFE, “Bolivia Sets Sights on Launching 2ndCommunicationsSatellite,” December 19, 2016. *https://www.efe.com/efe/english/technology/bolivia-sets-sights-on-launching-2nd-communications-satellite/50000267-3129307*; Ministry of Foreign Affairs of the People's Republic of China, *China's Relationship with Ecuador*[中国同厄瓜多尔的关系], March 2019. *https://www.fmprc.gov.cn/chn//gxh/cgb/zcgmzysx/nmz/1206_5/1206x1/t7924.htm*;NASA Space Science Data Coordinated Archive,*NEE-02 Krysaor. https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=NEE02KRY*; China Great Wall Industry Corporation, “In-Orbit Delivery: Alcomsat-1 Program.” *http://www.cgwic.com/CommunicationsSatellite/project.html*; Space Watch Global, “Algeria Considering Second Alcomsat Communications Satellite,” December 2018. *https://spacewatch.global/2018/12/algeria-considering-second-alcomsat-communications-satellite/*; SupremeSAT, “SupremeSAT-1.” *http://www.supremesat.com/satellites/supremesat-i/*; SupremeSAT, “SupremeSAT-2.” *http://www.supremesat.com/satellites/supremesat-ii/*; Pakistan Space & Upper Atmosphere Research Commission,*Badr-1 History*. *http://www.suparco.gov.pk/pages/badr1.asp?badr1linksid=1*; *Jane's by IHS Markit,* “Satellite Ground Station Expansion Shows Pakistan's Reliance on China,” 2019. *https://www.janes.com/images/assets/308/86308/Satellite_ground_station_expansion_shows_Pakistans_reliance_on_China.pdf*; *Xinhua*, “China Successfully Launches Two Pakistani Satellites in ‘One Arrow Two Stars'” [我国 “一箭双星” 成功发射两颗巴基斯坦卫星], July9, 2018. *http://www.xinhuanet.com/politics/2018-07/09/c_1123098481.htm*; China Great Wall Industry Corporation, “In-Orbit Delivery: PakSat-1R Program.” *http://www.cgwic.com/CommunicationsSatellite/project.html*; *Xinhua*, “China Successfully Launches Two Pakistani Satellites in ‘One Arrow Two Stars'” [我国 “一箭双星” 成功发射两颗巴基斯坦卫星], July 9, 2018. *http://www.xinhuanet.com/politics/2018-07/09/c_1123098481.htm*;*Xinhua*, “China's Domestic Communication Satellites Enter the Indonesian Market” [中国国产通信卫星首进印尼市场], May 23, 2017. *http://www.xinhuanet.com/tech/2017-05/23/c_1121016537.htm*; Caleb Henry, “China Great Wall Industry Corp Lands Indonesian Commercial Satellite Order,” *Space News*, May 17, 2017. *https://spacenews.com/china-great-wall-industry-corp-lands-indonesian-commercial-satellite-order/*; *PLA Daily*, “What Is the Significance of China Launching Satellites for Belarus?” [中国为白俄罗斯发射卫星意味着什么？], January 16, 2016. *http://www.81.cn/jmywyl/2016-01/16/content_6859544.htm*; LaoSat, “Satellite Info.” *https://www.laosat.la/en/satellite-info.php*; LaoSat, “Launching of LAOSAT-1.”*http://www.laosat.la/en/news-detail/1-21/Launching-of-LAOSAT-1*; Earth Observation Portal, “CBERS – 1stGeneration.” *https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cbers-1-2*; European Space Agency,

Beidou Achieving Global Reach

The PRC is actively pursuing the "going out" of its indigenous Beidou GNSS, which in December 2018 reached the initial stages of global coverage with the launch of Beidou 3.[383] Based on official Beidou reporting, it appears Beidou will now provide "basic" global coverage, meaning the PRC is still in the process of launching additional satellites to support "full" global coverage by the end of 2020.[384] Beidou "basic" global coverage is currently only available to participating OBOR nations, as the system is still under development.[385] "Basic" coverage is likely being offered only to OBOR countries as part of the Digital Silk Road (DSR; 数字丝绸之路) initiative, which prioritizes satellites and specifically promotes Beidou. In offering Beidou to OBOR partners, the PRC is undoubtedly attempting to gain influence as a regional technological power. Beidou nevertheless is currently being offered free of cost, similar to GPS and other GNSS, so the PRC is likely not gaining as much economically from these deals. However, the PRC is hoping to deploy Beidou as an alternative to U.S. GPS, suggesting it may eventually try to get countries to choose its system over GPS. The Beidou system has a range of dual-use applications, including smart agriculture, land surveying and mapping, autonomous vehicles and drones, storage logistics, airport management, precision-guided munitions, and combat drones.[386]

Beijing has cooperated with the United States, Russia, and the EU[387] on GNSS technology and interoperability throughout Beidou's development.[388] In 2003, China began collaborating with the

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"CBERS: Mission Facts and Figures." *https://earth.esa.int/web/guest/missions/3rd-party-missions/potential-missions/cbers*; *Xinhua*, "China, Brazil to Launch New Earth Resource Satellite Next Year," November 22, 2018. *http://www.xinhuanet.com/english/2018-11/22/c_137624776.htm*; Earth Observation Portal, "CBERS – 3 and 4." *https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cbers-3-4*.

383 Beidou, *The Beidou No.3 Basic System Was Completed and Global Service Launch Meeting Was Held* [北斗三号基本系统建成及提供全球服务情况发布会召开],December 27, 2018. *http://www.beidou.gov.cn/yw/xwzx/201812/t20181227_16864.html*. Also see Beidou, *The BDS-3 Preliminary System Is Completed to Provide Global Services*, December 27, 2018. *http://en.beidou.gov.cn/WHATSNEWS/201812/t20181227_16837.html*.

384 Jiaqing Ma, "Update on Beidou Navigation Satellite System," China Satellite Navigation System Office for the 13th Meeting of the International Committee on Global Navigation Satellite Systems, November 4, 2018. *http://www.unoosa.org/documents/pdf/icg/2018/icg13/01.pdf*.

385 Jiaqing Ma, "Update on Beidou Navigation Satellite System," China Satellite Navigation System Office for the 13th Meeting of the International Committee on Global Navigation Satellite Systems, November 4, 2018. *http://www.unoosa.org/documents/pdf/icg/2018/icg13/01.pdf*.

386 Beidou, *Beidou Satellite Navigation System Application Case Studies* [北斗卫星导航系统应用案例],December 2018. *http://www.beidou.gov.cn/xt/gfxz/201812/P020181227583462913294.pdf*; Yang Sheng, "Combat Drones Get Star Billing at Airshow as China Moves Closer to US Capability in Drone Design, Production," *Global Times*, November 4, 2018. *http://www.globaltimes.cn/content/1125864.shtml*; Sina Military, "Is Beidou Mature Enough to Be Used by the Chinese Military? In Actual Combat, Its Hit Rate Is Over 97%, Indicating It Is [中国军用北斗是否成熟？实战中命中率超 97%说明一切]," February 25, 2017. *http://mil.news.sina.com.cn/jssd/2017-02-25/doc-ifyavvsh6571217.shtml*.

387 United Nations Office for Outer Space Affairs, "Global Navigation Satellite Systems (GNSS)." *http://www.unoosa.org/oosa/en/ourwork/psa/gnss/gnss.html*.

388 Beidou, *Beidou Satellite Navigation System Development Report, Version 3* [北斗卫星导航系统发展报告（3.0版）],December 2018. *http://www.beidou.gov.cn/xt/gfxz/201812/P020181227529525428336.pdf.*

EU to develop both Beidou and the EU's Galileo Satellite System;[389] in 2003, the two signed strategic cooperation agreements to share Beidou's technology with European developers in exchange for access to Galileo technology as the system matured.[390] The following year, the United States and EU resolved lengthy negotiations on satellite R&D and interoperability, although the United States had allegedly expressed reservations about the EU's engagement policy toward the PRC and what it viewed as an inefficient export control system.[391] Analysis by the EU's Institute for Strategic Studies assesses that the U.S.'s move to subject satellite technology to International Traffic in Arms Regulations (ITAR) in the 1990s effectively blocked the Chinese market from Western launches and applicable technologies and pushed the PRC closer to the EU at a time when bilateral relationships between the two countries were already booming.[392] Attempts by U.S. policymakers to hinder China from acquiring satellite technology from the West arguably failed, as demonstrated by the April 2005 launch of the APSTAR VI communications satellite aboard a Chinese Long March rocket from Thales Alenia Space (then referred to as Alcatel Alenia Space) in Cannes, France.[393] Collaborations and sales of dual-use technology between PRC and EU entities during this period likely resulted in technology transfers that led to major advancements in the development of the Beidou system and the PRC's ASAT weaponry.[394]

The PRC and Russia have maintained a strong collaborative relationship on the mutual development of their respective GNSSs. First launched in 1982, Russia's Global Navigation Satellite System (GLONASS) is currently one of four GNSS "core providers," according to the UN's International Committee on Global Navigation Satellite Systems (ICG).[395] Over the past decade, China and Russia have entered into several cooperation initiatives aimed at improving interoperability of their two systems and finding new applications. Many of these initiatives have come out of the China-Russia Committee on Important Strategic Cooperation(中俄卫星导航重大战略合作项目委员会), including the Service Platform of Chinese-Russian Satellite Navigation Monitoring and Assessment, the Joint Demonstrations on Beidou and GLONASS-Based Cross-

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[389] Jose Carlos Matias, "E.U.-China Partnership on the Galileo Satellite System: Competing with the U.S. in Space," *Asia-Pacific Journal*5:7July 3, 2007. *https://apjjf.org/-Jose-Carlos-Matias/2473/article.pdf.*
[390] David Lague, "Special Report: In Satellite Tech Race, China Hitched a Ride from Europe," *Reuters*, December 22, 2013. *https://www.reuters.com/article/breakout-beidou/special-report-in-satellite-tech-race-china-hitched-a-ride-from-europe-idUSL4N0JJ0J320131222.*
[391] May-Britt U. Stumbaum, "Risky Business? The EU, China and Dual-Use Technology," *European Union Institute for Security Studies* Occasional Paper 80, October 2009. *https://www.iss.europa.eu/sites/default/files/EUISSFiles/op80.pdf.*
[392] Christopher J. Griffin and Joseph Lin, "China's Space Ambitions," *Armed Forces Journal* rehosted by the American Enterprise Institute, April 7, 2008. *https://www.aei.org/articles/chinas-space-ambitions/.*
[393] Christopher J. Griffin and Joseph Lin, "China's Space Ambitions," *Armed Forces Journal* rehosted by the American Enterprise Institute, April 7, 2008. *https://www.aei.org/articles/chinas-space-ambitions/.*
[394] May-Britt U. Stumbaum, "Risky Business? The EU, China and Dual-Use Technology," *European Union Institute for Security Studies* Occasional Paper 80, October 2009. *https://www.iss.europa.eu/sites/default/files/EUISSFiles/op80.pdf.*
[395] The other three "core providers" are the United States, the EU, and China. For more information, see United Nations Office for Outer Space Affairs, "International Committee on Global Navigation Satellite Systems (ICG): Members." *http://www.unoosa.org/oosa/en/ourwork/icg/members.html.*

Border Transporters, the Joint Design Center of Chinese-Russian Navigation Chips, and others.[396] The China-Russia Committee on Important Strategic Cooperation held its fifth meeting in September 2018 and expects to continue collaborating throughout 2019, according to a China Navigation Satellite Committee presentation for the UN Office of Outer Space Affairs (UNOOSA).[397]

The PRC has repeatedly highlighted U.S.-China cooperation on bilateral frequency coordination agreements at almost every annual presentation to the ICG.[398] In addition, in December 2017 the Office of Space and Advanced Technology at the U.S. Department of State, alongside the China Satellite Navigation Office, reportedly jointly established the U.S.-China Civil GNSS Cooperation Dialogue, aimed at promoting cooperation between the U.S. GPS and China's Beidou.[399] The two sides also signed the Joint Statement on Civil Signal Compatibility and Interoperability between the GPS and the Beidou Navigation Satellite System.[400] This agreement likely came in response to incentives on the part of the UN to encourage compatibility and interoperability among global and regional GNSS through organizations such as UNOOSA and the ICG.[401]

As of 2019, Beidou has been deployed in Indonesia, Kuwait, Uganda, Myanmar, Maldives, Singapore, Laos, Cambodia, Thailand, Pakistan, and Russia, demonstrating China's increased willingness to share access to its homegrown satellite system.[402] In an interview with the *South China Morning Post*, a Beidou expert from Wuhan University who took part in the Beidou negotiations with Thailand stated that the Chinese government "is eager to show the Thais that

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396 China Satellite Navigation Office, "Operation and Development of Beidou Navigation Satellite System," presentation for the United Nations Office for Outer Space Affairs, 2017. *http://www.unoosa.org/documents/pdf/copuos/2017/copuos2017tech06E.pdf*.

397 Jiaqing Ma, "Update on Beidou Navigation Satellite System," China Satellite Navigation System Office for the 13th Meeting of the International Committee on Global Navigation Satellite Systems, November 4, 2018. *http://www.unoosa.org/documents/pdf/icg/2018/icg13/01.pdf*.

398 Reference to Sino-U.S. satellite cooperation can be seen as early as 2012. For example, see China Satellite Navigation Office, "Development of the Beidou Navigation Satellite System," presentation for the Seventh Meeting of the International Committee on GNSS, November 5, 2012. *http://www.unoosa.org/pdf/icg/2012/icg-7/1.pdf*. It was also mentioned at the latest ICG meeting in November 2018.Jiaqing Ma, "Update on Beidou Navigation Satellite System," China Satellite Navigation System Office for the 13th Meeting of the International Committee on Global Navigation Satellite Systems, November 4, 2018. *http://www.unoosa.org/documents/pdf/icg/2018/icg13/01.pdf*.

399 Global Positioning System, *Joint Statement on Civil Signal Compatibility and Interoperability between the Global Positioning System (GPS) and the Beidou Navigation Satellite System (BDS)*,December 4, 2017. *https://www.gps.gov/policy/cooperation/china/2017-joint-statement/*.

400 Global Positioning System, *Joint Statement on Civil Signal Compatibility and Interoperability between the Global Positioning System (GPS) and the Beidou Navigation Satellite System (BDS)*, December 4, 2017. *https://www.gps.gov/policy/cooperation/china/2017-joint-statement/;* Beidou, *Beidou and GPS Signal Compatibility and Interoperability Joint Statement* [北斗与 GPS 信号兼容与互操作联合声明], December 9, 2017. *http://www.beidou.gov.cn/zt/gjhz/201712/t20171223_10893.html*.

401 Jeffrey Auerbach, "U.S. GPS Civil Service and International GNSS Activities Update," *U.S. Department of State Office of Space and Advanced Technology* rehosted by the United Nations Office for Outer Space Affairs, 24–28 June 2019. *http://www.unoosa.org/documents/pdf/psa/activities/2019/UN_Fiji_2019/S1-01.pdf*.

402 Beidou, *Beidou Satellite Navigation System Application Case Studies* [北斗卫星导航系统应用案例],December 2018. *http://www.beidou.gov.cn/xt/gfxz/201812/P020181227583462913294.pdf*.

Beidou can do anything GPS does, and in some areas, it can do better."[403] The researcher is also quoted as having claimed that "if Thailand can embrace Beidou, other countries may follow and the Americans' political, economic, and military power in the region will be reduced."[404] As part of the Beidou agreement with Thailand, Wuhan Optics Valley Beidou Holding Group established the first batch of three overseas Continuously Operating Reference Stations (CORS) in Thailand's Chonburi Province in December 2013 to improve Beidou networking.[405] Wuhan Optics Valley Beidou also plans to build a CORS overseas station in Sri Lanka, according to official PRC media reporting.[406]

Pakistan was the first nation to deploy Beidou. As of 2018, the system was undergoing trial operations in Karachi.[407] During a May 2014 visit to China, a representative from the Pakistan Space and Upper Atmosphere Research Commission stated that Beidou had successfully been applied to Pakistani urban management programs to assist with the urbanization process and allocation of resources.[408] He also stated that Beidou had improved agricultural production efficiency and reduced waste.[409] Beyond Pakistan, the China-Arab Beidou/GNSS Center was also inaugurated in Tunisia in April 2018. Beijing Unistrong promotes Beidou through training and R&D cooperation. Participating countries include Algeria, Iraq, Kuwait, Oman, Nigeria, and Sudan.[410]

Role in Overseas Tracking Stations

The PRC is also expanding its space R&D capabilities globally through the establishment of foreign space tracking and downlink stations overseas. As of 2019, the PRC had established four of these stations in various strategic regions around the world, sometimes in collaboration with host nations, to improve its capacity. Notably, a number of these locations are being utilized by

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403 Stephen Chen, "Thailand Is Beidou Navigation Network's First Overseas Client," *South China Morning Post*, April 4, 2013. ***https://www.scmp.com/news/china/article/1206567/thailand-beidou-navigation-networks-first-overseas-client.***

404 Stephen Chen, "Thailand Is Beidou Navigation Network's First Overseas Client," *South China Morning Post*, April 4, 2013. ***https://www.scmp.com/news/china/article/1206567/thailand-beidou-navigation-networks-first-overseas-client.***

405 *Xinhua*, "China's Beidou System to Expand Cooperation in SE Asia," *China Daily,* April 1, 2017. ***http://www.chinadaily.com.cn/china/2017-04/01/content_28774844.htm.***

406 *Xinhua*, "China's Beidou System to Expand Cooperation in SE Asia," *China Daily,* April 1, 2017. ***http://www.chinadaily.com.cn/china/2017-04/01/content_28774844.htm.***

407 *Xinhua*, "China's Domestic Navigation System Guides Pakistan," *People's Daily*, May 23, 2014. *http://en.people.cn/n/2014/0523/c202936-8731568.html*.

408 Beidou, *Syed Zahid Jamal: Introduction to Beidou in Pakistan* [Syed Zahid Jamal: 北斗在巴基斯坦应用情况介绍], May 22, 2014. ***http://www.beidou.gov.cn/zt/dhnh/dwjzgwxdhshnh/gdxw1/201712/t20171210_12585.html***.

409 Beidou, *Syed Zahid Jamal: Introduction to Beidou in Pakistan* [Syed Zahid Jamal: 北斗在巴基斯坦应用情况介绍], May 22, 2014. ***http://www.beidou.gov.cn/zt/dhnh/dwjzgwxdhshnh/gdxw1/201712/t20171210_12585.html***.

410 Beidou, *The First Overseas Beidou Center Was Completed and Operated to Help China-Arab Satellite Navigation Cooperation* [首个海外北斗中心落成运行，助力中阿卫星导航合作],April 10, 2018. ***http://www.beidou.gov.cn/zt/gjhz/201804/t20180411_14353.html***;Beijing Unistrong, "Beijing Unistrong Fully Supports the Construction of the First Overseas Beidou Center to Help Beidou Go to the World [合众思壮权力支持首个海外北斗中心建设助力北斗走向世界]," April 13, 2018. *http://www.unistrong.com/news/NewsShow_2700.aspx*.

entities with connections to the PLA; for example, the PLASSF's China Satellite Launch and Tracking Control General manages the Patagonia Telemetry Tracking and Command Station located in Argentina's Neuquén Province.[411] The Patagonia Station—referred to as the CLTC Station, according to the Argentine government[412]—was first announced in 2014 and construction was completed in 2017.[413]

PRC media claims China's tracking station in Kiruna, Sweden, is the PRC's first wholly owned overseas satellite ground station, whereas other ground stations are the products of joint ventures.[414] The ground station equipment in Kiruna was built and delivered in December 2016 by Space Star Technology Co., Ltd., (航天恒星科技有限公司)[415] otherwise known as the CASC Fifth Academy (CAST) 503 Institute. Official PRC reporting states that the station's location in Kiruna is ideal for remote sensing satellite data reception and will allow the PRC to acquire global data and respond to user application requirements more efficiently.[416] Hong Kong media claim that no official representatives from the Swedish government attended the Kiruna station's opening ceremony; however, Leif Osterbo, president of the Swedish Space Corporation's (SSC) Satellite Management Services Division, was in attendance. Notably, SSC co-owns Australia's Dongara satellite ground station with a U.S. subsidiary that assists the U.S. military, and this station was leased to CLTC in 2011.[417]

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[411] Argentina Ministry of Education, Culture, Science and Technology's National Commission of Space Activities [Comisión Nacional de Actividades Espaciales del Ministerio de Educación, Cultura, Ciencia y Tecnología], *Background* [Antecedentes]. *https://www.argentina.gob.ar/ciencia/conae/centros-y-estaciones/antecedentes-1*.

[412] Argentina Ministry of Education, Culture, Science and Technology's National Commission of Space Activities [Comisión Nacional de Actividades Espaciales del Ministerio de Educación, Cultura, Ciencia y Tecnología], *Background* [Antecedentes]. *https://www.argentina.gob.ar/ciencia/conae/centros-y-estaciones/antecedentes-1*.

[413] *People's Daily*, "China Will Build a Satellite Tracking Station in Argentina, Foreign Media Call It Intelligence Cooperation" [中国将在阿根廷建卫星跟踪站外媒体称或情报合作], February 27, 2015. *http://military.people.com.cn/n/2015/0227/c1011-26604126.html*; Victor Robert Lee, "China Builds Space-Monitoring Base in the Americas," *Diplomat*, May 24, 2016. *https://thediplomat.com/2016/05/china-builds-space-monitoring-base-in-the-americas/*; Ernesto Londoño, "From Economic Aid to Space Programs, China Has 'Landed' in Latin America" [从经济援助到太空计划，中国 "登陆" 拉丁美洲], *New York Times* (China Edition) [纽约时报中文网]. *https://cn.nytimes.com/world/20180730/china-latin-america/*.

[414] Stephen Chen, "China Launches Its First Fully Owned Overseas Satellite Ground Station near North Pole," *South China Morning Post*, December 16, 2016. *https://www.scmp.com/news/china/policies-politics/article/2055224/china-launches-its-first-fully-owned-overseas-satellite*.

[415] China Academy of Space Technology, "Press Release: China Aerospace Science and Technology Group's Space Star Technology Company Delivered High-Scoring Arctic Receiving Station Project" [航天科技集团所属航天恒星公司民用高分北极接受站项目交付], *State-Owned Assets Supervision and Administration Commission of the State Council*, December 21, 2016. *http://www.sasac.gov.cn/n2588025/n2588124/c3835088/content.html*.

[416] Cheng Yingqi, "China's Overseas Remote Sensing Satellite Station Starts Operation," *China Daily*, December 16, 2019. *http://www.chinadaily.com.cn/china/2016-12/16/content_27687937.htm*.

[417] *NASA Cybersecurity: An Examination of the Agency's Information Security*, Hearing before the Subcommittee on Investigations and Oversight, Committee on Science, Space and Technology of the House of Representatives, February 29, 2012. *https://www.govinfo.gov/content/pkg/CHRG-112hhrg72919/html/CHRG-112hhrg72919.htm*. Linda Reynolds and Mike Nahan, "Submission," *Review of Australia's Space Industry Capability,* August 2017. *https://consult.industry.gov.au/space-activities/review-of-australian-space-industry-capability/consultation/download_public_attachment?sqId=question.2017-07-27.4002791506-publishablefilesubquestion&uuId=1025203759*.

The PRC also previously owned a space tracking station on Kiribati's South Tarawa Island. Anecdotal reporting claims that the station, managed by CLTC, was used to monitor U.S. missile testing in the Marshall Islands; however, the station closed in 2003 following Kiribati's decision to sever ties with Beijing and recognize Taiwan.[418] After 16 years, Kiribati announced in September 2019 that it was switching its diplomatic recognition back to the PRC over Taiwan. International media reports have speculated that the station will be reopened, but no official statement has been made by Beijing or the government of Kiribati to that effect.[419]

Figure 5: Chinese Space Tracking Station in Kiribati

Source: Liu Zhen, "Could Ties with Kiribati Be a Boost to China's Space Ambitions?" *South China Morning Post*, September 21, 2019.

It is likely that the data collected at Chinese overseas ground stations is subject to the PRC's National Cybersecurity Law. The law stipulates that "critical information infrastructure operators that gather or produce personal information or important data during operations" outside of mainland China may be required to store that information within China where the PRC deems it "truly necessary for business requirements."[420]

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418 GlobalSecurity.org, "Kiribati – PRC Ground Station."*https://www.globalsecurity.org/space/world/china/kiribati.htm.*

419 *Reuters*, "China Sees Kiribati Ties Soon, No Word on Space Tracking Station," September 23, 2019. *https://www.reuters.com/article/us-china-kiribati/china-sees-kiribati-ties-soon-no-word-on-space-tracking-station-idUSKBN1W80VG.*

420 Rogier Creemers, Paul Triolo, and Graham Webster, "Translation: Cybersecurity Law of the People's Republic of China [Effective June 1, 2017]," *New America*, June 29, 2018. *https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-cybersecurity-law-peoples-republic-china/.*

Table 6: Chinese Overseas Tracking/Ground Stations

Location	Date Established	Chinese Operator	Local Partner
Dongara, Australia	2011	China Satellite Launch and Tracking Control General (CLTC)	Swedish Space Corporation
Swakopmund, Namibia	2000	China Manned Space Engineering Office (overseen by CMSP)	Ministry of Education of Namibia
Neuquén, Argentina	2014	China Satellite Launch and Tracking Control General (CLTC)	Comisión Nacional de Actividades Espaciales (CONAE)
Kiruna, Sweden	2016	CAS	Swedish Space Corporation

Source: Various.[421]

Leveraging Foreign Technology and Knowhow

Examples of potential U.S. export control violations are hard to identify with certainty. However, within the space field, the PRC appears to have found ways around export limitations such as the Wolf Amendment, including through academic and international collaborations and partnerships (as covered previously in this section) as well as acquisitions and Hong Kong-domiciled companies covered below. These efforts almost certainly have allowed the PRC to secure knowhow and technology critical to the PRC's space program development, including Beidou.

Large PRC SOEs are working to incorporate foreign knowhow and technology via strategic mergers and acquisitions and strategic cooperation agreements. Through these ventures, PRC companies gain necessary technologies and knowhow by transferring this information back to China to benefit Beijing's domestic R&D efforts in strategic S&T fields. The Aviation Industry Corporation of China (AVIC), a key state-owned aerospace company, provides a useful case study. Additionally, cases involving AVIC are applicable to space due to the PRC's history of targeting seemingly unrelated or innocuous aspects of various high-tech supply chains in order to gain access to key technology that may be applied in other instances.

In September 2010, AVIC entered into a strategic cooperation agreement with U.S. Aerospace Inc., a leading U.S. defense contractor. According to the official press release, under the agreement U.S.

[421] Sina Military News [新浪军事],"Western Australia Satellite Station Opened, Managed by a Swedish Company" [澳洲西部卫星跟踪站向中国开放由瑞典公司管理], December 1, 2011. *http://mil.news.sina.com.cn/2011-12-01/1443675831.html*;Republic of Namibia Ministry of Education, Arts and Culture, *Namibia and China Sign an Employment Agreement*, March 29, 2012. *http://www.moe.gov.na/news_article.php?id=60&title=Namibia%20and%20China%20sign%20an%20employment%20agreement*; Ernesto Londoño, "From Economic Aid to Space Programs, China Has 'Landed' in Latin America" [从经济援助到太空计划，中国 "登陆" 拉丁美洲], *New York Times* (China Edition) [纽约时报中文网], July 30, 2018. *https://cn.nytimes.com/world/20180730/china-latin-america/*; Chinese Academy of Sciences Institute of Remote Sensing and Digital Earth [中国科学院遥感与数字地球研究所],"China's First Overseas Terrestrial Satellite Receiving Station Put into Trial Operation" [我国首个海外陆地卫星接收站投入试运行], December 15, 2016. *http://www.radi.ac.cn/dtxw/rdxw/201612/t20161215_4722293.html.*

Aerospace will provide AVIC with potential projects on which the parties can jointly bid, or specifications for aircraft components to be manufactured by AVIC.[422] The agreement also stipulates that AVIC will supply all personnel, materials, facilities, and other resources necessary.[423] U.S. court documents state that U.S. Aerospace filed for bankruptcy in August 2017 after failing to secure contracts, including one joint bid to work with AVIC on VXX, the new Marine One helicopter program.[424] The company also cited issues related to disputes with lenders, an inability to close acquisitions and obtain significant financing, limited liquidity and capital resources, and an anticipated company reorganization.

In March 2015, AVIC also acquired Align Aerospace, a California-based company that provides supply chain services for the aerospace industries in North America, Europe, and Asia,[425] after receiving approval from the Committee on Foreign Investment in the United States (CFIUS).[426] Since being acquired by AVIC, Align has formed partnerships with other firms operating in the defense technology sector in the United States. For instance, in 2015 Align announced a long-term agreement with Pennsylvania-based Triumph Group Inc. (TGI) to support TGI's global efforts.[427] TGI has collaborated with leading U.S. defense contractors on platforms such as Lockheed Martin's F-35 and F-16, as well as Northrop Grumman's MQ-4C and RQ-4 remotely piloted vehicles,[428] which are used by the U.S. Navy[429] and U.S. Air Force,[430] respectively.

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[422] *Business Wire*, "U.S. Aerospace, Inc. and AVIC International Holding Corporation Enter into Strategic Cooperation Agreement," September 20, 2010. *https://www.businesswire.com/news/home/20100920006106/en/U.S.-Aerospace-AVIC-International-Holding-Corporation-Enter.*

[423] *Business Wire*, "U.S. Aerospace, Inc. and AVIC International Holding Corporation Enter into Strategic Cooperation Agreement," September 20, 2010. *https://www.businesswire.com/news/home/20100920006106/en/U.S.-Aerospace-AVIC-International-Holding-Corporation-Enter.*

[424] United States Bankruptcy Court for the District of Delaware, "Declaration of Robert Craig in Support of Chapter 11 Petition in re: USAE, LLC," October 21, 2017. *https://www.csbankruptcyblog.com/wp-content/blogs.dir/375/files/sites/55/2017/08/First-Day-Declaration-1.pdf.*

[425] Align Aerospace, "Press Release: AVIC International Expands Commercial Aerospace Services Portfolio with the Acquisition of Align Aerospace," March 2015. *http://alignaero.com/wp-content/uploads/2016/01/PRESS-RELEASE_Avic_3-31-15.pdf*

[426] Align Aerospace, "Press Release: AVIC International Expands Commercial Aerospace Services Portfolio with the Acquisition of Align Aerospace," December 5, 2014. *https://alignaero.com/wp-content/uploads/2016/01/PRESS-RELEASE_AVIC.pdf*; Covington & Bruling LLP, "CFIUS Representative Matters: $200 Million Acquisition of Align Aerospace."*https://www.cov.com/en/practices-and-industries/practices/regulatory-and-public-policy/cfius?r=%7B162A8E92-C52D-4E01-B087-0EE9EB39697D%7D.*

[427] Align Aerospace, "Align Aerospace Announces Long Term Agreement with Triumph Group, Inc.," *PR Newswire*, November 24, 2015. *https://www.prnewswire.com/news-releases/align-aerospace-announces-long-term-agreement-with-triumph-group-inc-300184280.html.*

[428] Triumph Group Inc., "Markets We Serve." *https://www.triumphgroup.com/what-we-do/markets-we-serve/#military.*

[429] United States Navy, *Fact File: MQ-4C Triton*. *https://www.navy.mil/navydata/fact_display.asp?cid=4350&tid=500&ct=4.*

[430] U.S. Air Force, *Fact Sheet: RQ-4 Global Hawk*, October 27, 2014. *https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104516/rq-4-global-hawk/.*

Similarly, in May 2016 AVIC acquired AIM Altitude, a UK-based engineering, design, and manufacturing firm focused on cabin interiors. In addition to providing services to commercial airlines like Boeing and Airbus, the AIM Altitude website claims it is a leading supplier of cabin interiors for the UK Ministry of Defense.[431] Three AVIC officials assumed leadership of AIM Altitude's Board of Directors following the acquisition: Xu Tongyu, president of AVIC International; Liu Zhonghua, CFO of AVIC International; and Huang Jun, AVIC International's director of Supply Chain Management and Procurement.[432]

In addition to AVIC, PRC development of its indigenous atomic clock provides insight into the PRC's significant reliance on foreign knowhow and technology for its domestic space program, as evidence suggests China would not have succeeded in developing indigenous atomic clocks without purchasing necessary technology from overseas. Beijing has long viewed the development of atomic clocks as a key challenge to advancing its Beidou system and has pushed to achieve this goal since the December 2018 launch of Beidou 3. Authoritative PRC S&T sources have often referred to atomic clocks as the "heart" of navigation satellites and also a key stumbling block to Beidou's development.[433] Beidou chief designer Yang Changfeng claimed in 2017 that the addition of atomic clocks would play a vital role in improving the system's positioning accuracy.[434]

In line with this goal, the PRC appears to have purchased atomic clocks from Swiss-based Orolia Group subsidiary, Spectratime, and used these to develop its own domestic version. Orolia Group's 2010 IPO announcement states that the company entered into export contracts with China as recently as 2008—contracts that Orolia Group claims required a political risk guarantee from Swiss insurance firm Coface.[435] A 2017 promotional article for CASIC's 203 Institute boasts of its ultimate success following "14 years of struggle on the atomic clock battle front."[436] In August 2019, CASIC 203 Institute announced it had started mass producing super-thin rubidium atomic clocks.[437] Official PRC media reporting notes that CASIC 203 Institute is the only group in China

[431] AIM Altitude, "History." *https://www.aimaltitude.com/company/history/.*
[432] AIM Altitude, "Board of Directors," January 1, 2018. *https://www.aimaltitude.com/company/about-us/.*
[433] *Xinhua*, "Demystifying the 'Chinese Heart' of Beidou satellites" [揭秘北斗卫星的 "中国心"], February 13, 2018. http://www.xinhuanet.com/tech/2018-02/13/c_1122411317.htm.
[434] *Xinhua*, "A New Generation of High-Precision Rubidium Atomic Clock Debuts on the Beidou 3 Satellite" [新一代高精度铷原子钟亮相北斗三号首发双星], November 6, 2017. *http://www.xinhuanet.com//science/2017-11/06/c_136731539.htm.*
[435] Orolia Group, "Offering Circular," June 21, 2010. *https://live.euronext.com/sites/default/files/Orolia_Offering_Circular_EN.pdf.*
[436] China Aerospace Science and Industry Corporation, "Our 'Chinese Heart' for Global Time and Positioning -- The Development Story of the Beidou Guided Navigation Satellite Atomic Clock Produced by Second Institute 203 Institute" [我们的"中国心"为世界时间定位——二院 203 所北斗导航星载原子钟研制发展记], February 23, 2018. *http://www.casic.com.cn/n103/n135/c6873806/content.html*.
[437] *Xinhua*, "CASIC Card-Sized Atomic Clock Goes into Mass Production" [航天科工 "卡片铷钟" 实现量产], August 7, 2019. *http://www.xinhuanet.com/tech/2019-08/07/c_1124845334.htm*.

that has developed this technology,[438] further suggesting the PRC was reliant on the original purchase from Spectratime to get this crucial technology.

Role of Hong Kong-Domiciled Companies

Beijing also allows PRC companies to register subsidiaries and other ventures under Hong Kong domicile to take advantage of laxer market and trade regulations there while remaining under Beijing's legal and political control. Furthermore, U.S. export controls consider the semiautonomous Hong Kong as separate from mainland China, allowing the PRC to use the island to skirt export control regulations. This provides PRC companies and their foreign business collaborators with a nominal veil over country-of-control, which—particularly in the case of strategic and dual-use S&T industries like aerospace—is frequently exploited to bolster representations made to foreign governments or businesses that these ventures have little to no connection to the PRC government. This, in turn, facilitates access to and acquisition of related knowhow and technologies that may otherwise be subject to U.S. export control regulations.

For instance, CASC's wholly owned Hong Kong subsidiary China Aerospace International Holdings Limited (CASIL; 中国航天国际控股有限公司) claimed in its 2018 annual report that as the only overseas listed company directly held by CASC, CASIL "will bring its unique advantages into play in the development of CASC and serve the internationalization strategy of CASC."[439] The annual report also stated that CASIL "will be able to contribute to the establishment of the international business flagship of CASC," suggesting its primary role as an intermediary between CASC and foreign entities.[440]

In November 2018, CASIL subsidiary CASC Import & Export Co., Ltd. (航天科技进出口有限责任公司) held a "centralized procurement ceremony" (集中采购签约仪式) at the China International Import Expo in Shanghai with participants from the United States, Russia, France, Italy, South Korea, United Arab Emirates, Japan, Germany, Switzerland, and the Czech Republic, according to official reporting from SASAC.[441] CNSA also claims the company established new business partnerships with airlines in the United States and Russia, including San Francisco-based SKY Leasing, during the November 2018 event.[442] CNSA asserts that CASC Import & Export Co.

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[438] *Xinhua*, "China's Super-Thin Atomic Clocks Achieve Mass Production," August 8, 2019. *http://www.xinhuanet.com/english/2019-08/08/c_138293522.htm.*

[439] China Aerospace International Holdings Limited [中国航天国际控股有限公司],"Annual Report 2018," April 18, 2019. *https://www1.hkexnews.hk/listedco/listconews/sehk/2019/0418/ltn20190418339.pdf.*

[440] China Aerospace International Holdings Limited [中国航天国际控股有限公司],"Annual Report 2018," April 18, 2019. *https://www1.hkexnews.hk/listedco/listconews/sehk/2019/0418/ltn20190418339.pdf.*

[441] State-Owned Assets Supervision and Administration Commission of the State Council, *At the Expo, Aerospace Accelerated Cooperation with International Partners* [金博会尚 "航天号"加速牵手国际伙伴], November 8, 2018. *http://www.sasac.gov.cn/n2588025/n2641611/n4518442/c9797740/content.html*.

[442] China National Space Administration, *CASC Group Held a Centralized Procurement Signing Ceremony during the Import Expo* [航天科技集团在进口博览会期间举行集中采购签约仪式], November 8, 2018. *http://www.cnsa.gov.cn/n6758823/n6758838/c6803795/content.html*.

had cooperated with Shanghai Bestar International Freight from July 2017 to July 2018 to rent a Boeing 747-400BCF freighter from the United States.[443]

California-based Loral Space and Communications has collaborated with both APT Satellite Company Limited (hereinafter referred to as APStar; 亚太通信街星有限公司) and Asia Satellite Telecommunications Limited (hereinafter referred to as AsiaSat; 亚洲街星有限公司 despite its previous controversial dealings with China's space program. In May 2009, Loral subsidiary Space Systems/Loral (SS/L) was selected to provide a new communications satellite, named AsiaSat 5C, for AsiaSat.[444] The same subsidiary was also selected two years later to construct AsiaSat 6 and AsiaSat 8.[445] In addition to its connections with AsiaSat, Loral has been involved in APStar's satellite development. APStar 5C, also referred to as TeleSat 18V, was a 2018 joint project by APStar and Canada-based Telesat—which is 62.7 percent owned by Loral Space and Communications[446]—and was built by Space Systems/Loral.[447]

In 2002, Loral Space and Communications Corporation agreed to pay a $20 million fine after it was found by the U.S. Department of Justice (DOJ) to have passed sensitive materials to China following a 1996 Loral satellite launch failure in China. Following the incident, China created an Independent Review Committee that included both Loral and U.S.-based Hughes Space and Communications to investigate the failure and report their findings to CGWIC, albeit without consent from the U.S. government. DOD concluded that both Loral and Hughes had committed a serious export violation "by virtue of having performed a defense service without a license"; DOD then recommended referral of the matter to DOJ for possible criminal prosecution, according to a report from the former Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, otherwise known as the Cox Report.[448]

APStar was founded in 1992 and touts itself as a leading commercial satellite operator in the Asia-Pacific region, with six in-orbit satellites covering approximately 75 percent of the world's population, according to the company's official website.[449] However, the company's 2018 annual

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[443] China National Space Administration, *CASC Group Held a Centralized Procurement Signing Ceremony during the Import Expo* [航天科技集团在进口博览会期间举行集中采购签约仪式], November 8, 2018. *http://www.cnsa.gov.cn/n6758823/n6758838/c6803795/content.html*.
[444] Loral Space and Communications, "AsiaSat Selects Space Systems/Loral for AsiaSat 5C," May 5, 2009. *http://s21.q4cdn.com/335413995/files/doc_news/archive/LORL_News_2009_5_5_General_Releases.pdf.*
[445] Loral Space and Communications, "AsiaSat Selects Space Systems/Loral to Provide Two Communications Satellites," November 11, 2011. *http://s21.q4cdn.com/335413995/files/doc_news/archive/LORL_News_2011_11_11_General_Releases.pdf.*
[446] Loral Space and Communications, "Company Profile." *http://www.loral.com/Company/Company-Profile/default.aspx.*
[447] Telesat, "Telesat Orders New Telstar 18 VANTAGE High Throughput Satellite and Launch Services," December 23, 2015. *https://www.telesat.com/news-events/telesat-orders-new-telstar-18-vantage-high-throughput-satellite-and-launch-services.*
[448] Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, *Satellite Launches in the PRC: Loral*, January 2, 1999. *https://www.govinfo.gov/content/pkg/GPO-CRPT-105hrpt851/html/ch6bod.html#anchor1645545.*
[449] APStar by APT Satellite, "Company Profile." *https://www.apstar.com/en/about-apstar/.*

report states that its two largest shareholders are CASC and China Satellite Communications Company, the latter of which is also 99.8 percent owned by CASC.[450] APStar is incorporated in Hong Kong and wholly owned by APT Satellite Holdings Limited, which is registered in Bermuda and incorporated in Hong Kong.[451] California-based Panasonic Avionics announced in March 2018 that it was collaborating with APSATCOM, a wholly-owned APStar subsidiary formed in August 2016,[452] on a new satellite—APStar-6—which Panasonic claims will help it to best serve its connectivity customers.[453]

Similarly, AsiaSat, founded in 1988, is advertised as a Hong Kong-based commercial satellite firm currently operating seven satellites and offering services in the Asia-Pacific region. However, the company's website claims its two major shareholders are Carlyle Asia Fund IV and CITIC Group.[454] CITIC Group is a wholly-owned PRC SOE managed by the PRC State Council;[455] its predecessor, the China International Trust and Investment Corporation (中国国际信托投资公司), was founded in 1979 with support from Deng Xiaoping, according to CITIC's official website.[456] In addition to its ownership, various aspects of AsiaSat's historical business ventures are also indicative of its connections to the PRC government. For example, an April 2019 investigation by the *Wall Street Journal* claims that since AsiaSat launched its first satellite around 30 years ago, the PRC government has used the company to link state-run broadcasters to the provinces.[457]

Furthermore, the *Wall Street Journal* notes that the Ministry of Public Security allegedly relied on both the AsiaSat 4 and AsiaSat 5 satellites to build rapid-response forces "capable of providing real-time audio and video from the field." [458] AsiaSat has consistently denied its connections to both the PLA and the PRC government; AsiaSat allegedly states that "China's

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450 APT Satellite Holdings Limited, "2018 Annual Report," *Hong Kong Stock Exchange News*, April 15, 2019. *https://www1.hkexnews.hk/listedco/listconews/sehk/2019/0415/ltn20190415959.pdf.*

451 APStar by APT Satellite, "Company Profile." *https://www.apstar.com/en/about-apstar/*; U.S. Securities and Exchange Commission, *Transition Report Pursuant to Section 13 or 15(d) of the Securities Act of 1934: APT Satellite Holdings Limited*, December 31, 2003. *https://www.sec.gov/Archives/edgar/data/1027229/000114554904000849/u99122e20vf.htm#124.*

452 APT Satellite Holdings Limited, "2018 Annual Report," *Hong Kong Stock Exchange News*, April 15, 2019. *https://www1.hkexnews.hk/listedco/listconews/sehk/2019/0415/ltn20190415959.pdf.*

452 APStar by APT Satellite, "Company Profile." *https://www.apstar.com/en/about-apstar/.*

453 Panasonic Avionics Corporation, "Press Release: Panasonic Avionics and APSatCom Bring Extreme Throughput Satellite Technology to Asian Mobility Markets," March 8, 2018. *https://www.panasonic.aero/whats-new/press-releases/panasonic-avionics-apsatcom-bring-extreme-throughput-satellite-technology-asian-mobility-markets.*

454 Asia Satellite Limited [亚洲街星有限公司], "About Us" [关于我们]. *https://www.asiasat.com/zh-hant/aboutus.*

455 Qichacha [企查查], "Entry for CITIC Group" [中国中信集团有限公司]. *https://www.qichacha.com/firm_227f47c376342dbaa0be61df2f5d5e94.html.*

456 CITIC Group [中信集团], "Group Introduction" [集团简介]. *https://www.group.citic/html/About_CITIC/Brief_Introduction/.*

457 Brian Spegele and Kate O'Keefe, "China Exploits Fleet of U.S. Satellites to Strengthen Police and Military Power," *Wall Street Journal*, April 23, 2019. *https://www.wsj.com/articles/china-exploits-fleet-of-u-s-satellites-to-strengthen-police-and-military-power-11556031771.*

458 Brian Spegele and Kate O'Keefe, "China Exploits Fleet of U.S. Satellites to Strengthen Police and Military Power," *Wall Street Journal*, April 23, 2019. *https://www.wsj.com/articles/china-exploits-fleet-of-u-s-satellites-to-strengthen-police-and-military-power-11556031771.*

military wasn't a direct customer but used capacity that was first procured by telecommunications operators for disaster relief," according to the *WSJ* investigation, and that the company "didn't know how the authorities used its bandwidth in response to uprisings in Xinjiang and Tibet."[459] Although AsiaSat's first few satellites (AsiaSat 1 and AsiaSat 2) were launched from China's Xichang Satellite Launch Center, more recent models—including AsiaSat 4,[460] AsiaSat 6,[461] and AsiaSat 8[462]—were launched at Cape Canaveral, and both 6 and 8 were launched by SpaceX with support from the U.S. Air Force Space Command's 45th Space Wing.[463]

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[459] Brian Spegele and Kate O'Keefe, "China Exploits Fleet of U.S. Satellites to Strengthen Police and Military Power," *Wall Street Journal*, April 23, 2019. *https://www.wsj.com/articles/china-exploits-fleet-of-u-s-satellites-to-strengthen-police-and-military-power-11556031771.*
[460] AsiaSat official website, "AsiaSat 4," March 2015. *https://www.asiasat.com/sites/default/files/AsiaSat%204%20Insert_March%202015_0_0.pdf.*
[461] U.S. Air Force Space Command, *Air Force Space Command 45th Space Wing Public Affairs Office: SpaceX Launches AsiaSat 6 Satellite from Complex 40 at "The Cape,"* September 2, 2014. *https://www.afspc.af.mil/News/Article-Display/Article/731241/spacex-launches-asiasat-6-satellite-from-complex-40-at-the-cape/.*
[462] Edwards Air Force Base, *45th Space Wing Supports SpaceX Launch of AsiaSat 8 Satellite*, August 5, 2014. *https://www.edwards.af.mil/News/Article/490712/45th-space-wing-supports-spacex-launch-of-asiasat-8-satellite/.*
[463] U.S. Air Force Space Command, *Air Force Space Command 45th Space Wing Public Affairs Office: SpaceX Launches AsiaSat 6 Satellite from Complex 40 at "The Cape,"* September 2, 2014. *https://www.afspc.af.mil/News/Article-Display/Article/731241/spacex-launches-asiasat-6-satellite-from-complex-40-at-the-cape/*; U.S. Air Force Space Command, *Air Force Space Command 45th Space Wing Public Affairs Office: SpaceX Launches AsiaSat 6 Satellite from Complex 40 at "The Cape,"* September 2, 2014. *https://www.afspc.af.mil/News/Article-Display/Article/731241/spacex-launches-asiasat-6-satellite-from-complex-40-at-the-cape/.*

CONCLUSIONS/RECOMMENDATIONS

The PRC is a global space power. Its modernization is creating growing uncertainties, intentions, and implications. Significant investments into space systems have the potential to deny the United States and its allies access to similar systems. China can achieve disruptive breakthroughs in space technology, including space launch, satellites, and counterspace capabilities.

Chinese political authorities view space power—a domain managed by a diverse set of military and civilian organizations—as one element of a broader international S&T competition.. With preservation of the CCP's monopoly on power as an overriding goal, a growing space presence consolidates the Party's domestic and international legitimacy. Fusing civilian and military resources and administration, Chinese investment into space technology supports economic development and advances national defense modernization.

China's ambitions in space are inherently dual-use in nature. Space technology increases the capacity of the PLA to project military power vertically into space and horizontally beyond its immediate periphery. Freedom of action in space offers the PLA potential military advantages on land, at sea, and in the air. The establishment of the PLA Strategic Support Force appears to have integrated organizational interests, operational planning, and acquisition. The PLASSF likely is integral to national- and theater-level command and control.

The PRC's advances in space are significant. In addition to supplying low-cost commercial launch services to international customers, the PRC's space program supports economic development through subsidized modernization of China's high-technology industries. International cooperation offers China opportunities to accelerate its space technology.

China's space program has matured rapidly. Looking out to 2030, the PLA and defense industry can be expected to expand its spacelift capacity and presence in space. An operational counterspace capability has significant implications for U.S. interests, including how these could be employed to target U.S. space assets or those of U.S. allies and partners. Space assets enable extended-range precision strike operations intended to deny U.S. access to or ability to operate within a contentious area in the Indo-Pacific region.

Greater vigilance over U.S technology is needed. The PRC routinely uses Hong Kong-domiciled companies to circumvent export controls, particularly in cases pertaining to advanced technologies with dual uses in defense, as made evident in the AsiaSat and APStar examples. Therefore, the U.S. government should work to reassess export control waivers for Hong Kong to ensure the protection of critical U.S. technology.

The CCP is executing a long-term strategy to exploit U.S. technology, talent, and capital to build up its military space and counterspace programs and advance its strategic interests. China's pursuit of space superiority harms U.S. economic competitiveness, weakens U.S. military advantages, and undermines strategic stability. In short, it represents a threat to U.S. national security. Barring significant action to counter CCP space-related programs and activities of concern, it is likely these efforts will continue to harm U.S. interests.

Given the findings of this report, seven important considerations for Congress stand out:

- The current laws to protect U.S. technology and prevent U.S. capital from funding China's military space programs and activities appear to be inadequate. Congress should consider passing new laws or enhancing existing laws in order to make it illegal for U.S. government departments and agencies, national labs, universities, companies, fund managers, and individual investors to support China's space program and activities, which are inherently military (not civil) in nature.

- To support U.S. government efforts to safeguard U.S. national interests, Congress should consider mandating and funding the production of a routinely updated, publicly available list of entities formally engaged with the PRC's space-related ecosystem. Such a list would serve to identify organizations and individuals that merit the imposition of U.S. government licensing requirements or sanctions, while providing the public with a resource to inform their decisions.

- The CCP's predatory space-related behavior thrives in permissive environments that allow for the exploitation of uninformed U.S. decision makers at all levels. Congress should consider mandating and funding a public education campaign directed at enhancing general knowledge of China's space programs and activities. Such a campaign might include more targeted congressional hearings and the allocation of grants for think tank and university research programs, public conferences, public-private consultative talks, and media outreach.

- Given the expansive nature of the threat, enhanced U.S. space competitiveness may require a departure from status quo spending habits. Congress should consider reviewing the budgets of NASA and the United States' leading aerospace university programs to ensure they have the education funding necessary to support young and emerging scientists and technology innovators.

- The creation of a newly empowered U.S. Space Command could significantly strengthen the U.S. pool of national security space experts. In DOD, powerful bureaucratic forces have long existed that militate against the development of a world-class space warfighting capability. Congress should consider how funding the establishment of a potential new U.S. Space Force may better enable the military to organize, train, and equip future leaders needed to keep our nation competitive with China's rapidly growing military space enterprise.

- Like-minded allies and partners play an important role in giving the United States a strategic edge in the space domain. Congress should consider how to offer greater incentives to the executive branch to deepen and broaden international space cooperation favoring U.S. interests, while at the same time mitigating the expansion of global CCP influence in space science and technology.

- The space competition between the United States and PRC will be waged on a number of fronts, one of which is informational. CCP-controlled entities and front organizations have prioritized the insertion of Beijing's space-related propaganda themes into Hollywood blockbusters. Congress should consider imposing regulations on the U.S. entertainment industry to forestall the continued infiltration of authoritarian propaganda and censorship in Hollywood. At a minimum, movies should have warning labels informing viewers if their content has been coproduced, funded, altered, or otherwise approved by CCP-affiliated entities and China's state censors.

APPENDIX

List of Newly Established Higher Education Discipline Innovation and Enlightenment Bases (Plan 111) in 2018

(2018 年度新建高等学校创新引智基地（111 计划）名单)

Number (序号)	**Base ID Number (编号)**	**Base Name (基地名称)**	**Support Unit (依托单位)**	**Person in Charge (负责人)**
1	B18001	Post-Moore Era Micro-Nano Electronic Discipline Innovation and Enlightenment Base (后摩尔时代微纳电子学科创新引智基地)	Peking University (北京大学)	Huang Ru (黄如)
2	B18002	Aerospace Multi-Scale Mechanics and Thermodynamics Innovation and Enlightenment Base (空天多尺度力学与热力学学科创新引智基地)	北京航空航天大学 (Beihang University)	Wen Dongsheng (文东升)
3	B18003	Advanced Manufacturing Disciplines for High-End Equipment and Medical Devices Innovation and Enlightenment Base (面向高端装备及医学器件的先进制造学科创新引智基地)	Beijing University of Chemical Technology (北京化工大学)	Yang Weimin (杨卫民)
4	B18004	High-Speed Rail Efficient Operation and Safety Assurance Discipline Innovation and Enlightenment Base 高速铁路高效运营与安全保障学科创新引智基地	Beijing Jiaotong University (北京交通大学)	Nie Lei (聂磊)
5	B18005	Medical Optical and Medical Imaging Disciplines Innovation and Enlightenment Base (医用光学与医疗成像学科创新引智基地)	Beijing Institute of Technology (北京理工大学)	Hao Qun (郝群)
6	B18006	Basin Water Safety and Comprehensive Management Discipline Innovation and Enlightenment Base (流域水安全与综合管理学科创新引智基地)	Northeast Normal University (东北师范大学)	Zhu Chen (朱晨)
7	B18007	Stem Cell Storage Technology R&D and Industry Health Intervention Research Discipline Innovation and Enlightenment Base	Peking Union Medical College (北京协和医学院)	Zhao Chunhua (赵春华)

		(干胞储存库工艺技术研发及业健康干预研究学科创新引智基地)		
8	B18008	Basic Theory of Internet of Things and the Innovation of Key Technology Disciplines Innovation and Enlightenment Base (物联网基础理论与关键技术学科创新引智基地)	Beijing University of Posts and Telecommunications (北京邮电大学)	Ma Huadong (马华东)
9	B18009	Dalian Maritime University Undersea Engineering Technology and Equipment Discipline Innovation and Enlightenment Base (大连海事大学海底工程技术与装备学科创新引智基地)	Dalian Maritime University (大连海事大学)	Sun Yuqing (孙玉清)
10	B18010	Environmentally Friendly Energy Development and Regulation Discipline Innovation and Enlightenment Base (环境友好能源开发与调控学科创新引智基地)	Dalian Institute of Technology (大连理工大学)	Song Yongchen (宋永臣)
11	B18011	Low-Power Microelectronics and Microsystems Discipline Innovation and Enlightenment Base (低功耗微电子与微系统学科创新引智基)	University of Electronic Science and Technology (电子科技大学)	Li Qiang (李强)
12	B18012	Grid Material Chemistry Innovation and Enlightenment Base (网格材料化学学科创新引智基地)	Northeast Normal University (东北师范大学)	Zhu Guangshan (朱广山)
13	B18013	Modern Urban Intelligent Transportation Technology Discipline Innovation and Enlightenment Base (现代城市智能交通技术学科创新引智基地)	Southeast University (东南大学)	Liu Pan (刘攀)
14	B18014	Global Value Chain Research Discipline Innovation and Enlightenment Base (全球价值链研究学科创新引智基地)	Foreign Economic and Trade University (对外经济贸易大学)	Zhao Zhongxiu (赵忠秀)
15	B18015	Computational Neuroscience and Brain-Like Intelligence Discipline Innovation and Enlightenment Base (计算神经科学与类脑智能学科创新引智基地)	Fudan University (复旦大学)	Feng Jianfeng (冯建峰)

16	B18016	Ship Dynamics Innovation and Enlightenment Base (船舶动力学科创新引智基地)	Harbin Engineering University (哈尔滨工程大学)	Li Wanyou (李玩幽)
17	B18017	Space Environment and Material Role Discipline Innovation and Enlightenment Base (空间环境与物质作用学科创新引智基地)	Harbin Institute of Technology (哈尔滨工业大学)	Guo Bin (郭斌)
18	B18018	Clean Energy and New Materials Technology Discipline Innovation and Enlightenment Base (清洁能源新材料与技术学科创新引智基地)	Hefei University of Technology (合肥工业大学)	Wu Yucheng (吴玉程)
19	B18019	Major Hydropower Project Multi-Field Coupling Mechanics Discipline Innovation and Enlightenment Base (重大水电工程多场耦合力学学科创新引智基地)	Hohai University (河海大学)	Xu Weiya (徐卫亚)
20	B18020	High-Performance Computing Discipline Innovation and Enlightenment Base (高效能计算学科创新引智基地)	Hunan University (湖南大学)	Li Kenli (李肯立)
21	B18021	China Green Power Development Research Discipline Innovation and Enlightenment Base (中国绿色电力发展研究学科创新引智基地)	North China Electric Power University (华北电力大学)	Niu Dongxiao (牛东晓)
22	B18022	High-Efficiency “Intelligence” of Microbial Drugs Discipline Innovation and Enlightenment Base (微生物药物的高效“智”造学科创新引智基地)	East China University of Science and Technology (华东理工大学)	Zhang Lixin (张立新)
23	B18023	Soft Matter Science and Technology Discipline Innovation and Enlightenment Base (软物质科学与技术学科创新引智基地)	South China University of Technology (华南理工大学)	Cheng Zhengdi (程正迪)
24	B18024	Computational Intelligence and Intelligent Control Discipline Innovation and Enlightenment Base (计算智能与智能控制学科创新引智基地)	Huazhong University of Science and Technology (华中科技大学)	Ceng Zhigang (曾志刚)
25	B18025	Micro-Nano Information Materials and Devices Discipline Innovation and Enlightenment Base (微纳信息材料与器件学科创新引智基地)	Jilin University (吉林大学)	Lu Geyu (卢革宇)

26	B18026	Population Mobility and Labor Economics Discipline Innovation and Enlightenment Base (人口流动与劳动经济学科创新引智基地)	Jinan University (暨南大学)	Feng Shuaizhang (冯帅章)
27	B18027	Individual Experience Design Frontier Method and Technology Discipline Innovation and Enlightenment Base (体验设计前沿方法与技术学科创新引智基地)	Jiangnan University (江南大学)	Zhang Linghao (张凌浩)
28	B18028	Intractable Material Additive Manufacturing Technology and Equipment Discipline Innovation and Enlightenment Base (难成形材料增材制造技术与装备学科创新引智基地)	Nanjing University of Technology (南京理工大学)	Liao Wenhe (廖文和)
29	B18029	Characteristics Horticultural Crop Breeding and Quality Control Research Discipline Innovation and Enlightenment Base (特色园艺作物育种与品质调控研究学科创新引智基地)	Nanjing Agricultural University (南京农业大学)	Chen Fayang (陈发棣)
30	B18030	Inorganic Solid Materials and Energy Chemistry Discipline Innovation and Enlightenment Base (无机固体材料与能源化学学科创新引智基地)	Nankai University (南开大学)	Bo Xianhe (卜显和)
31	B18031	Ecological River Dynamics Discipline Innovation and Enlightenment Base (生态河流动力学学科创新引智基地)	Tsinghua University (清华大学)	Fang Hongwei (方红卫)
32	B18032	Chan'an and Silk Road Cultural Communication Discipline Innovation and Enlightenment Base (长安与丝路文化传播学科创新引智基地)	Shaanxi Normal University (陕西师范大学)	Zhang Xinke (张新科)
33	B18033	Accounting Reform and Development Discipline Innovation and Enlightenment Base (会计改革与发展学科创新引智基地)	Shanghai University of Finance and Economics (上海财经大学)	Li Zengquan (李增泉)
34	B18034	Mental Health and Brain Science and Technology Discipline Innovation and Enlightenment Base (精神健康与脑科学技术学科创新引智基地)	Shanghai Jiaotong University (上海交通大学)	He Lin (贺林)

35	B18035	Targeted Drug and Drug Delivery System Discipline Innovation and Enlightenment Base (靶向药物与释药系统学科创新引智基地)	Sichuan University (四川大学)	Huang Yuan (黄园)
36	B18036	Integrated Energy and Power System Discipline Innovation and Enlightenment Base (综合能源电力系统学科创新引智基地)	Tianjin University (天津大学)	Wang Chengshan (王成山)
37	B18037	Evolution Mechanism and Adaptation Countermeasures of Hydrology and Water Resources System under Changing Environments Discipline Innovation and Enlightenment Base (变化环境下水文水资源系统演变机理及适应对策学科创新引智基地)	Wuhan University (武汉大学)	Xiong Lihua (熊立华)
38	B18038	Environmentally Friendly Building Materials Discipline Innovation and Enlightenment Base (环境友好建筑材料学科创新引智基地)	Wuhan University of Technology (武汉理工大学)	Zhao Xiujian (赵修建)
39	B18039	Radar Cognitive Detection Imaging Recognition Discipline Innovation and Enlightenment Base (雷达认知探测成像识别学科创新引智基地)	Xidian University of Electronic Technology (西安电子科技大学)	Liu Hongwei (刘宏伟)
40	B18040	Intelligent Aircraft Fluid Structure Coupling Mechanics and Bionics Technology Discipline Innovation and Enlightenment Base (智能飞行器流固耦合力学与仿生技术学科创新引智基地)	Xi'an Jiaotong University (西安交通大学)	Shen Shengping (申胜平)
41	B18041	Ocean Information Perception Discipline Innovation and Enlightenment Base (海洋信息感知学科创新引智基地)	Northwestern Polytechnical University (西北工业大学)	Yang Yixin (杨益新)
42	B18042	Crop Disease Resistance Breeding and Genetic Improvement Innovation and Enlightenment Base (作物抗病育种与遗传改良学科创新引智基地)	Northwestern Rural Science and Technology University (西北农村科技大学)	Dan Weixing (单卫星)
43	B18043	Financial Security and Development Discipline	Southwestern University of Finance and Economics (西南财经大学)	Yang Dan (杨丹)

		Innovation and Enlightenment Base (金融安全与发展学科创新引智基地)		
44	B18044	Citrus Pests and Diseases Continuous Control Basic Research Innovation and Enlightenment Base (柑桔主要病虫害持续控制基础研究学科创新引智基地)	Southwest University (西南大学)	Wang Jinjun (王进军)
45	B18045	Optical Information Transmission Processing and Sensing Application Discipline Innovation and Enlightenment Base (光信息传输处理与传感应用学科创新引智基地)	Southwest Jiaotong University (西南交通大学)	Yan Lianshan (闫连山)
46	B18046	Western Geological Hazards and Geological Engineering Discipline Innovation and Enlightenment Base (西部地质灾害与地质工程学科创新引智基地)	Chang'an University (长安大学)	Fan Wen (范文)
47	B18047	Geotechnical Engineering Long-Term Service Performance and Regulation Discipline Innovation and Enlightenment Base (岩土工程长期服役性能及调控学科创新引智基地)	Zhejiang University (浙江大学)	Chen Yunmin (陈云敏)
48	B18048	Magma Origins and Continental Crust Formation Discipline Innovation and Enlightenment Base (岩浆成因和大陆地壳形成学科创新引智基地)	China University of Geosciences (Beijing) (中国地质大学（北京）)	Zhu Dicheng (朱第成)
49	B18049	Environmental Hydrogeology Discipline Innovation and Enlightenment Base (环境水文地质学科创新引智基地)	China University of Geosciences (Wuhan) (中国地质大学（武汉）)	Wang Yanxin (王焰新)
50	B18050	Marine Biogenomics and Molecular Genetics and Breeding Discipline Innovation and Enlightenment Base (海洋生物基因组学与分子遗传育种学科创新引智基地)	Ocean University of China (中国海洋大学)	Bao Zhenmin (包振民)
51	B18051	Multi-Scale Dynamics of Complex Chemical Systems Discipline Innovation and Enlightenment Base (复杂化学体系多尺度动力学学科创新引智基地)	University of Science and Technology of China (中国科学技术大学)	Yan Yijing (严以京)

52	B18052	Carbon Dioxide Capture, Utilization, and Storage Discipline Innovation and Enlightenment Base (二氧化碳捕捉、利用与封存学科创新引智基地)	China University of Mining and Technology (Beijing) (中国矿业大学（北京）)	Peng Suping (彭苏萍)
53	B18053	Food Nutrition and Health Discipline Innovation and Enlightenment Base (食品营养与健康学科创新引智基地)	China Agricultural University (中国农业大学)	Ren Fazheng (任发政)
54	B18054	Marine Oil and Gas Production Safety Engineering Discipline Innovation and Enlightenment Base (海洋油气生产安全工程学科创新引智基地)	China University of Petroleum (Beijing) (中国石油大学（北京）)	Zhang Laibin (张来斌)
55	B18055	Deep/Super-Deep Oil and Gas Geophysical Exploration Discipline Innovation and Enlightenment Base (深层-超深层油气地球物理勘探学科创新引智基地)	China University of Petroleum (Huadong) (中国石油大学（华东）)	Fu Lijun (符力耘)
56	B18056	Natural Active Molecular Discovery and New Drug Innovation and Enlightenment Base (天然活性分子发现与新药创新引智基地)	China Pharmaceutical University (中国药科大学)	Kong Lingyi (孔令义)
57	B18057	Rule of Law and Global Governance Discipline Innovation and Enlightenment Base (法治与全球治理学科创新引智基地)	China University of Political Science and Law (中国政法大学)	Huang Jin (黄进)
58	B18058	New Era of Scientific and Technological Revolution and Intellectual Property Discipline Innovation and Enlightenment Base (新时代科技革命与知识产权学科创新引智基地)	Central South University of Finance and Economics (中南财经政府大学)	Wu Handong (吴汉东)
59	B18059	Medical Big Data Analysis Theory and Application Discipline Innovation and Enlightenment Base (医学大数据分析理论与应用学科创新引智基地)	Central South University (中南大学)	Zhang Yuxue (张尧学)
60	B18060	Soil Environmental Pollution Control and Restoration Discipline Innovation and Enlightenment Base	Zhongshan University (中山大学)	Qiu Rongliang (仇荣亮)

		(土壤环境污染控制与修复学科创新引智基地)		
61	B18061	Drama, Film, Television, and Art Teaching and Creation Discipline Innovation and Enlightenment Base (戏剧影视艺术教学与创作学科创新引智基地)	Central Academy of Drama (中央戏剧学院)	Hao Rong (郝戎)
62	B18062	High-Performance Wind Power Facilities and Their Efficient Operation Disciplines Innovation and Enlightenment Base (高性能风电设施及其高效运行学科创新引智基地)	Chongqing University (重庆大学)	Yang Qingshan (杨庆山)

Source: Sina Education (新浪教育).[464]

[464] Sina, "62 Colleges and Universities Nationwide Were Selected for the National 111 Plan in 2018" [62 所高校入选 2019 年国家 111 计划], January 23, 2018. *http://edu.sina.com.cn/gaokao/2018-01-23/doc-ifyquptv8808208.shtml.*

ACRONYMS

3PLA	GSD Technical Reconnaissance Department (Third Department)
4PLA	ECM and Radar Department (Fourth Department)
ABAE	Bolivarian Agency for Space Activities (Agencia Bolivariana para Actividades Espaciales)
APOSOS	Asia-Pacific Ground-Based Optical Space Object Observation System
APSCO	Asia-Pacific Space Cooperation Organization
ASAT	Anti-Satellite
AVIC	Aviation Industry Corporation of China
BIT	Beijing Institute of Technology
BITTT	Beijing Institute of Tracking and Telecommunications Technology
BUAA	Beijing University of Aeronautics and Astronautics
BX	Banxing
CALT	China Academy of Launch Technology
CAS	Chinese Academy of Sciences
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CASIL	China Aerospace International Holdings Limited
CASSACA	CAS South America Center for Astronomy
CAST	China Academy of Space Technology
CBERS	China-Brazil Earth Resources Program
CCJCA	China-Chile Joint Center for Astronomy
CCP	Chinese Communist Party
CETC	China Electronics Technology Group Corporation
CFIUS	Committee on Foreign Investment in the United States
CGSTL	Chang Guang Satellite
CGWIC	China Great Wall Industry Corporation
CICC	China International Capital Corporation
CLTC	China Satellite Launch and Tracking Control General
CMA	China Meteorological Administration
CMC	Central Military Commission
CMSP	China Manned Space Program
CNAGA	China National Administration of GNSS and Applications
CNSA	China National Space Administration
CONAE	Comisión Nacional de Actividades Espaciales (Argentina National Commission of Special Activities)

CORS	Continuously Operating Reference Stations
CPMIEC	China Precision Machinery Import-Export Company
CRESDA	China Center for Resource Satellite Data and Application
CSU	Technology and Engineering Center for Space Utilization
CX	Chuangxin
DOD	U.S. Department of Defense
DOJ	U.S. Department of Justice
DSR	Digital Silk Road
ECM	Electronic Countermeasures
EDD	Equipment Development Department
EO	Electro-optical
ESA	European Space Agency
EU	European Union
EVA	Extravehicular Activities
FAU	Florida Atlantic University
FY	Fengyun
FYP	Five-Year Plan
GAD	General Armaments Department
GEO	Geostationary Earth Orbit
GEOSS	China Group on Earth Observations
GIS	Geographic Information Systems
GLD	General Logistics Department
GNSS	Global Navigation Satellite System
GPD	General Political Department
GPS	Global Positioning System
GSD	General Staff Department
GWU	George Washington University
HADR	Humanitarian Assistance and Disaster Relief
HD	High-Definition
HT	Hangtian-Tsinghua
HXMT	Hard X-Ray Modulation Telescope
HY	Haiyang
IAA	International Academy of Astronautics
ICBM	Intercontinental Ballistic Missile
ICG	International Committee on Global Navigation Satellite Systems

INPE	Brazil National Institute for Space Research (Instituto Nacional de Pesquisas Especiais)
ISR	Intelligence, Surveillance, and Reconnaissance
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
ITU	International Telecommunication Union
JSD	Joint Staff Department
KKV	Kinetic Kill Vehicle
KT	Kaituozhe
LEO	Low-Earth Orbit
LM	Long March
LSU	Key Laboratory of Space Utilization
MCF	Military-Civil Fusion
MEMS	Micro-Electro-Mechanical System
MIIT	Ministry of Industry and Information Technology
MOE	Ministry of Education
MOFA	Ministry of Foreign Affairs
MOST	Ministry of Science and Technology
MUCD	Military Unit Cover Designator
NAOC	National Astronomical Observatory of China
NASA	National Aeronautics and Space Administration
NOSS	Naval Ocean Surveillance System
NSC	National Space Council
NSSC	National Space Science Center
NUAA	Nanjing University of Aeronautics and Astronautics
NWPU	Northwestern Polytechnic University
OBOR	One Belt, One Road
OSTP	Office of Science and Technology Policy
OTH	Over-the-horizon
PIE	Pixel Information Expert
PLA	People's Liberation Army
PLAA	PLA Army
PLAAF	PLA Air Force
PLAN	PLA Navy
PLARF	People's Liberation Army Rocket Force
PLASSF	People's Liberation Army Strategic Support Force

PNT	Positioning, Navigating, and Timing
PRC	People’s Republic of China
QUESS	Quantum Experiments at Space Scale
R&D	Research and Development
RD&A	Research, Development, and Acquisition
RMB	Renminbi
S&T	Science and Technology
SAR	Synthetic Aperture Radar
SASAC	State-owned Assets Supervision and Administration Commission
SAST	Shanghai Academy of Space Technology
SASTIND	State Administration for Science, Technology, and Industry for National Defense
SATCOM	Satellite Communication
SCASST	Sichuan Academy of Safety Science and Technology
SIIA	State-Industry Innovation Alliances
SOE	State-Owned Enterprise
SSA	Space Situational Awareness
SSC	Swedish Space Corporation
SSF	Strategic Support Force
SSO	Sun-Synchronous Orbit
SSTL	Surrey Satellite Technology, Limited.
SUPARCO	Pakistan Space and Upper Atmosphere Research Commission
SY	Shiyan
TC	Theater Command
TGI	Triumph Group, Inc.
U.S.	United States
UAV	Unmanned Aerial Vehicle
UFWD	United Front Work Department
UK	United Kingdom
UMD	University of Maryland
UN	United Nations
UNOOSA	United Nations Office for Outer Space Affairs
VLBI	Very-long-baseline interferometry