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China's Satellite Industry

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This report investigates China's satellite industry. Key questions addressed include the current number of Chinese satellites in Earth orbit, the technical specifications of China's military and civilian satellites, China's satellite manufacturing capabilities, major organizations involved in China's satellite production, and the Chinese government's funding and development priorities for its satellite industry. The questions were addressed by consulting leading industry experts and their previous work on the topic. This report has found that China had 541 satellites in orbit as of May 2022. Of these, 137 were confirmed to belong to the People's Liberation Army. Most of China's satellites are for Earth observation or for providing navigation services, although China likely has a number of early-warning satellites as well. Most of China's satellite production comes from large state-owned enterprises; however, China is also funding private enterprises to establish modern production facilities.

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A chief service of the DoD IACs is free technical inquiry (TI) research, limited to 4 research hours per inquiry. This TI response report summarizes the research findings of one such inquiry jointly conducted by DSIAC.

Abstract

This report investigates China's satellite industry. Key questions addressed include the current number of Chinese satellites in Earth orbit, the technical specifications of China's military and civilian satellites, China's satellite manufacturing capabilities, major organizations involved in China's satellite production, and the Chinese government's funding and development priorities for its satellite industry. The questions were addressed by consulting leading industry experts and their previous work on the topic. This report has found that China had 541 satellites in orbit as of May 2022. Of these, 137 were confirmed to belong to the People's Liberation Army. Most of China's satellites are for Earth observation or for providing navigation services, although China likely has a number of early-warning satellites as well. Most of China's satellite production comes from large state-owned enterprises; however, China is also funding private enterprises to establish modern production facilities.

Contents

1.0 TI Request

1.1 Inquiry

Can you provide a summary of current space-related research and capabilities in China?

1.2 Description

The inquirer requested information regarding Chinese capabilities for space—specifically, satellite manufacturing capacity (to include companies), number of satellites in orbit, and electro-optical (EO)/infrared (IR)/synthetic aperture radar (SAR) resolutions and refresh rates.

2.0 TI Response

To complete this technical inquiry (TI) request, the author employed a combined approach of original research based on Chinese primary sources and work BluePath Labs has completed in the past and consulted notable experts and organizations. Experts were consulted for information regarding China's military satellites, as this information is rarely published by Chinese organizations in an open-source manner, while Chinese primary sources were consulted for information regarding funding, government organizations, or China's civilian satellite industry.

This report seeks to be relevant to the U.S. Department of Defense (DoD) by providing an overview of China's satellite-related capabilities in terms of Earth observation, navigation, early warning, and overall satellite production. The space domain is an area of intense interest to the People's Liberation Army (PLA) and the Chinese government, and developments in this environment will directly impact all other domains of warfare.

A detailed response to the TI request is provided in six sections.

2.1 Number of Satellites in Orbit

According to data from the Union of Concerned Scientists' (UCS) Satellite Database, as of May 2022, China had 541 satellites in low Earth orbit (LEO), medium Earth orbit (MEO), geosynchronous orbit (GEO), or in an elliptical orbit [1]. China thus accounts for roughly 10% of the 5,465 man-made satellites currently orbiting Earth as reported by UCS. Among China's satellites, 137 were confirmed as affiliated with the PLA, 189 were owned or operated by the Chinese government (including state-owned enterprises), and 215 were owned or operated by private commercial entities or universities. A total of 289 satellites was reported to be used for Earth observation—100 for "technological development," 67 for communications, and 49 for global positioning services. There are 426 satellites in LEO, 29 in MEO, and 78 in GEO. According to the database, of the 541 satellites in orbit as of May 2022, 176 were launched from the Jiuquan Satellite Launch Center, 153 were launched from the Xichang Satellite Launch Center, 149 were launched from the Taiyuan Satellite Launch Center, 25 were launched from the Wenchang Space Launch Site, and 21 were launched from a location in the Yellow Sea (likely from the new Dongfang Launch Center in Haiyang, Shandong Province, opened in 2019, which offers seaborne space launch capabilities) [2].

Reportedly, the Zhejiang Provincial government is developing a new launch site in Xiangshan county near the city of Ningbo. It is anticipated to invest $2.8 billion between 2021 and 2025 for basic construction, with the completed center expected to be capable of carrying out up to 100 launch missions per year [3].

China's space launch capabilities increased dramatically during the 2010s. According to the Center for Strategic and International Studies, China conducted 207 launches between 2010 and 2019, with the number of launches per year increasing by a year-on-year basis [4]. In 2018, China conducted 38 launches—the most launches per country for the year. China kept up this pace in 2020, conducting 39 launches that placed at least 70 satellites in orbit [5]. Many of the launches were in support of China's Beidou navigation system constellation, which was completed in 2020 [6].

2.2 Military Satellite Missions, Capabilities, and Technical Specifications

The PLA's satellites are supported and operated by the People's Liberation Army Strategic Support Force (PLASSF) and its Space Systems Department, which operates all of the People's Republic of China space launch centers. The PLASSF's Space Systems Department operates at least eight bases, which are responsible for launching, tracking, and operating the PLA's satellites. In addition to these, the PLASSF has tracking, telemetry, and command stations in Namibia, Pakistan, and Argentina, as well as Yuan Wang space support ships used for tracking satellites and other early-warning capabilities around the world [5]. The PLASSF also operates several academic and research institutions related to space support, including the Information Engineering University, Space Engineering University, and the former General Support

Department's 56th and 57th Research Institutes [5]. Further, the PLASSF Xi'an Satellite Control Center is believed to be responsible for space and missile tracking and control [7].

This type of architecture has most likely been created to provide the PLA with command and control capabilities for anticipated joint operations, as well as a real-time monitoring system for reconnaissance and early warning. Beginning in 2015, China began to include space as a domain of warfare in various strategy and policy documents and will likely utilize its newly completed Beidou navigation system to support long-range precision strikes at the outbreak of hostilities, as well as attempt to deny requisite capabilities to its adversary [5]. Likewise, in 2015, China acknowledged improving strategic early warning as a nuclear modernization goal for 2020. According to the DoD, in 2021, China had at least one satellite in orbit explicitly dedicated to early-warning capabilities [5].

According to information provided to *The Space Review* by Henk Smid, retired Chief Officer of the Royal Netherlands Air Force, China's military satellites are often responsible for remote-sensing and possible early-warning purposes. The following information draws from his September 2022 article [8]:

- The Yunhai 2 six-satellite constellation was launched in 2018 with an 800-km circular orbit at 50° inclination. While ostensibly built for detecting ecological conditions in the marine, atmospheric, and space environments, the constellation has also been assessed to have military utility in remote sensing. The satellites were built by the Shanghai Academy of Spaceflight Technology.

- The Ludi Kancha constellation is a high-resolution optical Earth observation four-satellite constellation believed to be used for military topographical reconnaissance. Based on its hexagonal body shape with three radial fixed solar panels, the satellite is believed to be hosting a telescope of about 65 cm. In its 500-km orbit, the constellation would be able to achieve a possible ground resolution of up to 0.7 m for panchromatic images, and at least a 3-m resolution for multispectral and near-IR images. The constellation was completed in 2018.

- The Tianhui series is a network of several topographical satellites operated by the PLA, which uses optical, radar, gravity, and magnetic sensors for Earth observation missions. Currently, there are nine satellites belonging to this series. They operate in a 500-km orbit. The four Tianhui-1 satellites were launched between 2010 and 2021 and are equipped with two cameras with a visible range 5-m resolution and an IR band 10-m resolution. The two Tianhui-2 satellites use interferometric SAR technology to operate in the X-band with a resolution of 3 m. The three Tianhe-4 satellites operate in the visible and IR spectrum using two cameras with a resolution of less than 5 m.

- The Tongxin Jishu Shiyan (TJS) satellite series is believed to be used for electronic intelligence and early-warning capabilities. In particular, the TJS 2, 5, and 6, launched in 2017, 2020, and 2021, respectively, likely provide China with early warning for ballistic missile launches. It is speculated that the TJS satellites are part of the Huoyan series, designed by the Shanghai Academy of Spaceflight Technology, which likely feature IR sensors. TJS 1, 4, and 9 are likely used for electronic intelligence applications, with the TJS 1 having deployed China's first large-aperture reflector antenna with a 32-m diameter. The series is positioned in GEO.

Beyond the aforementioned series, it appears that satellites with military remote-sensing missions are generally designated as part of the Jianbing (Vanguard) or Yaogan (remote sensing) series. Satellites within this series typically use SAR, EO reconnaissance, and electronic intelligence for ocean surveillance. The Jianbing 5 series satellites are China's first-generation SAR reconnaissance satellites, equipped with an L-band SAR system with two working modes featuring 5-m and 20-m resolutions, respectively. The Jianbing 6 series satellites are EO reconnaissance satellites located in a 630-km orbit, which feature an X-band data link for sending image data to dedicated ground stations. The Jianbing 7 series satellites are second-generation radar reconnaissance satellites equipped with an SAR package that offers a 1.5-m resolution. The Jianbing 8 constellation is most likely used to detect naval vessels and early-warning aircraft launched by an aircraft carrier. The satellites operate in a triplet of a primary satellite and two subsatellites. From 2010 to 2022, nine such triplets have been launched into orbit. The Jianbing 9 series is believed to be the third generation of EO reconnaissance satellites designed by the Changchun Institute of Optics, which operate at a 1,200-km orbit. The Jianbing 10 series is a group of second-generation EO reconnaissance satellites that use the Phoenix Eye satellite bus and features an optical resolution of 0.77 m. The Jianbing 11 series satellites are high-resolution EO reconnaissance satellites that operate at a 490-km orbit and feature an image resolution of less than 1 m [8].

While they are likely used for reconnaissance, it is possible some Jianbing-series satellites may also have early-warning capabilities. One Chinese article, quoting *Science and Technology Daily*, reports that in 2016, the Chinese government publicly confirmed the existence of the

Jianbing series and further asserted the existence of a "Qianshao" series of space-based IR early-warning satellites [9]. The article further asserts that the satellites were launched between 2009 and 2014 and that the 11th Institute of Electronic Science and Technology of China is developing improved IR detectors for satellites.

2.3 Civilian Satellite Missions, Capabilities, and Technical Specifications

The line between civilian and military use can be difficult to parse in satellite missions. Satellites with inherently dual-use missions such as remote sensing and navigation can be easily co-opted by the PLA.

The Gaofen series of remote-sensing satellites is typically presented as civilian in nature, but at least one Chinese source reported that the Gaofen-1 (GF-1) was developed as part of the High-Resolution Earth Observation System Engineering Special Project between China's State Administration for Science Technology and Industry for National Defense and the PLA's then-General Armaments Department [10]. The GF-1 satellite is equipped with two cameras with a 2-m panchromatic and 8-m multispectral resolution capability, four 16-m resolution multispectral cameras, and a wide-format multispectral camera with an image width of 800 km. The follow-on GF-2 was launched in 2014 and reportedly has two cameras with a 1-m panchromatic and 4-m multispectral resolution capability, though it was unstated if it also possessed the GF-1's wide-format camera [11]. While the GF-1 and GF-2 have good imaging resolution capabilities, they are most likely in LEO and are not optimized for early-warning capabilities. The GF-3 is equipped with a C-band SAR, while the GF-5 has six sensors, including a hyperspectral camera and a directional polarization camera [8]. The GF-7 features an extra laser altimeter system that should enable three-dimensional research.

The GF-4 was developed in 2012 and launched into high geosynchronous orbit at 36,000 km in 2015 from China's Xichang Satellite Launch Center [12]. The satellite features a visible light camera with a resolution of 50 m and a midwave IR spectrum camera with a resolution of 400 m [9]. In addition, the GF-4 is equipped with two high-gain signal transmission antennas, which allow a data downlink rate of 300 Mbps, requiring only 3.5 seconds to complete the transmission of an image. Each image from the GF-4 covers an area of about 160,000 km^2, requiring about 60 pictures and 4 minutes to cover the western Pacific Ocean. According to one Chinese source, a GF-4 satellite is positioned in high geosynchronous orbit just south of China's Hainan province, where it can observe nearly a third of the Earth [9]. According to Henk Smid, the GF-8 and GF-11 also exist and are equipped with high-resolution capabilities; however, there is much more secrecy around these systems, possibly indicating dual use despite their purely civilian public missions [8].

The Beidou navigation system can also be considered among China's dual-use satellites. The system is an important part of China's Belt and Road Initiative Space Information Corridor and seeks to provide an alternative to the U.S.-operated Global Positioning System. The system began basic operation in 2000, while the third stage of the system was completed in June of 2020. The third stage of the project features 30 satellites in total, with 24 in MEO, 3 in inclined geosynchronous orbit, and 3 in GEO. The system was designed by the China Academy of Space Technology (CAST), a China Aerospace Science and Technology Corporation (CASC) subsidiary. According to CAST, the Beidou system can allow users to send a message of up to 1,200 characters and simple pictures and, through active positioning, provide the locations of users to the operators of the system. CAST claims the function will be used for search-and-rescue operations. Reportedly, the satellites are equipped with high-precision rubidium and hydrogen atomic clocks to improve accuracy and have an expected lifespan of 12 years [6].

2.4 Satellite Manufacturing Capacity

An exact estimate of China's satellite industrial capacity is difficult, as previously China had relied entirely on state-owned enterprises to produce satellites. CASC, China's principal entity relating to satellites, primarily relies on the 529 Factory, also known as the Beijing Satellite Manufacturing Factory Co., for production. The factory was established in 1958 and is responsible for mechanical, electronic, and thermal control product development, as well as final assembly, integration, and testing [13]. According to the CASC recruitment website, the factory has produced nearly 400 satellites in its history, including communication and broadcasting satellites, returnable satellites, earth observation satellites, scientific exploration and technology-testing satellites, and navigation and positioning satellites [14].

Another major Chinese aerospace state-owned enterprise (SOE) China Aerospace Science and Industry Corporation (CASIC) is reportedly establishing an advanced satellite manufacturing hub in Wuhan, Hubei Province. The factory is financially supported by the Wuhan government, while being owned by the CASIC Space Engineering Development Corporation. Reportedly, as part of the Wuhan government's goal of creating a local space industry worth $14 billion, the city is offering $7 million to organizations that establish manufacturing hubs in the city related to the space industry. The new CASIC factory is expected to be capable of producing 240 satellites per year when operating at full capacity [15, 16].

Beyond state-owned factories, China is also supporting private companies to continue developing its satellite manufacturing capabilities. According to analyst Josh Baughman, the Chinese government began this support in 2014 with the release of “Document 60” [17]. More recently, the Chinese government has been attempting to establish “super factories” for mass-production of satellites. In particular, Baughman identified three companies as potential forerunners in China’s satellite manufacturing drive: Geely, Galaxy Space, and Commsat [17].

Geely Technology Group, a subsidiary of the major auto company Geely, is a private commercial enterprise that received a license to produce satellites from China’s National Development and Reform Commission in 2021. Along with this license, the Chinese government made an investment totaling $326 million for the company to create a satellite production facility that draws on its previous experience producing automobiles to manufacture satellites for internet of things applications. The production facility is expected to have an annual output of 500 satellites per year [17].

Galaxy Space signed an agreement with the Nantong Economic and Technology Development Zone in July of 2020 to construct a satellite factory in Nantong, Jiangsu Province. The initial phase of construction is expected to result in a factory capable of producing up to 300 satellites a year, while future stages anticipate potential production rates of nearly 500 satellites per year. The company further anticipates a revenue of $700 million per year [17].

Finally, Commsat signed an agreement in September of 2020 to build a satellite production facility in Tangshan, Hebei Province. The company expects this factory to be capable of producing at least 100 50–500-kg satellites per year, with a focus on producing communication satellites and ground terminal components. Reportedly, the company received an investment of $39 million to establish this facility, though the article did not specify which organization provided the support [17].

If these estimates are accurate, China will be able to produce at least 1,100 satellites per year once construction is completed. However, accurate estimates are difficult to make, as these numbers are aspirational, and this does not consider China’s current production capabilities through its already established SOEs.

2.5 Major Organizations That Are Involved in the Field

In general, China's satellite field tends to be dominated by several research academies under two major SOEs: CASC and CASIC.

Founded in 1957, the CASC 1st Academy, also known as the China Academy of Launch Vehicle Technology, is the oldest launch vehicle organization in China [18]. It is best known as the developer of China's Long March family of space launch vehicles and Dongfeng family of ballistic missiles; although in recent years, it has diversified into a broad range of civilian sectors. It contains additional departments that specialize in space vehicles, rockets, and satellites.

The CASC 5th Academy, also known as the China Academy of Space Technology, is China's largest base for satellite technology and product development. The 5th Academy has contributed immensely toward developing the Beidou satellite navigation system, earth observation satellites, and communications and broadcasting satellites, including large, medium, small, and microsatellites. It played a major role in developing China's first satellite, the Dongfanghong-1, the Shenzhou-5 manned spacecraft, and the Chang'e-1 lunar exploration satellite. It contains at least 16 subsidiaries that are involved in satellite research, development, and production, including the aforementioned 529 Factory (Beijing Satellite Manufacturing Factory Co. Ltd.) [14].

The CASIC 1st Academy, also known as the China Academy of Information Technology, provides technical research, development, and production in the fields of space payloads, satellite navigation, satellite communications and information technology, and other types of information technology. It contains at least seven subordinate organizations focused on satellites, including the Beijing Aerospace Science & Industry Century Satellite Technology Company. It has at least two production facilities located in Beijing and Nanjing [19].

The CASIC 6th Academy also works in the satellite field, most notably having created the final solid stage for the Long March 1 rocket [20]. The 6th Academy has assisted in developing China's satellite-return technology and is involved in the production of high-performance fiber-optic cables, flexible functional composite materials, and intelligent internet of things products [21]. The Academy oversees five research institutes, three large-scale production enterprises, and two civilian product companies [22].

2.6 Funding, Intentions, and Priorities

Chinese funding and prioritization of the space sector have increased significantly since the beginning of the 21st century. Between the years 2000 and 2016, China's research and development spending on space-related production increased from $22.6 million to $386.6 million [4]. Likewise, patent filing related to space manufacturing increased from 10 applications in 2000 to 632 in 2016. As of 2018, China has ranked second in the world in terms of government spending on space activities, with a reported $5.8 billion. Reportedly, the Chinese government had set the goal of accounting for 15% of all satellites in orbit by 2020. However, as of 2022, it has been sitting just below 10% [23].

In recent years, the Chinese space sector has undergone a significant degree of commercialization. Between 2014 and 2021, over 100 private space-related companies were established in China, with an estimated $6.5 billion invested from outside organizations [24]. However, this amount of funding is quite small when compared to China's major space-related SOEs. According to the European Space Agency, 20% of this funding goes toward developing Earth observation technology and development of better satellite manufacturing capabilities [24]. Provincial governments also provide significant funding in an effort to establish lucrative satellite manufacturing parks in their provinces.

One major development in Chinese space capabilities has been the establishment of the PLASSF in 2016 and, in particular, its Space Systems Department. As mentioned previously, the Space Systems Department is responsible for launching, tracking, and operating Chinese military satellites, as well as research, development, and production of space-related platforms. Because of these capabilities, the PLASSF will play a significant role in the PLA's future joint operations. Reportedly, the PLA already utilizes the Beidou system for both training purposes and combat readiness preparations and anticipates its use in future combat scenarios [17].

According to information from Euroconsult, this increased attention to space-related developments is part of a larger trend in the international community [25]. The organization predicts roughly 2,500 satellites will be launched each year between 2022 and 2031—the majority of which will be from government organizations. Further, nearly 80% of satellites to be launched in this time frame will be parts of broader constellations. However, while commercialization is increasing in the space domain, most increased spending has come from larger defense budgets in recent years, a trend that is expected to continue for the foreseeable future [26].

References

[1] Union of Concerned Scientists. “UCS Satellite Database.” https://www.ucsusa.org/resources/satellite-database, accessed 17 May 2023.

[2] Anqi, F., and D. Xiaoci. "China Completes First Seaborne Hot Launch With Carrier Rocket Sending 14 Satellites to Orbit," *Global Times*, https://www.globaltimes.cn/page/202212/1281509.shtml, 9 December 2022.

[3] Woo, R., L. Zhang, and L. Gao. “China Begins Construction of Its Fifth Rocket Launch Site.” *Reuters,* https://www.reuters.com/world/china/china-begins-construction-its-fifth-rocket-launch-site-2021-04-08/, 8 April 2021.

[4] Center for Strategic and International Studies. “How Is China Advancing Its Space Launch Capabilities?” https://www.csis.org/analysis/how-china-advancing-its-space-launch-capabilities, *CSIS,* 5 November 2019.

[5] U.S. Department of Defense. “Military and Security Developments Involving the People’s Republic of China.” Annual Report to Congress, pp. 65, 66, and 94, Office of the Secretary of Defense, Arlington, VA, https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF, 3 November 2021.

[6] Xinhuanet Corporation Ltd. “China Launches Last BDS Satellite to Complete Global Navigation Constellation.” *News: Xinhuanet,* http://www.xinhuanet.com/english/2020-06/23/c_139161359.htm, 23 June 2020.

[7] Kania, E. B., and J. Costello. “Seizing the Commanding Heights: The PLA Strategic Support Force in Chinese Military Power.” *Journal of Strategic Studies*, vol. 44, issue 2, p. 31, https://www.tandfonline.com/doi/full/10.1080/01402390.2020.1747444?scroll=top&needAccess=true, 2021.

[8] Smid, H. H. F. “An Analysis of Chinese Remote Sensing Satellites.” *The Space Review*. https://www.thespacereview.com/article/4453/1, 26 September 2022.

[9] Ordnance Technology. “China’s Missile Early Warning Satellite Can Detect Large Ships at an Altitude of 36,000 Kilometers.” *Sina*, https://mil.news.sina.com.cn/zhengming/2021-02-23/doc-ikftssap8222612.shtml, 23 February 2021.

[10] Sohu, Inc. "The GF-1 Satellite Is Equipped With Two 2m Resolution Panchromatic/8m Resolution Multispectral Cameras." *Satellite Science Spectrum: The Universe,* https://www.sohu.com/a/591578345_100265683, 10 October 2022.

[11] Sohu, Inc. "Gaofen-2 (GF-2) Satellite Is Cost-Effective." *Satellite Science Spectrum: The Universe,* https://www.sohu.com/a/545243274_100265683, 9 May 2022.

[12] Weirong, Z. "China Successfully Launched GaoFen-4 Satellite." *China Defense Observation,* http://www.chinadefenseobservation.com/?p=1720, 28 December 2015.

[13] China Academy of Space Technology. "Beijing Satellite Manufacturing Plant." *CASC/CAST*, https://www.cast.cn/news/4066, 21 April 2016.

[14] China Aerospace Science and Technology Corporation Human Resources Department. "529 Factory." *CASC,* https://web.archive.org/web/20240104214203/https://www.spacetalent.com.cn/jituan_xxx.html?id=50&childDeptId=66&positionId=278, accessed 17 May 2023.

[15] Woo, R., and L. Gao "Wuhan Aims to Become China's 'Valley of Satellites' in Space Initiative." *Reuters,* edited by G, Doyle, https://www.reuters.com/technology/wuhan-aims-become-chinas-valley-satellites-space-initiative-2022-03-18/, 17 March 2022.

[16] SpaceWatch.Global GmbH. "A Sneak Peek Into China's First Smart Satellite Production Line." *SpaceWatch.Global,* https://spacewatch.global/2022/01/a-sneak-peek-into-chinas-first-smart-satellite-production-line/, 5 January 2022.

[17] Baughman, J. "China's Satellite Super Factories and U.S. National Security." *Cyber, the Magazine of the MCPA,* https://public.milcyber.org/activities/magazine/articles/2021/baughman-chinas-satellite-super-factories, 22 July 2021.

[18] Wood, P., and R. Cliff. "A Case Study of the PRC's Hypersonic Systems Development." *China Aerospace Studies Institute,* Air University, Montgomery, AL, https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Other-Topics/2020-08-25%20CASI_Hypersonic%20Case%20Study_WEB.pdf?ver=2WiFcyYi1dquXp7kfG_8UA%3d%3d, 2020.

[19] Private Equity Network. "China Aerospace Science and Industry First Academy." http://www.zhonghua-pe.com/2019/1203/233144.html, 3 December 2019.

[20] Inner Mongolia Development and Reform Commission. "CASIC 6th Academy." http://fgw.nmg.gov.cn/nmgzzqzsyzzt/qyzc/202101/t20210126_787280.html, 3 May 2011.

[21] Zhuqing, Z. "Documentary of Innovation Development of the Sixth Institute of CASIC: Raising the Backbone of Solid Power Business." *People's Daily,* http://s0citech.people.com.cn/n1/2018/1115/c1007-30403438.html, 15 November 2018.

[22] National University of Defense Technology. "CASIC 6th Academy 2021 Recruitment." https://www.nudt.edu.cn/zsjy/jyxx/2517e242f478409d92b25f9e8b7699c6.htm, 27 September 2020.

[23] South China Morning Post Publishers Ltd. "China Targets 15 pc of Satellite Launch Market." *SCMP,* https://www.scmp.com/news/china/article/1169890/china-targets-15-pc-satellite-launch-market, 2 March 2013.

[24] The European Space Agency. "China's Space Sector: Commercialisation With Chinese Characteristics." https://space-economy.esa.int/article/102/chinas-space-sector-commercialisation-with-chinese-characteristics, April 2021.

[25] Euroconsult. "Satellite Demand to Quadruple Over the Next Decade." https://www.euroconsult-ec.com/press-release/satellite-demand-to-quadruple-over-the-next-decade/, 12 December 2022.

[26] Euroconsult. "Euroconsult Predicts 10-Year Growth Cycle for Government Space Programs." https://www.euroconsult-ec.com/press-release/euroconsult-predicts-10-year-growth-cycle-for-government-space-programs/, 25 July 2019.

Biography

Thomas Corbett is a research analyst at BluePath Labs focusing on China-related projects and contracts. Previously, he has completed reports on Chinese strategic issues, Chinese politics, emerging technology, U.S.-China competition, and Indo-Pacific security concerns. Thomas has produced numerous works for the *Defense One* publication on various topics related to Chinese security issues. Prior to joining BluePath Labs, Thomas worked for both governmental organizations and public think tanks in research roles. He holds master's of arts degrees in China studies and international economics from the Johns Hopkins University School of Advanced International Studies.