

## CHAPTER 7: THE FINAL FRONTIER: CHINA'S AMBITIONS TO DOMINATE SPACE

### Executive Summary

China has embarked on a whole-of-government strategy to become the world's preeminent space power. Beijing views space as a warfighting domain and it seeks to achieve space superiority as a cornerstone of its broader effort to establish information dominance—a prerequisite to controlling the battlespace and gaining operational advantage in future conflicts. To this end, China has rapidly developed, deployed, and operationalized advanced capabilities in space launch, satellites, and ground-based infrastructure spanning its civil, military, and commercial sectors. These advancements are closing the gap in the strategic competition between the United States and China in space.

The People's Liberation Army (PLA) is rapidly expanding its space- and ground-based assets to enhance its battlespace awareness, operational coordination, and capacity for force projection. These capabilities improve China's ability to monitor, target, and challenge U.S. and allied forces across the Indo-Pacific. Over the past decade, China has launched more than 1,000 satellites, dramatically increasing its capacity for persistent surveillance, communications, and precision targeting in support of long-range strike systems. The PLA has also fielded both ground- and space-based counterspace capabilities designed to deter U.S. military action or, in the event of a conflict, degrade U.S. space-enabled operations and power projection. However, as Beijing has expanded its military space capabilities, it has also deepened its own dependency on space assets, potentially creating vulnerabilities of its own. Like any spacefaring nation, this dependency exposes China to counterspace threats that could disrupt its command and control (C2), precision strike, and situational awareness capabilities in a conflict.

Globally, China has harnessed its ambitious space program to deepen relations with developing countries and expand its space architecture in support of military, commercial, and broader strategic gains. China's rapid progress in establishing a private, though state-directed, commercial space ecosystem in just a decade poses a formidable technological, economic, and geostrategic challenge to the United States. Employing state-led industrial policy and drawing on its vast network of state-owned enterprises in aerospace and defense, China has quickly cultivated a dynamic startup sector focused on seeking to rival U.S. firms in commercial launch and satellite networks. With a growing list of civil space achievements, China is aggressively positioning itself as a

global leader in space technology and exploration. It is now seeking to reshape international space governance, influence the development of technical standards, and displace the United States as the world's premier space power.

## Key Findings

- China is pursuing an aggressive long-term, whole-of-government campaign to expand its space capabilities across military, commercial, and civil domains with the explicit intent of surpassing the United States. These rapid advances in space pose an escalating threat to U.S. national security, intensify U.S.-China strategic competition for international partnerships, and undermine the ability of U.S. commercial firms to compete internationally.
- China views space as a warfighting domain and has invested heavily in weapons and technologies that can degrade, damage, or destroy the U.S. satellites that provide the backbone of the U.S. military's C2 network as well as its targeting system. By seeking to deprive the U.S. military of the use of space-based assets, the PLA aims to deny the United States the ability to use its advanced military systems, eroding the foundations of U.S. power projection and joint operations.
- Over the past ten years, China has launched a wide variety of satellites on an aggressive schedule, fielding a growing array of space-based capabilities that has strengthened its ability to coordinate its own operations as well as to conduct the persistent surveillance and targeting of U.S. forces. The expansion reflects China's broader strategy to achieve space superiority and strengthen its ability to use long-range precision weaponry to target and disrupt the flow of U.S. forces in the Indo-Pacific.
- China is actively leveraging its space capabilities as strategic tools to expand its geopolitical influence. Through offering other countries the use of its satellite networks, launch services, and space infrastructure, China enhances the resilience and global coverage of its space architecture. At the same time, it draws partner nations more deeply into its technological ecosystem, creating long term strategic and economic dependencies on Chinese technology.
- China's military-civil fusion strategy erases the line between military and civilian space activities, enabling systems and technologies such as satellites, robotic arms, and launch systems to serve both commercial ends and PLA objectives. The dual-use nature of these systems—compounded by blurry lines between state-owned enterprises and nominally private firms—makes it difficult to distinguish commercial innovation from military capability.
- In just ten years, China has dramatically transformed an almost non-existent commercial space sector into a thriving, state-orchestrated startup ecosystem. Fueled by strong govern-

ment backing and industrial prowess, Beijing is now seeking to cultivate national champions that will challenge U.S. space companies on the global stage at a fraction of the cost. This strategy does not just seek innovation and commercial advancement—it seeks to reshape the competitive balance in what will be the most strategic domain of the 21st century.

- China has achieved major civil space milestones, such as the Chang'e-6 mission returning the first samples from the Moon's far side. These "global firsts" are much more than just about science; Beijing uses them to assert technological leadership to reshape global perceptions of power. The competition now extends beyond symbolic milestones to a contest over who will define the rules, infrastructure, and norms governing space. If the United States cedes leadership, China is poised to advance a state-driven, opaque governance model that could embed long-term global reliance on its systems and standards.
- Losing U.S. leadership in space would amount to relinquishing the advantage first secured during the original space race. China seeks to use its rapid advancements in space to position the country as a technological powerhouse and undermine U.S. prestige and economic competitiveness. Falling behind in space would not only diminish U.S. standing, it would also threaten U.S. national security, global influence, technological dominance, and commercial competitiveness in the growing space economy.

## Introduction

The Soviet launch of Sputnik in 1957 shocked the United States, driving then-President Dwight Eisenhower to accelerate space efforts. These initiatives were later expanded under then-President John F. Kennedy, who undertook a "Space Race" to the Moon to demonstrate to the world that the U.S. model for economic development and technological innovation was superior to that of the Union of Soviet Socialist Republics and worth emulating.<sup>1</sup> For over half a century, space has existed in the popular imagination as the "final frontier"—the last realm for humankind to explore and harness in favor of human progress.<sup>2</sup> Through rapid experimentation, technological advancement, visionary government support, and determination, the United States became the world's premier space power, bestowing many benefits on U.S. citizens, advantages to the U.S. military, and global prestige for the United States and its economic, innovation, and governance models. This leadership position secured during the Cold War is now at risk due to China's rapid advances in space.

China has undertaken a rapid and multifaceted expansion across its military, civil, and commercial space sectors that is presenting a comprehensive challenge to U.S. space leadership. This growing competition reflects the broader strategic rivalry between the United States and China as both countries view the space domain as critical to national security, economic growth, and global influence. If

the United States does not rededicate itself to winning the new race, it will surrender its military advantage, jeopardize critical space-based infrastructure, undermine key sectors of the U.S. economy, and be subject to a space environment increasingly shaped by China's strategic priorities for years to come.\*

## Intensifying U.S.-China Competition in Space

### China's Rapid Advancements in Space Capabilities Should Concern Every American

Most Americans depend on space far more than they realize. Many may think of GPS navigation and weather forecasting, but many do not comprehend the scope and breadth of our reliance on space. Cell phones, the internet, and streaming services routinely use satellites to increase the speed and resiliency of their networks. Banks, stock markets, and online payment services rely on satellites to ensure secure transactions. Utility companies rely on control systems that communicate via satellite to monitor energy flows and reroute electricity across power grids. Farmers use satellite imagery to monitor crop health, optimize fertilization and irrigation, and plan harvesting schedules. Airlines, railroads, and shipping and logistics companies use satellites to navigate, optimize routes, and track cargo. The U.S. military relies on space for a wide range of missions, including navigation, global communications, intelligence gathering, early warning, and targeting weapons systems, to name but a few. These capabilities are vital, especially in the context of a Western Pacific contingency, where long distances and dispersed forces require resilient space-based systems to coordinate military operations, monitor and target adversary movements, and project power effectively.

So, what are the risks to the United States if it is no longer the dominant space power? General B. Chance Saltzman, Chief of Space Operations of the U.S. Space Force, put it starkly: "Space superiority is not only a necessary precondition for Joint Force success but also something for which we must be prepared to fight. Gained and maintained, it unlocks superiority in other domains, fuels Coalition lethality, and fortifies troop survivability. It is therefore the basis from which the Joint Force projects power, deters aggression, and secures the homeland."<sup>3</sup>

#### Key Space Concepts

The space ecosystem involves interconnected sets of capabilities and assets. Below is a basic discussion of key space concepts and how they inter-relate.

- *Space-based assets:* These include satellites,<sup>†</sup> vehicles, and payloads in orbit that deliver mission-critical capabilities from space. Space-based assets include various types of satellites, including those dedicated to communications; intelli-

\*The chapter draws on the Commission's April 2025 hearing on "The Rocket's Red Glare: China's Ambitions to Dominate Space," consultations with experts, and open source research and analysis.

<sup>†</sup>Simply defined, a satellite is a body that orbits around another body in space. Catherine G. Manning, "What Is a Satellite?" NASA, September 5, 2018.

### Key Space Concepts—Continued

gence, surveillance, and reconnaissance (ISR); position, navigation, and timing (PNT); and those hosting sensors, such as for weather observation, as well as those that provide on-orbit support capabilities. While some space-based assets are solely designed for military use, others may support both military and civilian uses. This is particularly true of PNT satellites as they support systems like the U.S. Global Positioning System (GPS), which provides targeting data to the U.S. military, but also provides data to civilian companies that offer navigation services to U.S. consumers. Many civilian satellites are also capable of supporting military activities, if called upon.

- *Orbit types:* Different orbital regimes support different mission sets. In recent years, there has been increased focus and investment in “proliferated low Earth orbit” (pLEO) satellite constellations to enable global broadband, persistent surveillance, and resilience through redundancy. Other examples include medium Earth orbit, useful for PNT capabilities, and geo-stationary orbits used extensively for weather monitoring and communications. While space seems vast and limitless, orbit locations are a scarce resource. The International Telecommunications Union (ITU) is a specialized agency of the UN through which countries allocate radio frequency spectrum and coordinate orbital positions.
- *Deep Space:* A subset of space assets are those used in deep space, generally understood to mean beyond the Earth’s orbit and beyond “cislunar” space (defined as the areas of space between the Earth and the Moon). To date, deep space assets are generally used for science and civil space exploration (i.e., not commercial or military uses), though in recent years, commercial entities have begun planning deep space missions.
- *Launch:* Launch refers to the systems that propel assets from Earth into space, including the ground-based facilities that support launch operations. Launch technology varies depending on the size of the payload and the distance into space it must travel. The United States and China are both investing heavily in reusable launch vehicle (RLV) technologies. SpaceX is currently the global leader in these technologies, which provide cheaper and faster launch options, enabling greater activity in space.
- *Ground-Based Infrastructure:* This includes the terrestrial systems that link, connect, and communicate with space-based assets. These include ground stations that conduct telemetry, tracking, command and control, provide space-domain awareness (i.e., the ability to detect, track, and identify objects and threats in orbit), and receive down-links from satellites. Ground-based infrastructure is necessary for communication with and/or control of space-based assets.

China recognizes how dependent the U.S. general public and U.S. military are on space-based assets for day-to-day activities. Just as China has invested heavily in cyber tools to exploit U.S. reliance on the internet, China has invested heavily in counterspace capabilities—kinetic and non-kinetic weapons that can deny, degrade, or destroy U.S. satellites. Many U.S. satellites have limited defensive capabilities as many were deployed when the United States viewed space as a benign environment, not a warfighting domain.<sup>4</sup> The United States has also not markedly changed its restrictive guidance and direction that has long sought to avoid the perception of “weaponizing” space, leaving the United States with no real offensive space program of its own.

China leverages its bold space program to advance both domestic and international security goals. Under General Secretary of the Chinese Communist Party (CCP) Xi Jinping, space exploration has been closely tied to the “China Dream” of national rejuvenation with high-profile missions—such as lunar sample returns and the construction of a space station—used to showcase Party leadership, reinforce domestic confidence, and signal China’s rise as a global scientific and technological power. Internationally, these accomplishments are used to build prestige, grow China’s space economy, support efforts to reshape global space governance to reflect China’s interests, and position China as a strategic rival to the United States. Over the past decade, China has systematically expanded its space capabilities across military, civil, and commercial sectors. It has launched satellite constellations that provide global communications and navigation, deployed sophisticated counterspace weapons, and is developing a rapidly growing commercial space sector that could challenge U.S. leadership within the decade.<sup>5</sup> Enabled by a state-directed model and its military-civil fusion strategy, this holistic approach reflects China’s ambition to establish itself not only as a space power, but also as a global leader in science and innovation, using space development to boost its comprehensive national strength and international influence.<sup>6</sup>

## **China’s Military Has Rapidly Developed Space Capabilities**

“Mind-boggling.”<sup>7</sup> That is the word General Saltzman used in testimony before the Commission to describe China’s rapid military buildup of its space capabilities over recent years.<sup>8</sup> He added, “[China’s] potent and expanding arsenal of space-based capabilities multiplies its combat potential many times over” and threatens the U.S. military’s access to—and effective use of—space in conflict.<sup>9</sup>

Over the past ten years, China has launched increasing numbers of satellites—with more than 1,060 satellites in orbit as of December 2024—significantly enhancing the PLA’s use of space for warfighting.<sup>10</sup> These satellites support both intelligence, surveillance, and reconnaissance (ISR) and positioning, navigation, and timing (PNT) missions as well as provide a suite of counterspace capabilities that could monitor, target, deny, degrade, or destroy U.S. and allied space assets.

The PLA’s growing space capabilities undermine the U.S. military’s ability to rely on the space assets that are integral to the suc-

cess of its operations and force projection across all domains—land, air, sea, cyber, and space.<sup>11</sup> The degradation or destruction of U.S. space assets could prevent U.S. forces from fully seeing the battlefield, guiding munitions, providing missile warning, and supporting global command and control (C2). This could severely limit U.S. and allied forces in their ability to respond rapidly in any theater of operations, particularly in the Indo-Pacific.<sup>12</sup>

### **The PLA Views Space as a Critical Warfighting Domain and Seeks Space Superiority**

Although the PLA has long viewed space as a critical war fighting domain, China's test of an anti-satellite weapon in 2007 marked its growing ambitions in space.<sup>13</sup> China's military space program dates back to the 1950s, when it began the development of its first nuclear weapons. In 1970, China launched its first satellite and, in the 1990s, began development of various anti-satellite vehicles and possible directed-energy weapons.<sup>14</sup> General Saltzman referred to China's 2007 successful anti-satellite weapon (ASAT) test as a "pivot point" that demonstrated China's destructive capability using an offensive missile in space, creating the largest debris field in space and threatening other space assets in orbit.<sup>15</sup> In 2015, China published a Defense White Paper that was the first official government document to lay out the need for an advanced military space program, referring to outer space as one of the "new commanding heights in strategic competition" and describing these revolutions in military affairs—such as informationized warfare, precision strike capabilities, and space-enabled operations—as posing "new and severe challenges to China's military security."<sup>16</sup> The PLA's creation of the Strategic Support Force (SSF) in December 2015 and its subsequent reorganization as the Aerospace Force in April 2024, further solidified the integration and increased role of space capabilities in military operations.<sup>17</sup>

For the PLA, achieving space superiority is important to establish the information dominance that would allow it to control the battle space and gain operational advantage in wartime.<sup>18</sup> The 2020 edition of the strategic-level PLA textbook *Science of Military Strategy* highlighted the importance of space control, noting that without it, information control would be impossible, and consequently air control, sea control, and land control would quickly fall one after another.<sup>19</sup> PLA strategists also advocate targeting space systems such as communication satellites, early warning platforms, and reconnaissance assets, viewing them as critical nodes in the enemy's command, control, and intelligence capabilities.<sup>20</sup> China's expanding military space capabilities advance its warfighting concept of multi-domain precision warfare, enabling the PLA to exploit key vulnerabilities in an adversary's "network information system-of-systems."<sup>21</sup> China's development and expansion of its space and counterspace strategies and capabilities reflect how the PLA may conduct multi-domain precision warfare and target U.S. space assets as a means to deter and counter a U.S. military intervention during a regional military conflict.\*<sup>22</sup>

\*For more on China's military capabilities for "counter-intervention" designed to undermine the U.S. military's ability to become involved in a conflict between China and its neighbors, see U.S.-China Economic and Security Review Commission, Chapter 8, "China's Evolving Counter-Intervention Capabilities and the Role of Indo-Pacific Allies," in *2024 Annual Report to Congress*, November 2024, 552–561.

## The PLA Has Vastly Expanded its ISR and PNT Satellite Constellations

The PLA has acted with urgency to develop overhead intelligence, surveillance, and reconnaissance (ISR) capabilities to ensure it can persistently monitor U.S. and allied activity in the Pacific region.<sup>23</sup> Overhead ISR space systems provide support to warfighters through the collection and processing of signals and imagery, monitoring adversary weapons and force movements, generating accurate targeting data, and enabling battle damage assessments.<sup>24</sup>

Over the past decade, the PLA has rapidly increased the number and capabilities of satellites in orbit. The number of Chinese satellites in orbit since the end of 2015 has increased by approximately 620 percent (+875 satellites), with more than 1,060 satellites in orbit as of December 2024.<sup>25</sup> Currently, China has about 510 ISR-capable satellites equipped with a variety of optical, multispectral, radar, and radio frequency sensors that benefit the PLA, increasing its ability to detect U.S. military assets in the air and sea, including aircraft carriers, expeditionary forces, and air wings.<sup>26</sup> In addition, China has expanded its ISR capabilities by launching synthetic aperture radar (SAR) remote-sensing satellites in geostationary orbit (GEO) that offer higher-resolution imagery and persistent, all-weather condition surveillance.<sup>27</sup> In December 2023, China launched the Yaogan-41,\* its fourth optical surveillance satellite in GEO, which likely provides China with continuous surveillance of the Pacific and Indian oceans and the ability to identify and track car-sized objects, including U.S. military assets.<sup>28</sup> The PLA's increased investment in, and deployment of, remote sensing ISR capabilities means that even as U.S. forces in the Indo-Pacific are shifting to a more distributed, resilient posture, it is increasingly difficult for them to be undetected in the region.<sup>29</sup>

In addition to ISR, China has developed positioning, navigation, and timing (PNT) capabilities to ensure its forces and weapons platforms are able to navigate and more accurately target and achieve operational objectives across the globe. The third generation of BeiDou satellites, China's competitor to the U.S. Global Positioning System (GPS), achieved full operational capacity in 2020.<sup>30</sup> BeiDou's 49 operational satellites provide global, high-accuracy, all-weather, PNT services.<sup>31</sup> BeiDou has increased the PLA's capabilities to conduct precision strikes globally and offers the PLA global coverage for coordinated operations and maneuver across multiple theaters.<sup>32</sup> BeiDou's short messaging service could also provide real-time updates for missile systems and allow military operators to provide commands to autonomous weapons, enhancing the PLA's global command and control of weapons systems.†<sup>33</sup>

\*China referred to Yaogan-41 as a remote sensing satellite for civilian purposes such as land surveying, crop yield estimation, meteorological warning and forecasting, and disaster prevention and reduction. The Yaogan satellites have dual-use purposes, likely serving as electronic intelligence satellites for the PLA. Tate Nurkin et al., "China's Remote Sensing," *OTH Intelligence Group LLC* (prepared for the U.S.-China Economic and Security Review Commission), December 16, 2024, 55; "China Launches New Remote Sensing Satellite," *Xinhua*, December 15, 2023; Clayton Swope, "No Place to Hide: A Look into China's Geosynchronous Surveillance Capabilities," *Center for Strategic and International Studies*, January 19, 2024.

†BeiDou could also be used for anti-submarine warfare and subsurface navigation for tracking underwater vessels. Kevin Pollpeter, "To Be More Precise: BeiDou, GPS, and the Emerging Competition in Satellite-Based PNT," *China Aerospace Studies Institute*, May 2024, 36–37, 41–42.

### **The Inherent Dual-use Nature of China's Space Program**

Under China's military-civil fusion strategy, rather than maintaining a strict separation between sectors, China leverages its civilian and commercial industries to advance national defense and security capabilities.<sup>34</sup> As a result, many advancements and tests of space systems that are framed as having civil or commercial purposes may have potential military applications as well. The inherent dual-use nature of these technologies and programs is further complicated by blurry distinctions between state-owned enterprises (SOEs) and commercial companies—due to overlapping funding, firms founded by former SOE employees, or SOE spinoffs—which obscures the line between civilian and military activities.<sup>35</sup> The Party's oversight of commercial companies also gives it great influence in ensuring that commercial activities align with national policies and objectives. Civilian and commercial capabilities—including satellites, launch systems, ground stations, and on-orbit servicing technologies—support legitimate civil purposes such as communication, navigation, and maintenance operations, but they could also be adapted for military applications, such as targeting missiles, tracking adversary submarines, or disrupting and maneuvering adversary satellites. Specific examples of these dual-use systems and their applications are provided throughout this chapter.

While China's ISR and PNT systems provide high-resolution, persistent surveillance in the Indo-Pacific region, the build out of its global coverage holds serious consequences for U.S. global force posture.<sup>36</sup> A truly global ISR and PNT capability would be a major component of the PLA's expanding Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) infrastructure and support its efforts to develop what has variously been called a space "kill mesh" or "kill web." China's aspiration is to create an integrated, resilient network that would automatically collect, integrate, and analyze information from ISR and PNT satellites and rapidly distribute it to weapon systems to provide the PLA with accurate, space-enabled targeting of U.S. forces using its long-range precision weapons. China has designed its satellite constellations to focus coverage on the Western Pacific region, but as it launches additional satellites into a greater variety of orbits—and makes corresponding advancements in the other aspects of its C4ISR network—the "kill mesh" will provide broader coverage, enhanced precision, and increased resiliency to PLA operations. General Saltzman assessed that China's full deployment of such a space-enabled targeting network could "prevent [U.S.] forces from taking meaningful action before they even reach theater."<sup>37</sup> He further warned that if the threat posed by the network is not mitigated, it would mean U.S. military objectives "will be tough to meet" without significant threat of major U.S. casualties.<sup>38</sup>

## The PLA Has Invested Heavily in Counterspace Capabilities

Over the past two decades, China has invested heavily in capabilities to deny, degrade, or destroy U.S. satellites. Those capabilities would allow China to incapacitate U.S. communications, PNT, and ISR satellites (including those providing early warning of missile launches) as well as to undermine the ability of the United States to conduct joint operations and project power.<sup>39</sup>

China has continued to invest in a broad range of counterspace capabilities, including ground-based and space-based kinetic, radio frequency, and directed energy systems.<sup>\*40</sup>

- *Kinetic*: China has at least one, if not three, programs underway to develop direct-ascent anti-satellite (DA-ASAT) capabilities.<sup>41</sup> U.S. intelligence has assessed that by 2021, China had the capability to field ground-based ASAT missiles that could target and destroy satellites in low Earth orbit (LEO), and that the PLA intends to field ASAT weapons with the capability to destroy satellites in geostationary orbit (GEO) at 36,000 kilometers (about 22,369 miles).<sup>42</sup> The U.S. Department of Defense (DOD) assessed that since 2006, China has been researching space-based kinetic weapons, including technical areas such as reentry methods, payload separation, delivery vehicles, and transfer orbits—all of which are necessary to make space-based kinetic operations effective.<sup>43</sup> China has also conducted tests of satellite operations that could lead to a co-orbital anti-satellite capability, such as satellite maneuvers and rendezvous and proximity operations (RPOs) that could change the orbital trajectory of another satellite.<sup>†44</sup> China has been experimenting with on-orbit satellite maneuvers since 2010.<sup>45</sup>

### Robotic Arms and Rendezvous Operations: Civilian Maintenance Tools or Anti-Satellite Weapons?

China uses robotic arms powered by artificial intelligence (AI) for various civil space missions including satellite maintenance, refueling, and removal of space debris. Robotic arms have been used on China's Tiangong space station to support assembly, maintenance, and operations in orbit.<sup>46</sup> Orbital analysts and U.S. officials believe that in 2022, China's SJ-21 satellite was conduct-

\*Kinetic counterspace capabilities refer to two systems that run together to create an explosion or destructive force. Radio frequency weapons emit an intense focused beam of microwave energy that could cause damage to electronic circuitry. Directed energy weapons refer to systems that utilize concentrated beams of electromagnetic waves, such as lasers or particle beams that could dazzle or damage a satellite's sensors or systems. Secure World Foundation classifies radio frequency weapons as a type of directed energy weapon. Other counterspace capabilities include cyber activities that could interfere with a satellite's computer networks or disrupt the ability of a satellite or ground station to collect, process, and disseminate data. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 26; "Global Counterspace Capabilities," *Secure World Foundation*, April 2025; Jennifer DiMascio, "U.S. Counterspace Capabilities," *Congressional Research Service* (Report No. IN12420), September 11, 2024, 1.

†However, Secure World Foundation assessed that public evidence suggests China has not conducted an actual destructive intercept of a target indicative of a co-orbital ASAT capability and states there is "no proof that these technologies are definitively being developed for counterspace use as opposed to intelligence gathering or other purposes." "Global Counterspace Capabilities," *Secure World Foundation*, April 2025.

**Robotic Arms and Rendezvous Operations:  
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ing sophisticated rendezvous and proximity operations (RPO),\* using a robotic arm to capture and tow another object.<sup>47</sup> Although RPOs can be used for peaceful operations like inspection, repair, refueling, upgrades, or removal of space debris, they also have the potential for military purposes such as disabling or interfering with another country's satellites.<sup>48</sup> SJ-21's ability to dock with and tow a satellite introduces a potential counterspace capability that would allow China to disable a satellite without generating dangerous space debris or the associated reputational cost.<sup>49</sup> In counterspace operations, avoiding debris or international backlash is strategically valuable, making SJ-21's capabilities appealing for low-visibility, high-impact interference. In 2024, the U.S. Space Force reported that China conducted its first proximity operations involving five satellites, three Shiyao-24C and two Shijian-6 05A/B, in synchronized maneuvers in LEO.<sup>50</sup> This shift from simple two-satellite rendezvous to complex, coordinated movements signals China's advancing dual-use space capabilities and suggests potential for future "dogfighting" tactics intended to maneuver near or potentially interfere with other satellites, threatening the security and stability of space assets for strategic gain.<sup>51</sup> Despite China's peaceful framing of robotic arms and RPOs, SJ-21 demonstrates that these technologies and operations are inherently dual use, posing complex challenges for space security and military stability by enabling covert, reversible interference with adversary satellites without creating debris.

- *Radio frequency:* China has significant electronic warfare counterspace capabilities that can be directed against global navigation satellite systems and satellite communications.<sup>52</sup> The PLA regularly incorporates radio frequency jammers targeting space-based communications, radars, and navigation systems during military exercises.<sup>53</sup> Ground-based cyber and electronic warfare can also be used to degrade satellite services by interfering with an adversary's telemetry, tracking, and control (TT&C)† ground stations and jamming uplink and downlink communications with satellites.<sup>54</sup> DOD reported that China is probably developing jammers to target adversary synthetic aperture radar (SAR) satellites to protect its own ground-based assets from being imaged and targeted during a conflict.<sup>55</sup> China could use RPO satellite capabilities to position radio frequency jammers close to an adversary satellite, amplifying its ability to interfere with communications.<sup>56</sup>
- *Directed energy:* Lasers offer significant potential for military counterspace applications. Ground-based laser systems are ca-

\*RPO refers to the operation of two (or more) independent space objects that purposefully maneuver to within close "proximity" of each other via various rendezvous techniques.

†TT&C facilities use antennas to communicate with satellites by sending commands and receiving data. They can only track and manage satellites to which they are connected and cannot monitor space debris or satellites operating on different frequencies.

pable of dazzling or blinding Earth-orbiting satellites and can inflict thermal damage on most LEO satellites.<sup>57</sup> DOD assessed that the PLA has multiple ground-based laser weapons capable of disrupting, degrading, or destroying satellites and may also possess limited capabilities to target satellite sensors directly.<sup>58</sup> These lasers could provide a non-kinetic means of attack that is hard to detect and difficult to trace back to the source.<sup>59</sup>

### **The U.S. Approach to Counterspace Operations**

While China has continued to actively pursue both offensive and defensive counterspace capabilities, the United States has refrained from developing an offensive space program and has dutifully sought to avoid actions that could be seen as “weaponizing space.” This position was originally rooted in the principles for the peaceful use of outer space and later tied, especially during the Cold War, to the notion that satellites were stabilizing, as they would provide early warning of a nuclear strike and allow time for a response.<sup>\*60</sup> Thus, an attack on those satellites could be interpreted by an adversary as a sign of an imminent nuclear strike.<sup>61</sup>

However, as the space environment has evolved and is now seen by China as a warfighting domain, the U.S. Space Force is spearheading a new approach to counterspace operations to meet the growing threats to U.S. space assets.<sup>62</sup> In March 2025, the U.S. Space Force released a framework on space warfighting that emphasized the need to establish space superiority and described counterspace operations as essential to joint operations. The framework said the United States needed to be able to undertake offensive actions to disrupt, degrade, deny or destroy enemy counterspace capabilities and other space assets that support their military forces as well as defensive actions to protect friendly space capabilities from attack, interference, and unintentional hazards.<sup>63</sup> In testimony before the Commission, General Saltzman stated that much of the U.S. Space Force’s time and effort has been spent on delivering services, which has consequently led to underfunding of capabilities to defeat an adversary’s counterspace weapons.<sup>64</sup>

### **China’s Growing Dependency on Space Creates Vulnerabilities of its Own**

While U.S. space assets may increasingly be held at risk by the PLA’s space buildup, China has also exposed itself to vulnerabilities due to its own growing dependency on space assets that could be exploited by changes to the U.S. military’s approach to offensive and defensive space operations. As the PLA has increased the number and capabilities of satellites in orbit, it has become increasingly reliant on its space-based ISR, PNT, and communication satellites for its own joint warfighting.<sup>65</sup> The PLA’s long-range strike capabilities

\*The United States formally committed to the peaceful use of outer space with the signing of the Outer Space Treaty on January 27, 1967, which entered into force on October 10, 1967. U.S. Department of State, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, accessed August 28, 2025.

depend on ISR satellites for targeting and damage assessments, as well as communications for command and control (C2), and PNT to enable precision strikes.<sup>66</sup>

China's growing dependency on space may, in turn, also help deter escalatory activities in space. In a study assessing how the United States could deter China's use of force in space, Kevin Pollpeter, Director of Research at the U.S. Air University's China Aerospace Studies Institute, suggested that as China's dependency on its space assets increases, the ability of the United States to deter China from attacking space assets could also increase.<sup>67</sup> Mr. Pollpeter assessed that due to its advancements, China may be more reluctant to engage in escalatory behavior in space that risks a widening space war.<sup>68</sup> In his testimony to the Commission, General Saltzman noted that China has developed such a need for its space capabilities that the idea of irresponsible space behavior may be starting to affect the way the PLA views the space domain.<sup>69</sup> General Saltzman cited Russia's 2021 anti-satellite test as an example of irresponsible behavior that China could view as jeopardizing the way it may want to use space.<sup>70</sup>

### **China Uses Its Space Program to Leverage Relations with Developing Countries to Accrue Military Advantages and Geopolitical Influence**

China is actively cultivating space partnerships with developing countries as part of its broader strategy to expand its global influence. A central part of this effort is the Belt and Road Initiative (BRI) Spatial Information Corridor, also known as the Space Silk Road.<sup>71</sup> This initiative consists of constructing a global network of ground infrastructure across BRI countries to support Chinese space operations, which strengthens Beijing's ties to developing countries while enhancing its satellite, navigation, and remote sensing capabilities.<sup>72</sup> To entice countries to participate in the Space Silk Road, China offers free access to the BeiDou satellite navigation network as well as a wide range of services to partner countries including satellite communications, Earth imaging, and broadcasting capabilities, while encouraging regular reliance on, purchase of, and integration of Chinese satellite data into their own government and commercial operations.<sup>73</sup> Additionally, partner countries receive low-cost internet and telecommunications services as well as the ability to launch their own satellites using Chinese systems.<sup>74</sup> For many developing countries with limited means to build out their own indigenous space technologies, China presents an attractive option for securing access to space-based services.

In Africa, for example, China has been active in pursuing its space partnerships as part of the Space Silk Road. This year, China completed a satellite production facility in Egypt that manufactures satellites with remote sensing capabilities that can be used for defense intelligence gathering.<sup>75</sup> On April 20, 2025, the African Union opened the African Space Agency (AfSA) near Cairo, Egypt, to serve as the primary point of contact for other nations and organizations.<sup>76</sup> The agency's location is strategically significant, as it sits near the Chinese-funded satellite production facility in Egypt. This new institution will likely serve as a forum for deepening China-Af-

rica space collaboration as Beijing aims to position itself as a key partner in serving the region's space development needs.<sup>77</sup>

While China markets the Space Silk Road as supporting a wide range of civilian sectors—agriculture, disaster response, port logistics, telemedicine, transportation, financial services, and urban planning, to name a few—the PLA undoubtedly could benefit from the enhanced situational awareness and extended operational reach these capabilities provide across BRI regions.<sup>78</sup> In addition, China often promotes satellite services that are interoperable with its telecom, AI, and data platforms—such as Huawei's technology integrated into BeiDou applications. This enables China to essentially market an exportable tech ecosystem that extends beyond the space sector, creating long-term economic and strategic dependencies on Chinese technology and magnifying concerns about data security.<sup>79</sup> General Saltzman warns that there are significant strategic implications to China's expanding space partnerships, emphasizing that other countries' choices to adopt BeiDou are not merely technology issues, but also reflect deeper geopolitical alignment.<sup>80</sup> This strategy not only strengthens the resilience and global coverage of China's space architecture but also binds partner nations more deeply into Beijing's technological ecosystem.

### **BeiDou Seeks to Displace GPS as the World's Dominant Satellite Navigation System**

Originally designed to protect national security by providing the PLA with navigation and targeting capabilities, China's global satellite navigation system, the BeiDou Navigation Satellite System (BDS), has been increasingly marketed for commercial and scientific purposes in recent years.<sup>81</sup> China has offered BeiDou services as a key component of the Space Silk Road, claiming it offers affordable satellite services, equipment, and training to users globally.<sup>82</sup>

As of 2025, BeiDou has 49 operational satellites in orbit, significantly more than the U.S. GPS system's 31 operational satellites, and a global network of monitoring stations, many of which are located in developing countries.<sup>83</sup> China is using BeiDou as a strategic tool to expand its geopolitical influence, particularly in Southeast Asia, Africa, and other developing regions. It integrates BeiDou into economic development, infrastructure, and training programs through bilateral agreements and regional forums. As of 2019, China had signed agreements with 120 partners to use BeiDou satellites.<sup>84</sup> In 2021, Beijing hosted the first China-Africa BDS Cooperation Forum, which was attended by representatives from nearly 50 African countries and promoted BeiDou's role in economic and environmental development.<sup>85</sup> In Southeast Asia, countries such as Thailand, Brunei, Laos, Indonesia, and Malaysia have expanded cooperation through platforms like the China-ASEAN Technology Transfer Forum and the Mekong-Lancang Cooperation Forum.<sup>86</sup> China has also promoted BeiDou in Central Asian and Arab regions through similar forums.<sup>87</sup>

China is aggressively seeking to expand the use of BeiDou beyond navigation and transform it into a core component of its

### **BeiDou Seeks to Displace GPS as the World's Dominant Satellite Navigation System—*Continued***

global digital infrastructure. The upcoming BeiDou-4 constellation aims to provide more precise, resilient, and reliable positioning services, which will improve accuracy from meters to decimeters and expand applications for use in aerospace, maritime, and autonomous systems.<sup>88</sup> These upgrades could further reduce global reliance on the United States' GPS system, strengthen China's appeal as a space technology partner, and expand Beijing's ability to set technical standards in global navigation and positioning infrastructure.

China is actively working to grow its commercial space sector, including launch services, satellite manufacturing, and downstream applications, as part of a broader strategy to expand its global market share and reduce reliance on Western systems.<sup>89</sup> Currently, China Great Wall Industry Corporation, a subsidiary of the state-owned China Aerospace Science and Technology Corporation, is the primary commercial provider of international satellite services, offering launch, construction, and operational support to countries such as Pakistan, Nigeria, and Venezuela.<sup>90</sup> China's international expansion of its space services acts as a force multiplier for its geopolitical ambitions. Through a heavily state-led model, Beijing closely coordinates military, civil, and commercial activities—enabling civilian space services to directly support the PLA's goals while being marketed globally as purely commercial services. By embedding dual-use technologies in partner nations' infrastructure, China boosts its global space market share, gains access to sensitive data, and draws developing countries deeper into its geopolitical and economic orbit.<sup>91</sup>

### **China Uses Ground Infrastructure to Support Space Activities as Well as Advance Geopolitical Objectives**

In testimony before the Commission, Victoria Samson, Chief Director of Space Security and Stability at Secure World Foundation, noted that China often builds ground infrastructure and hosts satellites for other countries in regions that are rich in natural resources or have strategic value.<sup>92</sup> This approach allows China to gain access to those resources and collect sensitive data or communications that can be used to exert diplomatic leverage and secure support for its broader geopolitical objectives.<sup>93</sup> China's network of ground stations supports satellite constellations like BeiDou, as well as Earth observation and communications platforms, by enabling faster and more robust data transfer and enhancing China's ability to perform critical telemetry, tracking, and command (TT&C) functions.<sup>94</sup> China currently operates or is developing overseas ground stations in South America, Africa, and the Asia-Pacific.<sup>95</sup> Previously, China had access to ground stations operated by the Swedish Space Corporation in Sweden, Chile, and Australia, but in September 2020 the company decided not to renew its contract with China, citing geopolitical changes and security concerns.<sup>96</sup>

Figure 1: Map of Space Cooperation with China

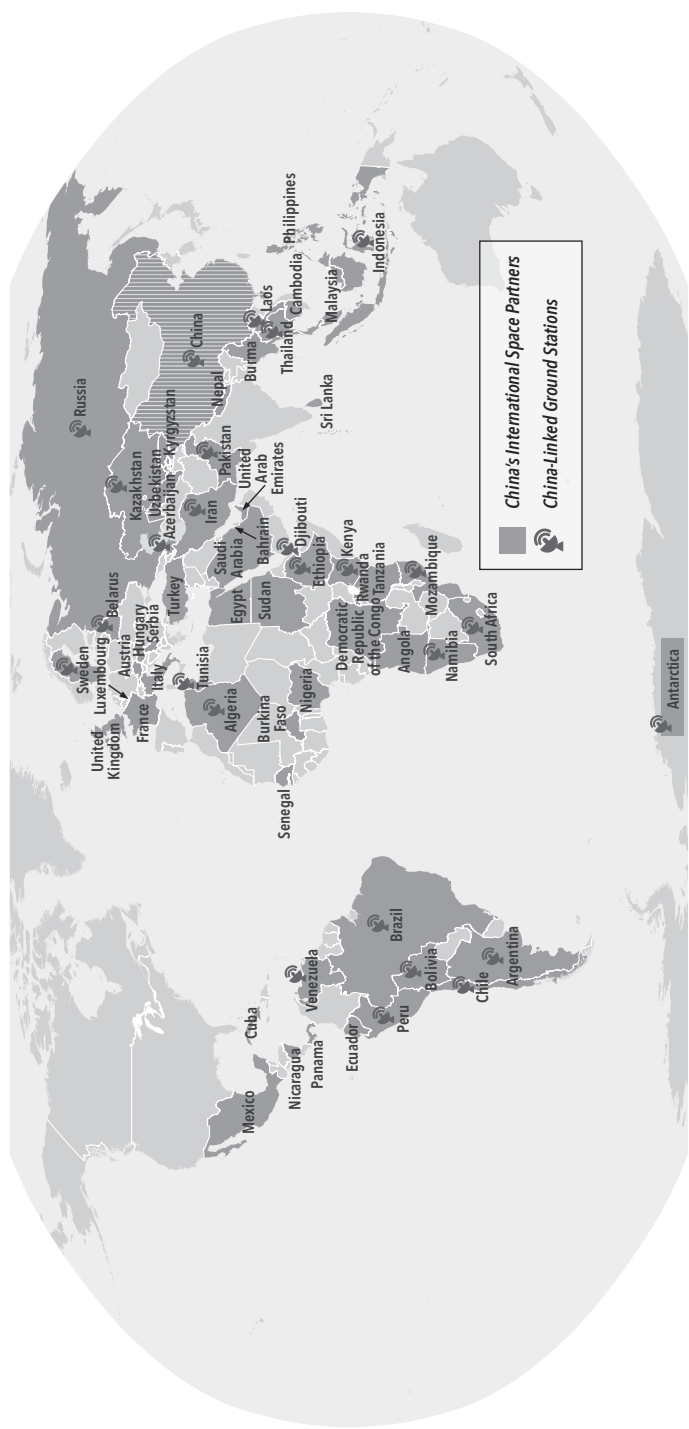


Table 1: Breakdown of Areas of Space Cooperation with China

| <u>Country</u>  | <u>Ground Station</u> | <u>Satellite/Launch</u> | <u>Partnership</u> |
|-----------------|-----------------------|-------------------------|--------------------|
| Algeria         | X                     | X                       | X                  |
| Angola          |                       |                         | X                  |
| Antarctica      | X                     |                         |                    |
| Argentina       | X                     | X                       | X                  |
| Austria         |                       |                         | X                  |
| Azerbaijan      | X                     |                         | X                  |
| Bahrain         |                       | X                       | X                  |
| Belarus         | O                     | X                       | X                  |
| Bolivia         | X                     | X                       | X                  |
| Brazil          | X                     | X                       | X                  |
| Burkina Faso    |                       | O                       | X                  |
| Burma (Myanmar) |                       |                         | X                  |
| Cambodia        |                       | □                       | X                  |
| Chile           | □                     |                         | □                  |
| Cuba            |                       |                         | X                  |
| DRC             |                       | O                       |                    |
| Djibouti        | O                     | X                       |                    |
| Ecuador         |                       |                         |                    |
| Egypt           | X                     | X                       | X                  |
| Ethiopia        | X                     | X                       | X                  |
| <u>Country</u>  | <u>Ground Station</u> | <u>Satellite/Launch</u> | <u>Partnership</u> |
| France          |                       |                         | X                  |
| Hungary         |                       |                         | +                  |
| Indonesia       | X                     | X                       | X                  |
| Iran            | O                     | X                       | X                  |
| Italy           |                       | X                       | X                  |
| Kazakhstan      | X                     | X                       | X                  |
| Kenya           | X                     |                         | X                  |
| Kyrgyzstan      |                       |                         | X                  |
| Laos            | X                     | X                       | X                  |
| Luxembourg      |                       |                         | +                  |
| Malaysia        |                       | X                       | X                  |
| Mexico          |                       | X                       | X                  |
| Mozambique      | X                     | X                       |                    |
| Namibia         | X                     |                         | X                  |
| Nepal           |                       | X                       |                    |
| Nicaragua       |                       |                         | X                  |
| Nigeria         |                       | X                       | X                  |
| Pakistan        | X                     | X                       | X                  |
| Panama          |                       |                         | X                  |
| Peru            | X                     |                         | X                  |
| <u>Country</u>  | <u>Ground Station</u> | <u>Satellite/Launch</u> | <u>Partnership</u> |
| Philippines     |                       |                         | X                  |
| Russia          | X                     | X                       | X                  |
| Rwanda          |                       |                         | X                  |
| Saudi Arabia    |                       | X                       | X                  |
| Senegal         |                       |                         | X                  |
| Serbia          |                       | O                       | X                  |
| South Africa    | X                     |                         | X                  |
| Sri Lanka       |                       | X                       |                    |
| Sudan           |                       | X                       | X                  |
| Sweden          | □                     | □                       | □                  |
| Tanzania        |                       |                         | X                  |
| Thailand        | X                     | X                       | X                  |
| Tunisia         | X                     | X                       | X                  |
| Turkey          |                       | X                       |                    |
| UAE             |                       |                         | X                  |
| United Kingdom  |                       |                         | X                  |
| Uzbekistan      |                       |                         | X                  |
| Venezuela       | X                     | X                       | X                  |

**Ground Station:** Countries allowing China to use and/or build local ground infrastructure, often to support telemetry, tracking, and command of space assets.

**Satellite/Launch:** Countries that have agreements to use Chinese satellites and/or to have China build or launch a satellite for them.

**Partnership:** Countries that have signed some type of agreement to work with China on space issues.

#### Caveats:

□ - Countries have cooperated with China on this in the past. However, the media reported that the cooperation has been or will be discontinued.

O - The media reported that China has reached an agreement to undertake certain activities, but there are no indications the activity has occurred.

+

- The cooperation is between a non-government entity and China.

Source for Figure 1 and Table 1: Various.<sup>97</sup>

China markets ground stations as providers of civilian services such as navigation, weather forecasting, disaster monitoring, and remote sensing, but experts raise concerns that the same infrastructure could also support the PLA's military objectives.<sup>98</sup> The majority of these facilities are built and operated by the China Satellite Launch and Tracking Control General (CLTC), a state-owned entity closely linked to the PLA's then-Strategic Support Force Space Systems Department.<sup>99</sup> All TT&C operations are centrally coordinated through the Xi'an Satellite Control Center, a subordinate arm of the CLTC, suggesting a high degree of military integration.<sup>100</sup> A prominent example is the Neuquén ground station operated by China in Argentina, which opened in 2017 under a 50-year, tax-free lease.<sup>101</sup> Despite its framing as a diplomatic and cooperative venture, the facility is staffed by Chinese military personnel and operated solely by the CLTC; Argentina is granted access for just 10 percent of its operational time.<sup>102</sup> Argentina is barred from interfering with the site's activities, and the site is surrounded by a 62-mile frequency exclusion zone under Chinese control.<sup>103</sup> Essentially, China is using Argentine territory to advance its strategic goals. This imbalance, where host countries have little visibility or authority, raises broader concerns that such installations may serve military functions, such as ISR, under the guise of peaceful civilian cooperation.<sup>104</sup>

From a military operations perspective, China's expansive global network of ground stations could enhance the PLA's ability to conduct resilient and survivable space operations in conflict.<sup>105</sup> TT&C stations are essential for monitoring satellite health, tracking orbits, and sending commands, but they require line-of-sight, limiting contact to brief windows between satellites and ground stations.<sup>106</sup> To maintain continuous control, China augments its network with Yuan Wang-class tracking ships and the new Liaowang-1 vessel.<sup>107</sup> This globally dispersed architecture provides global coverage, reduces vulnerability to localized disruptions, and could complicate adversary efforts to target satellite control. It also accelerates the reception of real-time ISR, navigation, missile warning, and secure communications, enabling faster, more precise decision-making.<sup>108</sup>

## **China's Commercial Space Sector Is Growing Rapidly**

In the competition to lead the emerging space economy—the commercial market to sell goods and services related to space—the United States is currently the global leader, but China has distinct capabilities that could translate to significant geostrategic and military advantage. Building on its established state-led aerospace and defense sector and network of research institutions, China has quickly fostered a dynamic startup ecosystem focused on rivaling U.S. firms in commercial launch and satellite networks. Though the United States currently leads in two capabilities vital to the future space economy—reusable launch rockets (RLRs) and LEO satellite constellations—China is deploying its industrial policy playbook and leveraging strengths in manufacturing and rocketry in an attempt to rapidly catch up. The stakes are high, as the competition extends beyond technological development to finite orbital positions for satellites, international influence in establishing ground stations, and

control over future markets and space-based applications—many of them with significant national security implications.

## The Commercial Space Economy Is Dramatically Transforming

The commercial space economy is on the precipice of a dramatic transformation due to several concurrent advances. In the upstream segment (see Table 2), launch frequency is accelerating and costs are dropping rapidly due to the advent of RLRs by companies like SpaceX,<sup>\*</sup> while innovations in satellite design are similarly enabling companies to build satellites at lower cost and faster. Both also have clear military implications, as the ability to rapidly deploy or reconstitute space assets could be vital in a space-based conflict. Meanwhile, in the mid-stream segment, improvements in satellites' onboard technology—like higher throughput for data transmission and faster processing through edge computing—are enabling larger satellite networks to communicate with each other and ground stations more efficiently and perform more complex tasks.<sup>109</sup> Taken together, these advances are enabling mega-constellations of LEO satellites to provide less expensive, more feature-rich applications in the downstream segment, including global telecommunications and internet connectivity, enhanced navigation and tracking, and remote sensing and imagery (for more on the transformation of the commercial space economy, see Appendix).<sup>110</sup> Starlink's essential role in Ukraine's defense since Russia's invasion in 2022—from providing real-time encrypted communications to imagery and geolocation used to coordinate attack drones—demonstrates the breadth of dual-use applications possible through LEO constellations.<sup>111</sup>

**Table 2: Commercial Space Market Segments and Ecosystem**

| Segment                               | Key Activities                                                                | Example Companies or Organizations                          |                                                  |
|---------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------|
|                                       |                                                                               | China †                                                     | United States                                    |
| Upstream—Components and manufacturing | Launch vehicle manufacturers                                                  | China Academy of Launch Vehicle Technology (CALT)           | SpaceX, Blue Origin                              |
|                                       | Satellite manufacturers                                                       | China Aerospace Science and Technology Corporation (CASC)   | Lockheed Martin, SpaceX                          |
|                                       | Propulsion developers and rocketry firms                                      | CASC, Shanghai Academy of Spaceflight Technology, LandSpace | Lockheed Martin, Anduril Industries Inc., SpaceX |
|                                       | Subsystems providers (e.g., satellite communication systems or power systems) | China Academy of Space Technology (CAST)                    | Northrop Grumman, Ball Aerospace                 |

<sup>\*</sup>It is not clear that any company other than SpaceX has yet used a reusable launch rocket to launch a satellite into space, though other companies have used RLRs for space tourism and experiments, and numerous companies are working on the technology. "Reducing the Cost of Space Travel with Reusable Launch Vehicles," *National Security Technology Accelerator*, February 12, 2024.

<sup>†</sup>Many of the entries under China are state-owned entities as these are currently the dominant providers in China in the space economy.

**Table 2: Commercial Space Market Segments and Ecosystem—Continued**

| Segment                                   | Key Activities                                | Example Companies or Organizations                                   |                                           |
|-------------------------------------------|-----------------------------------------------|----------------------------------------------------------------------|-------------------------------------------|
|                                           |                                               | China*                                                               | United States                             |
| Midstream—Operations and mission services | Satellite constellation management            | China Satellite Network Group Co. Ltd.                               | Starlink, Planet Labs, ViaSat             |
|                                           | Ground control systems and mission management | Chang Guang Satellite Technology                                     | Kratos, General Dynamics                  |
|                                           | Secure data relay                             | China Satellite Communications Co. Ltd                               | Starlink, Capella Space                   |
|                                           | On-orbit services (e.g., satellite repair)    | China Academy of Space Technology                                    | Maxar Technologies                        |
| Downstream—Space-enabled applications     | Satellite internet                            | SpaceSail (Qianfan), China SatNet (Guowang)                          | Starlink, ViaSat                          |
|                                           | Geolocation and navigation                    | BeiDou Navigation Satellite System (BDS)†                            | Global Positioning System (GPS)†          |
|                                           | Remote sensing and imaging                    | Chang Guang Satellite Technology, Space View Technology, and Spacety | Planet Labs, Maxar Technologies, BlackSky |

Source: Various<sup>112</sup>

In just a decade, China has gone from having an almost non-existent private commercial space sector to a vibrant ecosystem of space startups. Like other strategic industries, this rapid progress is an outgrowth of extensive government support to break through technological “chokepoints,” foster innovation, and catch up to and surpass competitors, particularly in the United States.<sup>113</sup> At the same time, space has been a heavily-regulated and state-dominated industry in China, so industrial policy initially took a gradualist approach, and commercial activity remains largely dependent on technical support and regulatory coordination from state-owned aerospace conglomerates.<sup>114</sup> After China declared space a strategic sector in 2023, several provinces and cities announced plans for regional clusters that compete with and complement one another, developing redundant capabilities and alternative paths to achieve the same goals.

China’s approach builds on the lessons of its other industrial policy successes, drawing on extensive government support and adjacent manufacturing capabilities to accelerate industry development. At the same time, it is contributing to similar challenges as other market-distorting Chinese industrial policies, with unprofitable startups propped up by government support as too much supply

\* Many of the entries under China are state-owned entities as these are currently the dominant providers in China in the space economy.

† While there is a robust economy of companies using geolocation and navigation services, BDS is constructed and operated by the China National Space Administration; GPS is owned by the U.S. government and operated by navigation warfare unit Mission Delta 31. U.S. Space Force Space Operations Command, *Mission Delta 31 - PNT & SCN Integrated Mission Delta*; U.S. Department of Defense, “Global Positioning System Standard Positioning Service Performance Standard,” September 2008; “Beidou Constellation,” *SatNow*.

chases too little demand.<sup>115</sup> As with other sectors, the likely outcome is that China's competitors will bear the brunt of these distortions: with commercial firms relentlessly cutting costs to compete in an oversaturated domestic market, China is poised to develop a few national champions capable of rivaling the leading international firms at a fraction of the cost.

### ***From Deregulation to Regional Clusters***

China's policy support for private commercial space firms evolved fairly rapidly while being implemented through incrementally larger opportunities for the private sector. A 2021 white paper on China's space sectors made growth of China's private space sector a central element of many objectives.\*<sup>116</sup> Before 2014, China's space sector was confined to state-led aerospace conglomerates that focused mostly on civil and military applications as well as navigation.<sup>117</sup> These SOEs were poorly positioned to innovate and compete in emerging areas like low-cost satellite production and commercial space applications.<sup>118</sup> Seeking to rectify these weaknesses, in 2014 China's state planning agency, the National Development and Reform Commission, relaxed restrictions on satellite manufacturing and commercial launch.<sup>119</sup> A broader strategy for industrial development followed in 2015, with a focus on reducing foreign reliance, and in 2016 China announced plans to promote commercial satellite services abroad through the BRI.<sup>120</sup> The private space economy further accelerated after 2019, when China reduced barriers to private investment in rocketry.<sup>121</sup> Then in 2020, telecommunications firms became more involved as China encouraged the growth of satellite internet in its sweeping "new infrastructure" investment plan.<sup>122</sup> Only in 2023 did China designate commercial space as a "strategic emerging sector," the same label it first applied to new energy vehicles and other major beneficiaries of industrial policy in 2007.<sup>123</sup>

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\*Among other goals, the white paper notes Beijing's intention to accelerate commercial launch and satellite manufacturing, offer more space-based services, and further ease market restrictions for private firms. China's State Council, *Full Text: China's Space Program: A 2021 Perspective*, January 28, 2022.

**Figure 2: Active Rocket Production in China for 7 Leading Commercial Space Firms**



*Note:* Among China's commercial space companies, Orienspace, Landspace, Space Pioneer, Galactic Energy, Interstellar Glory, Deep Blue, and CAS Space (a subsidiary of the Chinese Academy of Sciences) are the only firms to hold the Launch Vehicle Overall Technical Research and Production License as of August 2025. Space Office, "中国商业运载火箭之路将何去何从?" (Where Is China's Commercial Space Launch Path Going?), *Huxiu*, August 13, 2025.

*Source:* "我国7个民商公司，搞出了51个火箭基地！是不是太多了？" [Seven Chinese civilian and commercial companies have built 51 rocket bases! Is that too many?], *Hangtianfan*, July 15, 2025.

The 2023 designation, later codified in 2024, kickstarted a series of provincial-level action plans to build regional commercial space clusters.<sup>124</sup> For instance, the plan for Wenchang, located in southern Hainan province, builds on the city's preexisting strengths as China's southernmost spaceport and launch site for Long March rockets

used in space station missions and deep space exploration. The regional plan seeks to expand the volume of commercial launches and position Wenchang as a space tourism hub.<sup>125</sup> A nearby “satellite mega factory” announced in 2024 is projected to have an output of 1,000 satellites annually, using processes from auto-manufacturing to mass-produce satellites that could then be put into orbit immediately from adjacent launch sites.<sup>126</sup> Beijing, Shanghai, Shenzhen, and Wuhan, among other cities and provincial-level municipalities, have announced similar plans that build on preexisting strengths, such as Shanghai’s civil aviation industry, Shenzhen’s telecommunications industry, and Beijing’s rocketry industry and research institutes and universities. Notably, many of these plans include fiscal incentives for satellite manufacturers, driving a surge in production capacity.<sup>127</sup>

### **State-Owned Enterprises Provided the Foundation for China’s Commercial Space Sector**

State-owned enterprises (SOEs) were the foundation of China’s commercial space economy and remain dominant players today even as private space firms have grown rapidly. Prior to 2014, virtually all space initiatives were under China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC), the two major state-owned aerospace and defense conglomerates.<sup>128</sup> Aside from their military focus and efforts in space exploration, these firms and their affiliates led almost all commercial space activity, with CASC subsidiaries the China Academy of Launch Vehicle Technology (CALT) and Shanghai Academy of Spaceflight Technology (SAST) conducting most of China’s launches. CASC also led China’s highly successful buildout of the BeiDou Navigation Satellite System (see “BeiDou Seeks to Displace GPS as the World’s Dominant Satellite Navigation System” textbox above).<sup>129</sup>

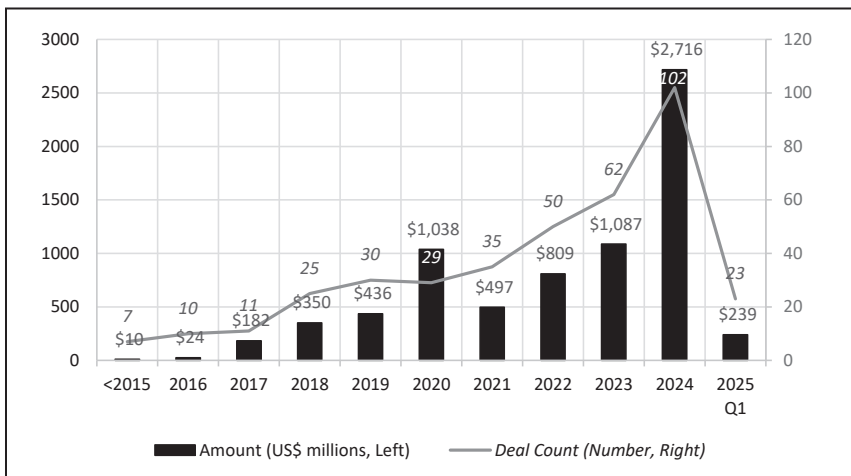
Today, the breadth of SOEs’ operations complements the targeted capabilities of China’s private firms, and they are both competitors and collaborators. CASC still leads in annual launches (including non-commercial launches), with 49 in 2024—the second-most globally, behind SpaceX’s 140.<sup>130</sup> CASC is also leading the buildout of one of China’s two LEO mega-constellations, with the other being state-coordinated but mostly privately built. It remains the top Chinese manufacturer of GEO satellites, while Chinese startups focus on cheaper LEO satellites. At the same time, SOEs are investors in and customers of China’s private space firms, and private firms seek partnerships with SOEs to clear regulatory hurdles.<sup>131</sup> CASC’s investment arm, China Aerospace Investment Holdings, funds startups that advance China’s strategic objectives like Beijing Xingtū (Space Trek), a rocketry firm developing solid-fueled rapid launch capabilities.<sup>132</sup> Many Chinese space startups were also founded by former CASC employees, including MinoSpace, Spacety, and Galaxy Space.<sup>133</sup>

### ***Commercial Space Investment Follows Policy Lead***

Investment in China's commercial space firms has closely tracked the expansion of policy support, accelerating to a crescendo with China's designation of the sector as a strategic emerging industry in 2023 (Figure 3). The following year, China surpassed the United States in venture capital (VC) funding for commercial space startups for the first time, receiving \$2.7 billion compared to the U.S. funding of \$2.6 billion.<sup>134</sup> Preceding that, China's commercial space market has grown rapidly since China eased private investment in rocket companies in 2019—growing from \$113 billion in 2019 to \$268 billion in 2023, with projections reaching \$900 billion by 2029.<sup>135</sup> Capital from both U.S. and foreign investors has also contributed at least in part to China's commercial space sector, with Sequoia, Lightspeed, and Matrix as notable funders.\*<sup>136</sup> Aside from VCs, foreign funds such as the state-led Abu Dhabi Investment Authority (ADIA) have also invested in Chinese commercial space firms, notably rocketry.<sup>137</sup>

This funding landscape has led to a rapid increase in the number of commercial space firms, with private companies now outnumbering state-owned counterparts four to one, even as the latter maintain much larger, more complex operations by comparison.<sup>138</sup> In 2024, the Chinese government accounted for the majority of investment in China's commercial space sector, rising from 49 percent in 2023 to 51 percent in 2024 and reaching 54 percent in the first quarter of 2025.<sup>139</sup> However, government support comes with strings attached, as commercial space firms face pressure to focus on long-term goals in chokepoint technologies rather than near-term profitability.<sup>140</sup>

**Figure 3: Venture Capital Investments in Chinese Commercial Space Firms**



Source: Adapted from Denis Kalinin, "China: Private Space Ecosystem of the Rising Superpower," *Space Ambition*, April 25, 2025.

\*While these global VCs do invest in China's commercial space ecosystem, these investments are orchestrated by fully local and separate entities, for example Sequoia China. Denis Kalinin, "China: Private Space Ecosystem of the Rising Superpower," *Space Ambition*, April 25, 2025; House Select Committee, *Gallagher, Krishnamoorthi Probe Sequoia's PRC High-Tech Investments, Examine Implications of Announced Split*, October 18, 2023.

### ***China's Nascent but Growing Commercial Launch and Satellite Ecosystem***

Compared to the United States, China's commercial space ecosystem appears fairly nascent, but the breadth of companies competing in similar technologies, government support, and synergies from the substantial capabilities of China's aerospace SOEs provide firm footing to close this gap. For the moment, SpaceX and Starlink are market leaders in RLR and LEO constellations, respectively, and retain a substantial first mover advantage due to vertical integration: SpaceX reduces market risk with Starlink as a guaranteed customer, while near-cost access to space through in-house launch has enabled Starlink to rapidly and affordably scale its satellite network.<sup>141</sup> Although China trails in satellites currently in orbit, its construction of multiple mega factories puts it on track to rival production volumes at SpaceX's Redmond facility, which in August 2025 indicated it was producing 70 satellites per week or roughly 3,600 annually.<sup>142</sup> According to research from intelligence firm Ex-overa and *SpaceNews*, planned mega-factories and projected output include:

- Geespace Mega Factory in Zhejiang—500 satellites annually.<sup>143</sup>
- Aerospace Satellites Mega Factory in Hainan—1,000 satellites annually.<sup>144</sup>
- Galaxy Space Nantong Intelligent in Jiangsu—300 small satellites and 100–150 medium satellites annually.<sup>145</sup>
- Shanghai Gesi Aerospace Technology (Genesat)—300 satellites annually.<sup>146</sup>

Similarly, although China trails in total launches, it has firms experimenting with far more approaches to propulsion and reusable launch, from liquid and solid fuels (SpaceX uses liquid methane) to novel technologies such as Maglev launch systems akin to high-speed trains.<sup>147</sup> The vibrancy of China's ecosystem could ultimately provide a competitive edge over the United States, which is highly concentrated in a few companies and heavily invested in a narrow set of approaches.<sup>148</sup> These limitations create a higher risk of setbacks and may leave the U.S. government with limited leverage when negotiating with a monopolistic or oligopolistic industry.

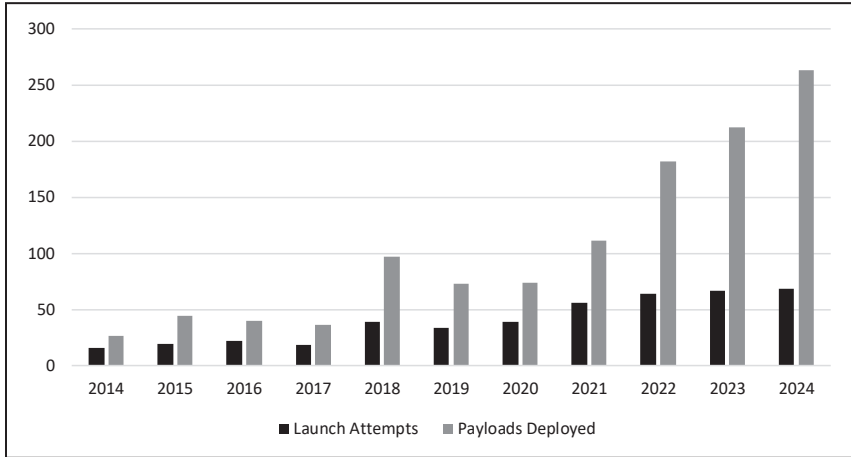
#### ***Launch and RLR***

China currently has about 50 commercial launch firms, a number Orbital Gateway Consulting founder Blaine Curcio highlighted in his testimony before the Commission on its diversity and breadth compared to U.S. firms.<sup>149</sup> While U.S. leader SpaceX is far ahead of China's leading commercial launch company, Galactic Energy, and U.S.-based Rocket Lab is also ahead of China's second most developed commercial launch company, Mr. Curcio estimates that China's fifth-most-developed company is probably on par with its U.S. counterpart.<sup>150</sup> In 2024, China had 66 successful launches carrying 263 satellites, compared to 66 launches carrying 212 satellites in 2023.\*<sup>151</sup> Mr. Curcio's tracking found 15 launches by commercial

\*This figure does not include Chang'e 5's successful launch from the moon in June 2023 to return to Earth. By comparison, the United States had 158 launches deploying 2,256 spacecraft

firms that sent 67 satellites into orbit.<sup>152</sup> The country is aiming to exceed 100 launches in 2025; as of September 25, 2025, it had conducted 55 launches (by comparison, the United States had conducted 126).<sup>153</sup>

**Figure 4: Chinese Orbital Launch Attempts and Satellite Payloads\* Deployed, 2014–2024**



*Note:* The graph shows launch attempts rather than successful launches as a more apt industrial indicator, demonstrating the expansion of China's capacity. Generally, a small number of launches each year will not be successful; for instance, in 2024, China attempted 68 launches and succeeded in 66. In some cases, satellite payloads deployed may include satellites launched in a preceding year; for instance, China launched 263 and deployed 264 satellites in 2024.

*Source:* Jonathan McDowell, "Space Activities in 2024," *Jonathan's Space Report*, January 24, 2025, 4, 9, 61; Jonathan McDowell, "Space Activities in 2023," *Jonathan's Space Report*, January 15, 2024, 4, 9, 63; Jonathan McDowell, "Space Activities in 2022," *Jonathan's Space Report*, January 17, 2023, 4, 9, 111; Jonathan McDowell, "Space Activities in 2021," *Jonathan's Space Report*, January 3, 2022, 3, 8, 92; Jonathan McDowell, "Space Activities in 2020," *Jonathan's Space Report*, January 15, 2021, 3, 8, 93.

Numerous Chinese firms are also advancing in RLR development, with both SOEs and commercial firms planning test flights for reusable rockets. In 2024, China made significant strides in developing reusable space launch vehicles, including a successful 12-kilometer (7.4 miles)-high vertical takeoff and landing test.<sup>154</sup> At least seven Chinese commercial RLR prototypes are scheduled for their maiden launch in 2025, with experts predicting they will be competitive with SpaceX's RLR by 2030.<sup>155</sup> Landspace, Space Pioneer, Galactic Energy, Deep Blue Aerospace, and iSpace, are among the major Chinese commercial companies working towards launchers that could

in 2024, counting four near orbital launches from Starship and 14 launches from New Zealand by Rocket Lab subsidiary Electron. Jonathan McDowell, "Space Activities in 2024," *Jonathan's Space Report*, January 24, 2025, 5, 6, 9; John Holst, "The Ill-Defined Space Global Orbital Launch Summary: 2024," *Ill-Defined Space*, January 3, 2025.

\*A payload refers to a device or instrument onboard a spacecraft or rocket, which can vary depending on the spacecraft's mission. A payload on a rocket or spacecraft could include satellites, warheads, or humans. Other payloads include: cargo payloads that transport supplies and equipment for the international space station; observation payloads that include cameras, radar, and lidar; communication payloads that include radio antennas, modems, and transponders; and navigation payloads that are used to determine the position and orientation of a spacecraft such as star trackers. "What is...A Payload," *EVONA*; Glenn Research Center, "Payload Systems," NASA; Brandon Bailey, "Using SPARTA to Conduct Space Vehicle Cyber Assessments," *Aerospace Corporation*, 2024, 6, 7, 12, 14.

be made reusable in the future.<sup>156</sup> iSpace's chief designer estimated that in 2025, the firm's RLR could achieve technological parity with SpaceX's 2015 rocket technology.<sup>157</sup> General Saltzman highlighted China's investment in reusable launch as one of the inflection points in space access that may result in China overtaking U.S. leadership in launch.<sup>158</sup>

### *LEO Satellite Constellations*

China's investment in LEO satellite constellations supports both military and geopolitical aims as Chinese companies attempt to catch up to and compete against U.S. constellations, in particular Starlink's.<sup>159</sup> China currently has about ten commercial companies working to build LEO communication satellites for two prominent state-owned mega constellations, Thousand Sails (Qianfan) and Guowang (China Satnet). Both currently trail Starlink, with 2,272 U.S. satellites launched in 2024 compared to China's 270.<sup>160</sup> However, Guowang aims to launch a total of 13,000 satellites, primarily for domestic telecommunications and potential military use.<sup>161</sup> Qianfan plans to launch 15,000 satellites focused on providing service to foreign telecom companies. Hongqing Technology has filed a plan with the ITU to launch a third mega constellation of 10,000 satellites, bringing China's total close to Starlink's planned constellation.<sup>162</sup> Finally, smaller entrants like Geespace (a satellite manufacturer funded by commercial firm Geely Automotive) and commercial space firm GalaxySpace are also planning satellite constellations of 6,000 and 1,000 satellites, respectively.<sup>163</sup>

The state-backed Guowang and Qianfan constellations programs will be the largest driver of demand for China's commercial space sector, including commercial manufacturing and development of satellite systems, subsystems, and components.<sup>164</sup> Since 2023, the Shanghai Engineering Center for Microsatellites (SECM) and its joint venture subsidiary Genesat have been the key entities building the Qianfan constellation.<sup>165</sup> China's SOE China Academy of Space Technology (CAST) will likely continue to be the prime manufacturer of the Guowang constellation, and Mr. Curcio expects all other LEO communications manufacturers will likely become system suppliers to SECM and CAST.<sup>166</sup>

**Table 3: Chinese Companies Developing LEO Satellites Compared to StarLink**

| Organization                                           | Commercial or SOE | LEO Satellite Constellation Plan | Satellites Launched |
|--------------------------------------------------------|-------------------|----------------------------------|---------------------|
| Shanghai Lanjian Hongqing Technology Company           | Commercial        | 10,000                           | TBD                 |
| China Satellite Network Group Ltd. (Guowang/Xingwang)  | SOE               | 13,000                           | 110 <sup>167</sup>  |
| Shanghai Spacecom Satellite Technology (SSST/ Qianfan) | SOE               | 15,000 <sup>168</sup>            | 90 <sup>169</sup>   |
| Geespace                                               | Commercial        | 6,000                            | 64 <sup>170</sup>   |

**Table 3: Chinese Companies Developing LEO Satellites Compared to StarLink—Continued**

| Organization | Commercial or SOE | LEO Satellite Constellation Plan | Satellites Launched  |
|--------------|-------------------|----------------------------------|----------------------|
| GalaxySpace  | Commercial        | 1,000 <sup>171</sup>             | TBD                  |
| Starlink     | Commercial        | 42,000 <sup>172</sup>            | 9,868 <sup>173</sup> |

Source: Various.<sup>174</sup>

As China's satellite manufacturing and launch capabilities increase, Chinese LEO satellite offerings could inundate the global market and offer developing countries a cheaper alternative to Starlink.<sup>175</sup> The role of Chinese SOEs in the development of LEO constellations could also afford the Chinese government and the PLA the benefit of state control over how LEO satellites are accessed and operated.<sup>176</sup>

### ***China's Advances in Satellite Communications and Remote Sensing***

In parallel to its advances in launch and satellite manufacturing capacity, China has reached new milestones in demonstrating key enabling technologies for satellite communications and other space-based applications. In March 2025, China's Chang Guang Satellite Technology announced that its Jilin-1 satellite constellation achieved a record-setting 100 gigabit-per-second laser transmission to a mobile ground station (roughly equivalent to transmitting ten full-length high-definition feature films in one second).<sup>177</sup> Laser-based communications offer higher data transfer rates, less susceptibility to interference, and greater security than conventional radio signals,\* though greater risk of atmospheric disruption (e.g., from rain or fog).<sup>178</sup> Chang Guang's demonstration of the laser communication to a mobile ground station has clear commercial and defense implications and suggests China may be ahead in providing satellite communications for contexts requiring secure highspeed links in remote or austere environments.<sup>179</sup>

Relatedly, in May 2025, *South China Morning Post* reported that SatNet, the SOE that manages the Guowang mega-constellation, completed the first 5G satellite-to-smartphone video call.<sup>†</sup><sup>180</sup> The demonstration stands out both for the volume of data transmitted and the use of 5G standards rather than special equipment unique to a network. To date, "direct-to-device"

\*Laser or optical communications transmit infrared light broadcast in narrow, precise beams to specific ground stations, and are capable of transmitting data in much higher volumes. DVD players use similar technology in a controlled space. By contrast, radio waves are broadcast to a much larger geographic area, increasing the likelihood communications are intercepted or run into interference from nearby satellites, terrestrial broadcasts in adjacent frequency bands, and intentional jamming. Starlink uses laser communications between satellites but radio communications for transmission to ground stations. Laura Heckmann, "Optical Comms Beaming Through Technological Barriers," *National Defense Magazine*, April 29, 2024.

†UK Telecom operator Vodafone UK and satellite provider AST SpaceMobile reported making the world's first video call to a standard smartphone via satellite in January 2025, using a special base station and satellite designed to connect to Vodafone's network. Luke Pearce and Ben Wood, "What Vodafone's Historic Satellite Video Call Means for Direct-to-Device Services," *CCS Insight*, February 6, 2025; Paul Sandle, "Vodafone Makes World's First Satellite Video Call Using Standard Smartphone," *Reuters*, January 29, 2025.

(D2D) communications—satellite-to-smartphone connectivity—has focused on transmitting text messages and voice calls, rather than video, with T-Mobile and Starlink partnering to soft launch satellite text messaging in January 2024 on select handsets.<sup>181</sup> Moreover, other satellite-to-terrestrial network communications, including Starlink's partnership and Vodafone and AST SpaceMobile's partnership, use custom technology rather than global 5G standards.<sup>182</sup> D2D connections via 5G protocols would effectively enable satellites to become an orbiting extension of terrestrial networks, delivering coverage to remote areas and potentially opening up competition for new markets with limited ground-based telecommunications infrastructure. China Telecom has already announced hopes to expand its D2D geosynchronous Tian-tong satellite constellation from Hong Kong and the Mainland to Southeast Asia, South Asia, and Belt and Road participants in other regions.<sup>183</sup>

Chinese satellite constellations are also surpassing U.S. capabilities in orbital remote sensing, or collecting information from a distance using reflected or emitted radiation to provide imagery or other data. In an October 2024 ranking of global commercial space-based remote sensing systems, researchers from the Center for Strategic and International Studies, Taylor Geospatial Institute, Taylor Geospatial Engine, and the U.S. Geospatial Intelligence Foundation, found Chinese firms led in five of eleven areas, compared to just four for the United States (see Table 3).<sup>184</sup> The findings build on a U.S. National Geospatial-Intelligence Agency ranking in 2021 that found that U.S. and China tied, each leading a third of the market across nine areas.<sup>185</sup>

China's emerging dominance in remote sensing poses both national security and market risks. The U.S. Department of the Treasury sanctioned Chang Guang Satellite Technology in December 2023 for providing satellite imagery to the Wagner Group, the private military contractor supporting Russia's military in Ukraine.<sup>186</sup> In April 2025, the U.S. Department of State indicated Chang Guang supplied Houthi rebels with satellite imagery to target U.S. warships and international vessels in the Red Sea.<sup>187</sup> Aside from supporting attacks on U.S. assets and aiding Russia's invasion of Ukraine, Chang Guang is attempting to seize global market share for its services by undercutting competitors.<sup>188</sup> As in other industries, including potentially commercial satellite communications, below-market pricing threatens the viability of U.S. remote sensing startups.<sup>189</sup>

**Table 4: Remote Sensing Categories and National Rank**

| Category                 |                                       | Description                                                                                                                                               | China Rank (firm)               | U.S. Rank (firm)            |
|--------------------------|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------------|
| Electro-optical          | Electro-optical (EO) imaging          | A sensing technology that combines visual spectrum and thermal imaging, often used for surveillance and domain awareness                                  | 1 (China Siwei SuperView Neo-1) | 3 (Maxar Worldview)         |
|                          | EO revisit                            | How quickly a provider can revisit a target for imaging                                                                                                   | 1 (Chang Guang Jilin-1)         | 3 (Planet Sky SkySat)       |
|                          | EO video                              | How high a resolution and the number of frames a provider can capture relative to time over a target                                                      | 3 (Chang Guang Jilin-1)         | 1 (Planet Sky SkySat 16-21) |
| Synthetic aperture radar | Synthetic aperture radar (SAR) X-band | Especially high-resolution imagery, good for monitoring small changes on the ground                                                                       | not in top 3                    | 1 (Umbra SAR)               |
|                          | SAR revisit                           | How quickly a provider can revisit a target for imaging with SAR X-band                                                                                   | not in top 3                    | 2 (Umbra Constellation)     |
|                          | SAR C-band                            | Wider than X-band, C-band imaging is good for monitoring broader areas                                                                                    | 1 (SAST Gaofen -12)             | not in top 3                |
| Spectral                 | Multispectral capability              | Imaging that collects data on specific wavelengths, often used in agriculture such as to detect pests                                                     | 1 (China Siwei SuperView Neo-3) | 3 (Planet Sky-Sat 16-21)    |
|                          | Hyperspectral capability              | Imaging that collects high definition data on the electromagnetic spectrum, useful for identifying materials like ores and petroleum based on reflectance | 3 (Zhuhai Orbita)               | 1 (Orbital Sidekick GHOST)  |
| Infrared                 | Short-wave infrared                   | Imaging at wavelengths beyond the visible spectrum, good for sensing through fog and smoke                                                                | 3 (SAST Gaofen—5)               | 1 (Maxar WorldView—3)       |
|                          | Mid-wave infrared                     | Imaging beyond the visible spectrum, good for tracking heat signatures (e.g., of jet engines).                                                            | 2 (SAST Gaofen—5)               | not in top 3                |
|                          | Long-wave infrared                    | Imaging beyond the visible spectrum, good for detecting objects solely based on temperature                                                               | 1 (CAST Ziyuan)                 | not in top 3                |

*Source:* Adapted from Kari Bingen, David Gauthier, and Madeleine Chang, “Gold Rush: The 2024 Commercial Remote Sensing Global Rankings,” *Center for Strategic and International Studies*, October 2024, 5, 7.

### **China's Commercial Space Ambitions in the Middle East & North Africa**

China's commercial space firms are increasingly turning to the Middle East as a growth market, with Abu Dhabi—and to a lesser extent Egypt and Saudi Arabia—at the center of these efforts. In early 2024, USpace, a Hong Kong-based firm with several satellites already on orbit, unveiled plans for the Abu Dhabi Space Eco-City, a massive project designed to serve as a global hub for aerospace innovation and trade.<sup>190</sup> The development will span three million square meters in the Khalifa Economic Zones, rolled out in two phases, and is intended to provide commercial aerospace services worldwide.<sup>191</sup> In parallel, USpace also signed 2024 agreements with Egypt to establish satellite factories, and it plans to sign similar agreements with Saudi Arabia, further extending China's presence in the region.<sup>192</sup>

Alongside USpace, the UAE's space initiatives have also drawn a host of Chinese commercial space firms. XSat, a satellite payload and communications systems manufacturer, was among the first partners to join.<sup>193</sup> It was followed by China Unicom Airnet, a subsidiary focused on satellite provided in-flight internet, InterstellOr, a Beijing-based commercial crewed spaceflight startup, and Fujian Ji-wang Huimin Group, a diversified technology and industrial firm.<sup>194</sup>

For Chinese companies, the appeal is clear: exporting industrial capacity abroad while expanding their international footprint, often with state support and fewer restrictions on technology transfer than Western competitors. Middle Eastern governments, for their part, are eager to develop their domestic space industries and have welcomed Chinese firms as partners in building local capabilities.<sup>195</sup> With Chinese, Middle Eastern, and North African leaders championing expanded civil, commercial, and TT&C cooperation along the Space Silk Road, initiatives like the Abu Dhabi Eco-City and Egypt's recently completed satellite assembly, integration, and testing (AIT) Center are likely just the beginning of a wider Chinese commercial space presence across the Middle East and North Africa.<sup>196</sup>

### ***China's Investments in Emerging Space Technologies***

While commercial launch, mega-constellations, and the infrastructure they require as well as downstream applications they enable are the primary arenas of U.S.-China commercial space competition, China is also investing in several “over-the-horizon” space-based technologies. Though in nascent stages, success in these projects could give China a decisive advantage in elements of a space-based competition. Even failure or delay would provide China's research community and aerospace engineers with valuable insights, much as the United States' government-led space initiatives led to numerous consumer products. Some key technologies include:

- *Quantum communication satellites:* Quantum communication satellites use quantum networking to enable highly encrypted communications, which potentially offer faster and more secure

data transmission for finance, government, or military users.<sup>197</sup> China launched its first LEO satellite designed for quantum communication, the Micius, in 2016 and its second LEO satellite, the Jinan-1, in 2022.<sup>198</sup> China is planning to launch a third quantum communications satellite into LEO in 2025.<sup>199</sup> Eventually, China is also planning to experiment with building a quantum communications satellite network based on low-earth orbit quantum satellites.<sup>200</sup>

- *Space planes*: Space planes are aircraft designed to fly both within the atmosphere and outer space, unlike space shuttles that rely on propulsion from auxiliary rocketry to transcend the atmosphere. Like RLRs, space planes are reusable, but they can both take off and land on runways designed for airplanes.<sup>201</sup> This makes them ideal for commercial applications that require frequent deployment, such as staffing or resupplying space missions, as well as for military uses, including domain awareness and counterspace operations like disabling adversary satellites.<sup>202</sup> In 2024 China began testing a highly secretive orbital spacecraft believed to mimic the U.S. Space Force's X-37B military-use space plane.<sup>203</sup> Space planes are not suitable substitutes for RLRs due to their design limitations.<sup>204</sup>
- *Space-based computing and AI*: Higher volumes of space-based computing could sharply increase the demand for real-time data processing, particularly in dual-use applications like earth observation. In May 2025, China launched the first 12 satellites of its “three-body computing constellation,” a space-based supercomputer comprising a planned constellation of 2,800 satellites.<sup>205</sup> Slated for completion in 2030, the full constellation aims to reach 1,000 peta operations per second—putting it on track to rival the world's most powerful supercomputers.<sup>206</sup> While space-based computing can reduce energy costs due to uninterrupted access to solar power and lower cooling requirements than terrestrial data centers, the harsh environment of space requires especially durable materials, likely raising construction costs and limiting the performance of space-based data centers. Current radiation-hardened processors are generations behind the performance of leading-edge off-the-shelf chips.<sup>207</sup>
- *Space solar power satellites*: Leading scientific organizations in China have called for space solar power satellites (SSPS) as a potential breakthrough in clean energy and a new frontier in space-based competition.<sup>208</sup> SSPS involves orbiting satellites equipped with solar arrays that collect solar energy and wirelessly beam it—typically as microwaves or lasers—to receiving stations on Earth, where it is converted into electricity.<sup>209</sup> Unlike terrestrial solar power, SSPS has been dubbed the “Manhattan Project” for the energy industry, given its revolutionary potential to provide continuous, weather-independent energy and deliver reliable, high-volume power to areas with limited infrastructure.<sup>210</sup> In 2023, Xidian University announced it had begun testing “Chasing Sun,” the world's first complete ground verification system to receive transmissions from SSPS.<sup>211</sup> Alongside these present-day efforts, the Chinese Academy of

Engineering (CAE) revealed that a major SSPS project, known colloquially as “Three Gorges Dam in Space,” is currently in the planning stages, with a vision of collecting in one year the energy equivalent of “the total amount of oil that can be extracted from the Earth.”\*<sup>212</sup> As with other emerging space technologies, SSSP has distinct dual-use potential: satellites capable of delivering concentrated energy could be adapted for military use, with CAS scientists stating that space-based energy grids could be used to power “airships, drone fleets, [and] mobile maritime platforms.”†<sup>213</sup>

- *Nuclear thermal propulsion*: China is investing in nuclear-powered space propulsion technologies that, if realized, could drastically reduce the time required for deep space missions and unlock a new era of strategic space mobility.<sup>214</sup> In early 2024, Chinese researchers revealed a compact, lithium-cooled fission reactor capable of delivering 1.5 megawatts of power—a reactor that fits in a container-sized package on Earth but expands in orbit to the size of a 20-story building.<sup>215</sup> Ground tests have validated key components, including advanced lithium cooling systems and power conversion cycles, and officials claim the system could reduce a round-trip Mars mission to just three months.<sup>216</sup> While the technology remains in the prototype stage and no nuclear-powered craft has been launched to date, Beijing is reportedly developing launch safety protocols and autonomous AI controls to enable long-duration missions.<sup>217</sup> These efforts, though early, signal China’s ambitions to field nuclear thermal propulsion capabilities that could outpace the United States and establish a new technological beachhead in deep space.<sup>218</sup> China’s progress suggests it is preparing not just to reach farther but to get there faster—and potentially first.‡

## China’s Civil Space Program Seeks to Outpace NASA, Become World Leader

### China Has Achieved Significant Civil Space Milestones and Has Ambitions to Become the Global Leader

China’s civil space ambitions go beyond science and technology and are a means to gain long-term strategic advantage. In addition to accumulating an impressive list of achievements, China has ar-

\*For an SSPS of this scale to be possible, experts acknowledge that China will need to massively improve the load-carrying capabilities of the country’s reusable launch rocket fleet, as well as overcome technical challenges such as space-based robotics and improved microwave transmission and reception. Henri Bardi, “A Skeptic’s Take on Beaming Power to Earth from Space,” *IEEE Spectrum*, May 9, 2024; Zhang Tong, “China Plans to Build ‘Three Gorges Dam in Space’ to Harness Solar Power,” *South China Morning Post*, January 9, 2025.

†However, experts have flagged the cost of SSPS as another potential obstacle to its viability. These include cost effectiveness relative to Earth-based energy sources, significant upfront capital investment relative to speculative completion, and revenue generation. Henri Bardi, “A Skeptic’s Take on Beaming Power to Earth from Space,” *IEEE Spectrum*, May 9, 2024.

‡Nuclear and systems engineers note there are numerous challenges to developing nuclear thermal propulsion, including developing cooling systems and heat-resistant materials, building lightweight and compact reactor systems, and designing systems that can simultaneously release propellant at a controlled rate while containing fuel. Additionally, there are significant public safety considerations in launching nuclear reactors into space. Michael G. Houts, L. Dale Thomas, and Bahram Nasser-sharif, “Centrifugal Nuclear Thermal Rocket Challenges and Potential,” 45th Annual American Astronautical Society, Guidance, Navigation and Control Conference, January 12, 2023; Sinead Harvey, “Ensuring Safety on Earth from Nuclear Sources in Space,” *International Atomic Energy Agency*, October 28, 2020.

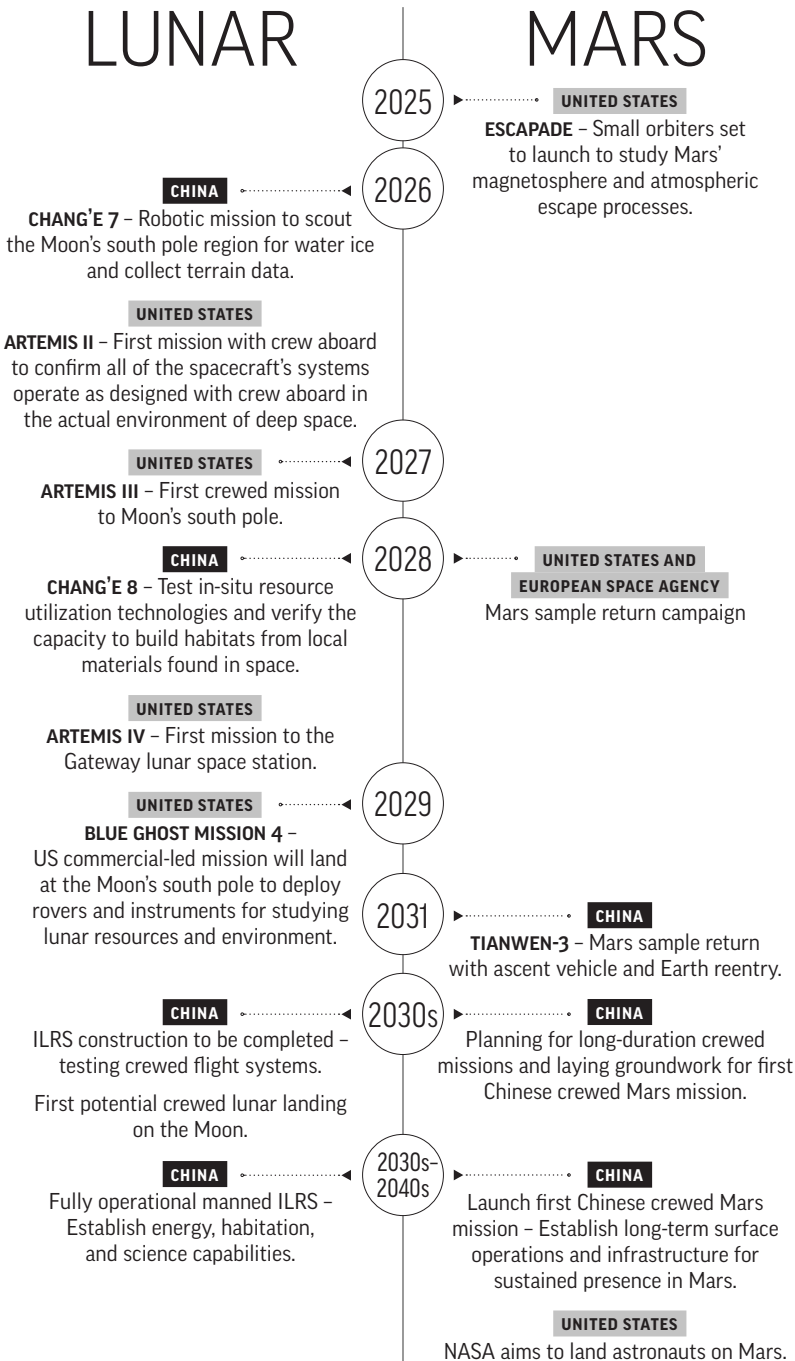
ticated ambitious plans to establish itself as the global leader in space technology and exploration, sought to reshape rules regarding international space governance, and aimed to position itself as a strategic rival to the United States.<sup>219</sup> China has made it clear it does not seek to merely repeat U.S. efforts, but to achieve “global firsts,” such as its June 2024 Chang’e-6 mission that returned the first-ever lunar samples from the Moon’s far side.<sup>220</sup> These accomplishments serve not only scientific and technological goals, but also political and diplomatic ones, bolstering national pride and supporting China’s narrative of global leadership.

### **China Seeks to Shape Outcomes in International Space Governance Bodies and Influence Technical Standards**

China has actively sought to shape the rules and norms governing outer space to align with its own strategic interests, while undermining existing standards and U.S. leadership. Existing rules and norms support transparent practices and multilateral cooperation, while China has promoted bilateral arrangements and frameworks that emphasize sovereign rights gained through exploration. For example, this includes claiming rights to extract lunar minerals, which challenges the norm of space being a global commons. By pursuing high-profile “firsts” and leading initiatives like the International Lunar Research Station (ILRS), China has sought to boost its global influence and attract partners to support its preferred model of space governance. If China is able to reshape the norms and rules of outer space, future missions to the Moon and Mars could give China early access to strategic resources, support the development of onsite infrastructure, and allow it to set technical standards that influence how other nations operate in space.<sup>221</sup> Increasingly, China’s civil space program is a tool of global competition not just over capabilities but also over who sets the rules on the Moon and beyond.

#### **China Overwhelms, Obstructs the ITU to Advance its Preferred Standards**

China has adopted a strategy to both inundate and obstruct deliberations within the International Telecommunication Union (ITU) in an effort to shape the foundational architecture of global communications, including the management of satellite constellations and the adoption of global technology standards.<sup>222</sup> The ITU is a specialized agency of the UN responsible for coordinating global telecommunication networks, setting standards, creating regulatory frameworks, and allocating resources, including those used in space.<sup>223</sup> If China can exert influence over the global spectrum and orbital slot allocations—which are coordinated primarily through the ITU—it could restrict other countries’ and companies’ ability to launch or expand satellite constellations.<sup>224</sup> China has inundated these groups with proposals and technical specifications on critical issues such as satellite positioning, spectrum allocation, space-based internet, AI, and next-generation communications infrastructure.<sup>225</sup> Beijing has reportedly instructed its delegations to block consensus in negotiations, applying pressure until its preferred standards are adopted.<sup>226</sup>

**Figure 5: Timeline of U.S. and China's Civil Space Goals**

### **China Overwhelms, Obstructs the ITU to Advance its Preferred Standards—*Continued***

Beijing's assertive role in the ITU is part of its broader China Standards 2035 plan, which aims to set global benchmarks in high-tech sectors, including those central to its space power.<sup>228</sup> By seeking to institutionalize Chinese-led standards in multilateral bodies like the ITU, China hopes to boost its technological market share, secure long-term commercial advantages, and marginalize foreign competitors.<sup>229</sup> If Chinese standards become dominant, others may be forced to redesign products or adopt technical baselines that reduce interoperability and increase costs, which would have significant implications for U.S. companies and those of its allies.

Beijing has also leveraged international bodies not only to legitimize its space activities and advance rules favorable to its interests, but also to challenge U.S.-led initiatives, most notably the Artemis Accords and the Artemis Program. The Artemis Accords, established by the United States through bilateral diplomacy beginning in 2019 and formally announced in 2020, set forth voluntary principles to guide the peaceful exploration and use of outer space.<sup>230</sup> The Accords include provisions promoting transparency, interoperability, emergency assistance, space object registration, scientific data sharing, preservation of space heritage, space resource extraction, deconfliction of activities, and orbital debris mitigation.<sup>231</sup> Rooted in the 1967 Outer Space Treaty, the Accords have been signed by over 50 partner nations that support these principles.<sup>232</sup>

### **Key Principles of the 1967 Outer Space Treaty**

The 1967 Outer Space Treaty, formally known as the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, is the foundational framework of international space law.<sup>233</sup> Initially signed by the United States, the Soviet Union, and the United Kingdom and now ratified by over 110 countries, the treaty establishes key principles for the peaceful use of outer space. Some of these principles include:<sup>234</sup>

- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
- The Moon and other celestial bodies shall be used exclusively for peaceful purposes;
- States shall be liable for damage caused by their space objects; and
- States shall avoid harmful contamination of space and celestial bodies.

While many of the norms promoted by the Accords, such as debris mitigation and spacecraft disposal, are consistent with standards China has also endorsed, Beijing views the initiative as a geopolitical tool intended to constrain its space ambitions. Instead, China, alongside Russia, is leading its own multilateral initiative, the ILRS. The initiative is framed as an inclusive alternative to the Artemis Program, the U.S.-led initiative to return humans to the Moon and eventually to Mars. The ILRS offers technical cooperation and lunar mission opportunities, particularly for developing countries. China has announced goals to build an operational ILRS on the south pole of the Moon by 2035. As of 2025, 17 countries and international organizations have joined the ILRS along with a dozen subnational entities and firms that have signed ILRS cooperation agreements with China.\*<sup>235</sup> Wu Weiren, chief designer of China's lunar exploration program, announced plans to attract 50 countries, 500 foreign research institutions, and 5,000 researchers to participate.<sup>236</sup> If realized, this would enable China to build a coalition of countries that may eventually back its preferred norms on space resource utilization, sovereignty-related claims, and standards of behavior on the Moon and beyond. Over time, such support could erode the universality of U.S.-led frameworks and lead to competing legal and operational regimes in outer space, complicating international coordination and undermining efforts to promote transparency, interoperability, and peaceful cooperation in the lunar exploration domain.

## Implications for the United States

**Losing U.S. leadership in space would amount to relinquishing the advantage first secured during the original space race—when space became essential to military superiority, global prestige, and geopolitical influence.** Today's contest with China is about who controls the critical infrastructure and rulemaking mechanisms that will define the future of the space domain. If the United States retreats, China is prepared to fill the void with a model of space governance that serves its interests—state-directed, opaque, and designed to embed long-term global dependencies on Chinese systems.

China's rapid expansion of space capabilities across the military, commercial, and civil/diplomatic realms—and intent to displace the United States as the world's premier space power—should concern all Americans. The challenges the United States faces in space are not only in the military sector. China's space capabilities allow it to threaten vital services enabled by satellites that affect the health and welfare of everyday U.S. citizens. China's attempts to reset international norms and standards in its favor could also undermine key sectors of our economy. **U.S. policymakers must act urgently to ensure that the United States wins this new space race and retains the strategic high ground that has long underpinned our military and economic leadership.**

Even as the U.S. military increasingly relies on space-enabled assets to fight and win modern wars, many of those assets are vulnerable to China's sophisticated offensive space capabilities. **Although**

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\*The 13 countries that have joined the ILRS include Belarus, Pakistan, Azerbaijan, Venezuela, Thailand, Serbia, Nicaragua, Senegal, Djibouti, Bolivia, Egypt, Ethiopia, and South Africa.

**the U.S. Space Force was established at the end of 2019 with the mission of ensuring continued U.S. space superiority, longstanding policy constraints have placed effective limits on its ability to achieve its critical mission.** These constraints include limits on developing and using offensive counterspace capabilities like ASAT weapons, electronic jamming, and cyber operations as well as limited resources to update legacy systems or build new capabilities.

The practical limits on the U.S. Space Force are in stark contrast to China's commitment. In his testimony to the Commission, General Salzman clearly laid out the broad military implications of China's advances in space, warning that without space superiority, other domains of warfare become untenable. **"Taken as a whole, China's potent and expanding arsenal of space-based capabilities multiplies its combat potential many times over... China can hold U.S. and allied forces at risk with long-range precision weapons, preventing our forces from taking meaningful action before they even reach theater. The consequence of failing to mitigate this threat means military objectives will be tough to meet without unacceptable loss of American lives."**<sup>237</sup>

China has sought to leverage its notable civil space achievements to gain a normative and technological edge to shape the future of global norms and standards in space exploration in its favor. If China succeeds in establishing a sustained presence on the Moon or takes the lead in developing lunar infrastructure, it could set precedents in areas such as resource utilization, territorial access, and the management of satellites, communications networks, lunar bases, or other orbital and lunar assets. Over time, China's approach could erode the universality of U.S.-led frameworks and lead to competing legal and operational regimes in outer space, complicating international coordination, and undermining efforts to promote transparency, interoperability, and peaceful cooperation in the lunar exploration domain. **The United States must confront the reality that civil space exploration is increasingly part of the broader U.S.-China strategic competition and that China's achievements could reshape global norms, shift technological power centers, and determine who sets the rules for the next era of human space activity.** This web of influence not only gives Beijing a broader diplomatic coalition—it provides physical access, data advantages, and potential staging points for strategic operations in future conflicts.

China's expanding use of space technologies and applications to leverage partnerships with low- and middle-income countries not only has led to more resiliency and redundancy in its space architecture, but also has advanced its broader geostrategic interests. China has developed a network of ground stations around the world and has increasingly used a variety of government tools to tighten relations with those governments, pulling them further into China's orbit. **By offering favorable launch terms and free access to the BeiDou satellite navigation network and embedding technologies from firms such as Huawei into critical infrastructure, China has sought to bind these nations into its technological**

**ecosystem, creating long-term economic and strategic dependencies in its favor.** In the long run, there may be significant commercial implications to China's approach—China may use these relationships to lock in a greater share for its providers in launch and satellite markets, reducing market share for U.S. commercial space companies.

China's rapid progress in establishing a private—though state-guided—commercial space ecosystem in just a decade demonstrates the significant technological, market, and geostrategic challenge China's commercial space sector poses to the United States. Building on its extensive industrial policy experience, vast operations of its state-owned aerospace conglomerates, and affiliated research network, China has fostered a broader range and larger number of commercial space firms to compete with the United States' leading, but highly concentrated sector. The next five years could determine a generation of market dynamics in reusable launch and proliferated LEO satellite constellations—where China's ambitious plans could lead to a scarcity of orbits, limiting future competitors. Winners of this commercial competition will gain geopolitical influence and military advantage. **Though U.S. companies currently enjoy an early lead, China's proven playbook of extensive government support, development of excess capacity, leveraging of adjacent manufacturing capabilities, and use of other government programs to advance its commercial interests (in this case, its civil space program), could position it to close the gap and potentially surge ahead if the United States takes a misstep—a higher threat with a limited roster of U.S. firms.**

**Without urgent efforts to develop innovative technologies, modernize the U.S. space infrastructure, acquire robust counterspace capabilities, and strengthen international partnerships, the United States risks ceding its leadership in the space race to China.** Winning this race is not only about securing dominance in orbit—it is about protecting critical infrastructure, maintaining operational resilience, safeguarding democratic values in space governance, and ensuring that U.S. standards guide the development of rules and norms in space. Otherwise, China will use space to advance its own strategic interests to the disadvantage of the United States.

## Recommendations

The Commission recommends:

- To preserve and strengthen U.S. primacy in the critical space domain as China pursues sweeping advancements across military, commercial, and civil space sectors, Congress should:
  - Increase or reallocate appropriations for the U.S. Space Force to levels necessary to achieve space control and establish space superiority against China's rapidly expanding space and counterspace capabilities.
  - Direct the U.S. Department of Defense to enhance the U.S. Space Force's capacity to conduct space wargaming and develop realistic modeling and simulation of potential threats from China, including training programs for space operators

on warfighting tactics, techniques, and procedures necessary for space control.

- Conduct oversight hearings and other activities to ensure the United States maintains primacy in the space domain by identifying investments in cutting-edge space technologies and assessing China's space capabilities and threats to U.S. space industrial base capacity.
- Direct the U.S. Department of Commerce, in coordination with the U.S. Departments of Defense, State, and the Treasury, to produce an unclassified report to Congress within 180 days identifying China's commercial space capabilities, the dual-use nature of Chinese space technologies, and China's commercial space industry's support to the People's Liberation Army.
- Direct the U.S. National Space Council to increase international outreach on space launch services and ensure the United States remains the partner of choice for both government and commercial space launch.
- Express support for the strategic importance of U.S. leadership in civil space exploration and direct relevant agencies to assess the progress of the Artemis Accords, evaluate risks China poses to U.S. civil space priorities, including National Aeronautics and Space Administration (NASA) programs, and ensure program delays do not undermine U.S. credibility in establishing global norms for lunar and Martian exploration.

## **Appendix: Evolution of the Commercial Space Economy**

Several concurrent and mutually reinforcing advances are leading to rapid development of the commercial space sector, driven by increased demand for satellite internet, remote sensing, and other space-based commercial services.

### ***Advances in launch and satellite manufacturing***

Space used to be the provenance of governments and a limited number of large companies because of the immense costs associated with developing, launching, and operating space assets. Space launch and related infrastructure required hundreds of millions, if not billions, of dollars in investment. At the same time, satellite launches demanded heavier, more expensive rocketry because satellites were larger and were headed to very high geo-stationary orbits (GEO, roughly 22,000 miles above the Earth).<sup>238</sup> Much of the technology needed was complex and had limited commercial application outside of the space sector.

Within the last decade, parallel cost reductions and efficiency gains from reusable launch rockets (RLRs) and satellites have accelerated the commercial space market. Even before the advent of RLRs, economies of scale from higher launch cadences and reduced launch costs from smaller satellites that orbit closer to Earth's surface have made it quicker and cheaper to send satellites into space. RLRs reuse their first-stage booster, payload fairings, or other critical launch components that can account for as much as 70 percent of the rocket's total cost.<sup>239</sup> At the same time, satellite design has improved and manufacturing costs have dropped significantly due to the advent of "SmallSats" and even miniaturized "CubeSats," advances in technology, improvements in production processes like 3D printing, and developments in durable, lightweight materials.<sup>240</sup>

### ***Advances in satellite constellations, ground stations, and laser communications***

The cost reductions from RLRs and cheaper, miniaturized satellites are critical to the economic viability of low Earth orbit (LEO) mega-constellations—groups of hundreds to tens of thousands of satellites in LEO.<sup>241</sup> Because data transmissions from satellites in LEO reach Earth more quickly, they enable applications requiring low latency like satellite internet, offering solutions where ground-based infrastructure is not viable, such as on airplanes or ships, or in remote areas where building terrestrial networks is costly.<sup>242</sup>

However, unlike GEO satellites that remain in a fixed position relative to the Earth, LEO satellites close to the Earth's surface move quickly, providing coverage in a given area for only a short time. Ensuring continuous coverage for terrestrial users requires networks of hundreds or thousands of satellites, so the same location on earth's surface remains continuously serviced (i.e., a proliferated constellation). Moreover, the satellites must communicate with each other to handoff data transfers as different satellites orbit out of range and new ones replace them. The complexity of coordinating these constant transitions requires a wide network of

ground telemetry, tracking, and control (TT&C) stations capable of tracking satellites in real time.<sup>243</sup> The bandwidth for transmissions has also improved dramatically with intersatellite laser links that transmit higher volumes of data via lasers rather than traditional radio waves.<sup>244</sup>

***Competition for limited “orbital real estate” and third country ground stations***

Aside from competition for the underlying technologies, the future space economy is fueling a competition for satellite network positions in low-earth orbit and supportive ground infrastructure. The governing body for international satellites is the UN’s International Telecommunication Union (ITU), which has a system for allocating satellite spectrum—the radio frequencies satellites use to transmit data back to Earth—and orbital slots on a first come, first served basis (for more on China’s role in the ITU, see “China Overwhelms, Obstructs the ITU to Advance its Preferred Standards” textbox in the main chapter).<sup>245</sup> Before launching satellites, companies must file with the ITU to secure spectrum rights for ground-space communication. ITU rules give firms seven years to launch their first satellite and another seven to show steady deployment, or they risk losing their allocations.<sup>246</sup> Thus, companies are incentivized to stay on schedule, rapidly and repeatedly launching LEOs, or risk losing their claims.<sup>247</sup> With an estimated 70,000 LEO satellites expected to launch by 2029, commercial space firms are in a race against time to secure the best spectrum for their LEO satellites—Starlink alone hopes to launch 42,000 satellites by 2029 (as of September 25, 2025, it had 8,460 working satellites in orbit).<sup>248</sup>

## ENDNOTES FOR CHAPTER 7

1. U.S. Department of State, *Milestones: 1953–1960*, accessed July 9, 2025; Maddie Davis, “The Space Race,” *UVA Miller Center*.
2. “Star Trek,” *National Air and Space Museum*, accessed August 11, 2025.
3. U.S. Space Force, *Space Warfighting: A Framework for Planners*, March 2, 2025, 2.
4. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 1–2.
5. Liu Zhen, “China is Making Rapid Space Tech Gains. Here’s How the Military Could Use Them,” *South China Morning Post*, July 7, 2025; B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 3–4; Andrew Jones, “China Expands Counterspace Capabilities, New Report Finds,” *SpaceNews*, April 3, 2025; Sandra Erwin, “U.S. Intelligence Report: China’s Commercial Space Sector to Become Global Competitor by 2030,” *SpaceNews*, March 8, 20–23.
6. Ranson Lo, “China’s Space Capabilities and Ambitions,” *Bloomsbury Intelligence and Security Institute*, June 10, 2024.
7. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 24; Gregory Gagnon, “Why Military Space Matters,” *NDU Press*, July 7, 2023.
8. Gregory Gagnon, “Why Military Space Matters,” *NDU Press*, July 7, 2023; B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 24.
9. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 24; Gregory Gagnon, “Why Military Space Matters,” *NDU Press*, July 7, 2023.
10. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 3; U.S. Space Force, *Space Threat Fact Sheet*, February 21, 2025.
11. Gregory Gagnon, “Why Military Space Matters,” *NDU Press*, July 7, 2023; David Vergun, “Official Details Space-Based Threats and U.S. Countermeasures,” *DOD News*, April 26, 2023.
12. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 4; Gregory Gagnon, “Why Military Space Matters,” *NDU Press*, July 7, 2023; David Vergun, “Official Details Space-Based Threats and U.S. Countermeasures,” *DOD News*, April 26, 2023.
13. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 3; U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People’s Republic of China 2024*, December 18, 2024, 97; Khyle Eastin, “A Domain of Great Powers: The Strategic Role of Space in Achieving China’s Dream of National Rejuvenation,” *National Bureau of Asian Research*, May 10, 2024; U.S. Defense Intelligence Agency, *Challenges to Security in Space*, 2019, 14; William J. Broad and David E. Sanger, “China Tests Anti-Satellite Weapon Unnerving U.S.,” *New York Times*, January 18, 2007.
14. Khyle Eastin, “A Domain of Great Powers: The Strategic Role of Space in Achieving China’s Dream of National Rejuvenation,” *National Bureau of Asian Research*, May 10, 2024; Dean Cheng, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on China’s Space and Counterspace Programs*, February 18, 2015, 6.
15. Greg Hadley, “Saltzman: China’s ASAT Test was ‘Pivot Point’ in Space Operations,” *Air and Space Forces Magazine*, January 13, 2023; Michael D. Swaine, “Assessing the Meaning of the Chinese ASAT Test,” *Carnegie Endowment for International Peace*, February 7, 2007.
16. “In Their Own Words: Science of Military Strategy,” *China Aerospace Studies Institute*, 2020, 143. Translation; 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, 3; China’s State Council, 中国的军事战略 [China’s Military Strategy], May 2015, 5, 14. Andrew Erickson: English-Chinese Annotation.

17. J. Michael Dahm, "A Disturbance in the Force: The Reorganization of Peoples Liberation Army Command and Elimination of China's Strategic Support Force," *China Brief*, April 26, 2024; 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, 3.
18. U.S. Defense Intelligence Agency, *Challenges to Security in Space*, 2019, 14.
19. "In Their Own Words: Science of Military Strategy," *China Aerospace Studies Institute*, 2020, 143. Translation.
20. "In Their Own Words: Science of Military Strategy," *China Aerospace Studies Institute*, 2020, 137. Translation.
21. U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2023*, October 19, 2023, 41.
22. U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2024*, December 18, 2024, 97; U.S.-China Economic and Security Review Commission, *2024 Annual Report to Congress*, November 2024, 553–558.
23. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 3.
24. Thomas D. Taverney, "The Evolution of Space-Based ISR," *Air and Space Forces Magazine*, August 10, 2022.
25. U.S. Space Force, *Space Threat Fact Sheet*, February 21, 2025.
26. U.S. Space Force, *Space Threat Fact Sheet*, February 21, 2025.
27. Tate Nurkin et al., "China's Remote Sensing," *OTH Intelligence Group LLC* (prepared for the U.S.-China Economic and Security Review Commission), December 16, 2024, 11; Clayton Swope, "No Place to Hide: A Look Into China's Geosynchronous Surveillance Capabilities," *Center for Strategic and International Studies*, January 19, 2024.
28. Brien Alkire, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 2; Clayton Swope, "No Place to Hide: A Look into China's Geosynchronous Surveillance Capabilities," *Center for Strategic and International Studies*, January 19, 2024.
29. Tate Nurkin et al., "China's Remote Sensing," *OTH Intelligence Group LLC* (prepared for the U.S.-China Economic and Security Review Commission), December 16, 2024, 55.
30. Ralph Jennings, "China's Next-Gen BeiDou Satellite System to Ramp Up Rivalry with US-Based GPS," *South China Morning Post*, November 29, 2024.
31. U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2024*, December 18, 2024, 85.
32. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 4; Kevin Pollpeter, "To Be More Precise: BeiDou, GPS, and the Emerging Competition in Satellite-Based PNT," *China Aerospace Studies Institute*, May 2024, [v].
33. Kevin Pollpeter, "To Be More Precise: BeiDou, GPS, and the Emerging Competition in Satellite-Based PNT," *China Aerospace Studies Institute*, May 2024, 36–37, 41–42.
34. U.S. Department of State, *Military-Civil Fusion and the People's Republic of China*, accessed August 28, 2025.
35. Blaine Curcio, "Developments in China's Commercial Space Sector," *National Bureau of Asian Research*, August 24, 2021.
36. Tate Nurkin et al., "China's Remote Sensing," *OTH Intelligence Group LLC* (prepared for the U.S.-China Economic and Security Review Commission), December 16, 2024, 63.
37. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 4.
38. Miranda Nazzaro, "US Space Chief Warns China, Russia are Greatest Risks to Space Defense Capabilities," *The Hill*, May 15, 2025; B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 4; Josh Dinner, "China Now Has a 'Kill Mesh' in Orbit, Space Force Vice Chief Says," *Space*, March 21, 2025; Michael A. Guetlein, 2025 16th Annual McAleese "Defense Programs" Conference, *McAleese and Associates*, March 19, 2025. [13:12–13:52].
39. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 4.

40. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 26.
41. "Global Counterspace Capabilities," *Secure World Foundation*, April 2025, 03–12.
42. "Global Counterspace Capabilities," *Secure World Foundation*, April 2025, 03–14; U.S. Space Force, *Space Threat Fact Sheet*, February 21, 2025.
43. U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2024*, December 18, 2024, 101.
44. "Global Counterspace Capabilities," *Secure World Foundation*, April 2025, [xxiii], 03–01.
45. "Global Counterspace Capabilities," *Secure World Foundation*, April 2025, 03–01–03–05.
46. Liu Zhen, "Chinese Space Station Reaches for Next Stage of Construction with Robotic Arm Test," *South China Morning Post*, January 6, 2022.
47. Kari A. Bingen et al., *Space Threat Assessment 2023*, *Center for Strategic and International Studies*, April 2023, 11; Andrew Jones, "China's Shijian-21 Towed Dead Satellite to a High Graveyard Orbit," *SpaceNews*, January 27, 2022.
48. Kaitlyn Johnson, Thomas G. Roberts, and Brian Weeden, "Mitigating Noncooperative RPOs in Geosynchronous Orbit, *AETHER: Journal of Strategic Airpower and Spacepower* 1, no. 4 (2022): 86; Andrew Jones, "China Launches Classified Space Debris Mitigation Technology Satellite," *SpaceNews*, October 24, 2021.
49. Henry Sokolski, *Space: America's New Strategic Front Line* (Nonproliferation Policy Education Center, 2023), 186; Matthew Mowthorpe and Markos Trichas, "A Review of Chinese Counterspace Activities," *Space Review*, August 1, 2022.
50. Courtney Albion, "China Demonstrated 'Satellite Dogfighting,' Space Force General Says," *Defense News*, March 18, 2025.
51. Simone McCarthy, "China is Practicing 'Dogfighting' with Satellites as it Ramps Up Space Capabilities: US Space Force," *CNN*, March 21, 2025; Audrey Decker, "China is Practicing 'Dogfighting' in Space, Space Force says," *Defense One*, March 18, 2025.
52. "Global Counterspace Capabilities," *Secure World Foundation*, April 2025, 03–18–03–19.
53. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 5.
54. Kristin Burke, "PLA Counterspace Command and Control," *China Aerospace Studies Institute*, December 2023, 26–29.
55. U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2024*, December 18, 2024, 100.
56. "Global Counterspace Capabilities," *Secure World Foundation*, April 2025, 03–12.
57. "Global Counterspace Capabilities," *Secure World Foundation*, April 2025, 03–20–03–23.
58. U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2024*, December 18, 2024, 86.
59. Andrew Erickson, "Commentary on 'China Adds Hundreds of Satellites for Use in War; Russia Building Nuke to Destroy Enemies' Assets," *AndrewErickson.com*, September 26, 2024; Gabriel Honrada, "Chinese Subs May Soon Sport Satellite-Killing Lasers," *Asia Times*, July 22, 2024.
60. Jennifer DiMascio, "U.S. Counterspace Capabilities," *Congressional Research Service* (Report No. IN12420), September 11, 2024, 1; Matthew J. Mowthorpe, "The United States Approach to Military Space During the Cold War," *Air and Space Power Chronicles*, March 8, 2001; Lance K. Kawane, "History of Space Policy," *United States Army War College, Strategy Research Project*, March 22, 2012, 8, 10–11.
61. Theresa Hitchens, "Exclusive: US Loosens Some Rules for Offensive Counterspace Ops, Wargaming," *Breaking Defense*, May 12, 2025; Peter Hays and Sarah Mineiro, "Modernizing Space-Based Nuclear Command, Control, and Communications," *Atlantic Council*, June 2024, 10–12.
62. Theresa Hitchens, "Exclusive: US Loosens Some Rules for Offensive Counterspace Ops, Wargaming," *Breaking Defense*, May 12, 2025; B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 13–14; U.S. Space Force, *Space Warfighting: A Framework for Planners*, March 2025, 5.
63. U.S. Space Force, *Space Warfighting: A Framework for Planners*, March 2025, 8–10.

64. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 21.

65. Kevin Pollpeter, Elizabeth Barrett, and April Herlevi, "Deterring China's Use of Force in the Space Domain: A Proposed Scorecard for Weighing the Risks," *Center for Naval Analyses*, May 2025, 17–18; Brien Alkire, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 141.

66. Brien Alkire, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 141.

67. Kevin Pollpeter, Elizabeth Barrett, and April Herlevi, "Deterring China's Use of Force in the Space Domain: A Proposed Scorecard for Weighing the Risks," *Center for Naval Analyses*, May 2025, 17–18.

68. Kevin Pollpeter, Elizabeth Barrett, and April Herlevi, "Deterring China's Use of Force in the Space Domain: A Proposed Scorecard for Weighing the Risks," *Center for Naval Analyses*, May 2025, 17–18.

69. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 41–42.

70. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 41–42.

71. Rob Miltersen, "Chinese Aerospace Along the Belt and Road," *China Aerospace Studies Institute*, June 2020.

72. Rob Miltersen, "Chinese Aerospace Along the Belt and Road," *China Aerospace Studies Institute*, June 2020, 7.

73. Rob Miltersen, "Chinese Aerospace Along the Belt and Road," *China Aerospace Studies Institute*, June 2020, 9.

74. Fazal Gilani, "The Belt and Road Initiative Space Information Corridor," *Grandview Institution*, May 6, 2022.

75. Joey Roulette, "China Builds Space Alliances in Africa as Trump Cuts Foreign Aid," *Reuters*, February 11, 2025.

76. Mustapha Iderawumi, "African Space Agency Now Operational," *Space in Africa*, April 20, 2025.

77. Samuel Nyangi, "Senegal Joins China's ILRS Moon Project," *Space in Africa*, September 5, 2024; Andrew Jones, "China Wants 50 Countries Involved in Its ILRS Moon Base," *SpaceNews*, July 23, 2024; Julie Michelle Klinger and Temidayo Isaiah Oniosun, "China's Space Collaboration with Africa: Implications and Recommendations for the United States," *United States Institute of Peace*, September 19, 2023.

78. Nadège Rolland, "Securing the Belt and Road Initiative," *National Bureau of Asian Research*, September 2019, 25.; Hui Jiang, "Programme and Development of the 'Belt and Road' Space Information Corridor," *China National Space Administration*, April 2019.

79. Yu Dawei and Denise Jia, "China's own GPS, BeiDou Satellite System, Comes Down to Earth," *Nikkei Asia*, October 7, 2023; David H. Millner, Stephen Maksim, and Marissa Huhmann, "BeiDou: China's GPS Challenger Takes Its Place on the World Stage," *National Defense University Press*, April 14, 2022.

80. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on the Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 37.

81. John Dotson, "The Beidou Satellite Network and the 'Space Silk Road' in Eurasia," *Jamestown Foundation*, July 15, 2020.

82. China's State Council, *China's BeiDou Navigation Satellite System in the New Era*, November 4, 2022; John Dotson, "The Beidou Satellite Network and the 'Space Silk Road' in Eurasia," *Jamestown Foundation*, July 15, 2020.

83. Federal Aviation Administration, *Satellite Navigation - Global Positioning System (GPS)*, accessed July 26, 2025; Sumit Ahlawat, "BeiDou Vs GPS: A New Tech-War Brews between China & US to Control Global Satellite Navigation System," *Eurasian Times*, May 21, 2025; U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2024*, December 18, 2024, 85; "More BeiDou than GPS in 130 of 195 Countries," *Resilient Navigation and Timing Foundation*, August 22, 2019.

84. David H. Millner, Stephen Maksim, and Marissa Huhmann, "BeiDou: China's GPS Challenger Takes Its Place on the World Stage," *National Defense University Press*, April 14, 2022; "More BeiDou than GPS in 130 of 195 Countries," *Resilient Navigation and Timing Foundation*, August 22, 2019.

85. Mustapha Iderawumi, "China and Africa to Strengthen Collaboration on BeiDou Satellite System," *Space in Africa*, November 9, 2021.

86. Rumi Aoyama, "China's Dichotomous BeiDou Strategy: Led by the Party for National Deployment, Driven by the Market for Global Reach," *Journal of Contemporary East Asia Studies* 11, no. 2 (February 2023): 282–299.

87. "4th Arab-China States BDS Cooperation Forum," *Arab Information and Communication Technologies Organization*, accessed July 16, 2025; "China Endeavors to Foster More United, Prosperous SCO Community," *Xinhua*, July 5, 2024; "The First China-Central Asia BDS Cooperation Forum Convened in Nanning, Guangxi," *BeiDou Navigation Satellite System*, October 19, 2019; "China Opens First Overseas Center for BeiDou Navigation Satellite System in Tunisia," *Xinhua*, April 11, 2018.

88. Fan Wei, Fan Anqi, and Liang Rui, "China to Build Next-Gen BeiDou System, Planning Test Satellite Launches in 2027 and System Completion by 2035," *Global Times*, November 28, 2024; Andrew Jones, "China to Launch Next-Generation Beidou Satellites in 2027," *SpaceNews*, November 28, 2024.

89. Tereza Pultarova, "China's Push for a More Commercial Space Industry," *Via Satellite*, May 28, 2024.

90. "Nigeria's NigComSat Confirms Acquisition of Two Satellites from China Great Wall Industry Corp.," *Space Watch*, May 2, 2018; Caleb Henry, "Back-to-Back Commercial Satellite Wins Leave China Great Wall Hungry for More," *SpaceNews*, August 22, 2017.

91. Cate Cadell and Marcelo Perez del Carpio, "A Growing Global Footprint for China's Space Program Worries Pentagon," *Washington Post*, November 21, 2023.

92. Victoria Samson, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 146–147.

93. Victoria Samson, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 146–147.

94. Peter Wood, Alex Stone, and Taylor A. Lee, "China's Ground Segment," *China Aerospace Studies Institute*, March 1, 2021, 5, 12.

95. Victoria Samson, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 147.

96. Victoria Samson, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 147.

97. **Algeria:** Rui Barbosa, "Chinese Long March 3B lofts Alcomsat-1 for Algeria," *NSF*, December 10, 2017; Ayooluwa Adetola, "Algeria Signs 5-year Strategic Cooperation Agreement with China," *Space in Africa*, November 9, 2022. **Angola:** Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025. **Antarctica:** "China opens Antarctic station south of Australia, New Zealand," *Reuters*, February 7, 2024. **Argentina:** Matthew Funaiole, Dana Kim, Brian Hart, and Joseph Bermudez, "Eyes on the Skies," *Center for Strategic and International Studies*, October 4, 2022; "China successfully launches 13 satellites, including 10 for Argentina, with a single rocket," *The Economic Times*, November 6, 2020; Cassandra Garrison, "China's military-run space station in Argentina is a 'black box,'" *Reuters*, January 31, 2019. **Austria:** Dean Cheng, "How China has Integrated its Space Program into its Broader Foreign Policy," *China Aerospace Studies Institute*, 2020, 8. **Azerbaijan:** "Azercosmos partner with Chinese Satellite-herd on satellite ground station," *Satellite Evolution Group*, July 5, 2021; Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025; Irene Klotz, "Azerbaijan Joins China's Lunar Program," *Aviation Week Network*, October 11, 2023. **Bahrain:** Bahrain Space Agency, "The NSSA Launches Advanced Bahraini Artificial Intelligence Algorithms into Space," May 25, 2024; Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025. **Belarus:** Jeffrey Hill, "China Wins First European Satellite Construction, Launch Contract," *Via Satellite*, September 21, 2011; "Belintersat," *Sky Brokers*, accessed October 16, 2025; Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025; "Partner nations on China's Lunar Research Station Programme," *Reuters*, October 26, 2023. **Bolivia:** Cate Cadell and Marcelo Perez del Carpio, "A Growing Global Footprint for China's Space Program Worries Pentagon," *Washington Post*, November 21, 2023; Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025; "China-Africa Space Cooperation Benefits People Across Continent," *Xinhua*, August 30, 2024; "Latin America Space Roundup: 25 April to 8 May 2025," *Latin America Space Mon-*

itor by AzurX, May 8, 2025. **Brazil**: “Chinese Satellite Facilities Database,” *Center for Strategic and International Studies*, accessed on October 16, 2025; Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025. **Burkina Faso**: Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025; Samuel Nyangi, “2024 in Review: Burkina Faso’s Growing Space Ambitions,” *Space in Africa*, December 23, 2024; “China-Africa Space Cooperation Benefits People Across Continent,” *Xinhua*, August 30, 2024. **Burma (Myanmar)**: Jonathan Roll and Oliver Du Bois, “Redshift: The Acceleration of China’s Commercial and Civil Space Enterprise & The Challenge to America,” *Commercial Space Federation*, September 2025, 8; “China Strengthens International Space Cooperation,” *Xinhua*, April 19, 2018. **Cambodia**: Jonathan Roll and Oliver Du Bois, “Redshift: The Acceleration of China’s Commercial and Civil Space Enterprise & The Challenge to America,” *Commercial Space Federation*, September 2025, 8; Caleb Henry, “Cambodia to Buy Chinese Satellite as Relations Tighten on Belt and Road Initiative,” *SpaceNews*, January 12, 2018; Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025. **Chile**: Deirdre Kirsten Tatlow, “Chinese Space Project Under Review After Newsweek Investigation,” *Newsweek*, March 26, 2025; Pamela Arostica Fernandez, “Chile’s once-pioneering relationship with China is turning into dependency,” *Merics*, August 18, 2022; Valentina Fuentes, “Chinese Telescope Puts Chile in Geopolitical Bind With US,” *Bloomberg*, April 29, 2025; Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025; Sweden in Chile-China: Matthew Funairole, Brian Hart, Joseph Bermudez, and Aidan Powers-Riggs, “Frozen Frontiers: China’s Great Power Ambitions in the Polar Regions,” *Center for Strategic and International Studies*, April 18, 2023. **Cuba**: Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025. **DRC**: United Nations, Congo-Sat1: Chinese Company will Launch DR Congo’s First Satellite, *Office for Outer Space Affairs*, November 28, 2012. **Djibouti**: “A Planned Spaceport in Djibouti may give China a Boost,” *Economist*, January 19, 2023. **Ecuador**: Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025. **Egypt**: Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025; Andrew Jones, “Egypt Joins China’s ILRS Moon Base Initiative,” *SpaceNews*, December 7, 2023. **Ethiopia**: Joey Roulette, Eduardo Baptista, Sarah El Safty, and Joe Brock, “China Builds Space Alliances in Africa as Trump Cuts Foreign Aid,” *Reuters*, February 11, 2025; Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025; Zhao Lei, “Chinese Rocket Sends Ethiopia’s 1st Satellite into Space,” *China Daily*, December 20, 2019; Ling Xin, “2 Major Space Institutes in Africa join China-led Moon Project,” *South China Morning Post*, April 20, 2024. **France**: Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025. **Hungary**: Ling Xin, “Hungarian Solar Research Lab Signs up for China-led ILRS Moon Project,” *South China Morning Post*, July 22, 2024. **Indonesia**: “Indonesia Makes Major Progress in Building 1st VGOS Radio Telescope in Collaboration with China,” *Xinhua*, July 11, 2025; Rui Barbosa, “Long March 3B Fails Firing Indonesian Satellite Launch,” *NASA Space Flight*, April 9, 2020; United Nations, China and Indonesia Sign Remote-Sensing Agreement, *Office for Outer Space Affairs*, October 20, 2014. **Iran**: Jemima Baar, “BeiDou and Strategic Advancements in PRC Space Navigation,” *Jamestown Foundation*, March 1, 2024; Han Zhen, “Chinese Commentators Cheer Over Iran Ditches GPS for BeiDou,” *China Global South Project*, August 3, 2025. **Italy**: “China-Italian Space Agency Partnership for Earth Natural Disaster Monitoring,” *Friends of NASA*, June 16, 2025; China’s National Space Administration, *Administrator Ma Met with ASI President and Signed CSES MOU*, September 27, 2013. **Kazakhstan**: Yunis Sharifi, “China-Central Asia Weekly Digest,” *China Global South Project*, August 2, 2025; “China’s satellite internet provider Spacesail sets up in Kazakhstan,” *Intellineus*, January 23, 2025; Reid Standish, “Kazakh Plan to Join Chinese-Led Moon Base Would Strengthen Space Partnership,” *Radio Free Europe*, August 13, 2024. **Kenya**: Andrew Erickson and Amy Chang, “China’s Navigation in Space,” *U.S. Naval Institute*, April 2012; Mustapha Iderawumi, “SSGI and KAIST Join China-led Moon Project, ILRS,” *Space in Africa*, April 21, 2024. **Kyrgyzstan**: “Kyrgyzstan Join Lunar Research Station Project,” *Interfax*, March 7, 2024. **Laos**: Cate Cadell and Marcelo Perez del Carpio, “A Growing Global Footprint for China’s Space Program Worries Pentagon,” *Washington Post*, November 21, 2023; Stephen Clark, “China Launches First Satellite for Laos,” *Spaceflight Now*, November 22, 2015; China’s National Space Administration, *International Cooperation in outer space*, January 7, 2022. **Luxembourg**: Luxembourg Space Agency, *Luxembourg Cooperates with China in the Exploration and Use of*

*Outer Space for Peaceful Purpose*, January 17, 2018. **Malaysia:** John Tanner, "MEA-SAT to Collaborate with China's SpaceSail on Multi-Orbit Services," *Developing Telecoms*, February 6, 2025. **Mexico:** Ling Xin, "China Launches Tiny Mexican Satellites in Rare North American Rocket Contract," *South China Morning Post*, August 31, 2025; "China's CAS Space Rocket to Carry Mexican Satellites on Historic Mission," *Orbital Today*, August 18, 2025; "China Demonstrates Openness, Inclusiveness in Int'l Space Cooperation," *Xinhua*, June 13, 2019. **Mozambique:** Samuel Nyangi, "China's Role in Developing Africa's Meteorology Through Fengyun Satellites," *Space in Africa*, September 3, 2024; "Mozambique the First African Country to Use Chinese Meteorological Satellite Monitoring," *CL Brief*, March 12, 2021. **Namibia:** Jevans Nyabiage, "China-built Satellite Station a 'Shining' Example of Support for Namibian Space Programme," *South China Morning Post*, August 2, 2025; Wang Zefei, "China-Namibia Dream Shines in Space," *Global Times*, October 14, 2021. **Nepal:** "Satellite Communication Services to Help Ensure Tourist Safety in Nepal," *Asia & Pacific*, July 16, 2025. **Nicaragua:** Andrew Jones, "Nicaragua Signs Up to China's ILRS Moon Program," *SpaceNews*, April 25, 2024. **Nigeria:** Jevans Nyabiage, "China-built Satellite Station a 'Shining' Example of Support for Namibian Space Programme," *South China Morning Post*, August 2, 2025; Chris Bergin, "China Launches First Communications Satellite for Nigeria," *NASA Space Flight*, May 13, 2007. **Pakistan:** Peter Wood, Alex Stone, and Taylor Lee, "China's Ground Segment," *China Aerospace Studies Institute*, 2021, 66; Andrew Jones, "China Launches Remote Sensing Satellite for Pakistan with Kuaizhou-1A rocket," *SpaceNews*, July 31, 2025; Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025; Andrew Jones, "Pakistan Becomes Latest Country to Join China's ILRS Moon Project," *SpaceNews*, October 20, 2023. **Panama:** Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025. **Peru:** Cate Cadell and Marcelo Perez del Carpio, "A Growing Global Footprint for China's Space Program Worries Pentagon," *Washington Post*, November 21, 2023; R. Evan Ellis, "China-Latin America Space Cooperation: An Overview," *Diplomat*, February 16, 2024. **Philippines:** Jonathan Roll and Oliver Du Bois, "Redshift: The Acceleration of China's Commercial and Civil Space Enterprise & The Challenge to America," *Commercial Space Federation*, September 2025, 8. **Russia:** Jack Lau, "China and Russia to Boost Satellite Navigation Systems with New Ground Stations," *South China Morning Post*, September 30, 2022; Kevin Pollpeter, Elizabeth Barrett, Jeffrey Edmonds, Amanda Kerrigan, and Andrew Taffer, "China-Russia Space Cooperation," *Center for Naval Analysis*, April 25, 2023; Meia Nouwens, "China's dual-use space sector goes global," *International Institute for Strategic Studies*, July 17, 2025; Victoria Bela, "China and Russia sign nuclear reactor deal to fuel lunar research station," *South China Morning Post*, May 14, 2025. **Rwanda:** Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025. **Saudi Arabia:** "Saudi Arabia Launches 2 Satellites from China's Jiuquan Satellite Launch Center," *Xinhua*, December 7, 2018; Zhang Ming, "the Space Silk Road and China-Arab States Space Cooperation," *Insights* no. 309 (June 2024), 11; Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025. **Senegal:** Samuel Nyangi, "Senegal Joins China's ILRS Moon Project," *Space in Africa*, September 5, 2024; Andrew Jones, "Senegal Among New Members of China's ILRS Moon Base Project," *SpaceNews*, September 5, 2024. **Serbia:** Radomir Ralev, "Serbia, China's Space Agency to Jointly Develop Satellite Systems," *SeeNews*, June 8, 2020; Andrew Jones, "Serbia Becomes Latest Country to Join China's ILRS Moon Base Project," *SpaceNews*, May 10, 2024. **South Africa:** Victoria Bela, "Is this Quantum Microsatellite the Start of a Global Network? A Chinese-South African Team Tested the Idea," *South China Morning Post*, March 21, 2025; Joey Roulette, Eduardo Baptista, Sarah El Safty, and Joe Brock, "China Builds Space Alliances in Africa as Trump Cuts Foreign Aid," *Reuters*, May 21, 2025. **Sri Lanka:** "China Launches Sri Lanka's First Satellite as India Watches Ties Grow," *Reuters*, November 27, 2012. **Sweden:** China's National Space Administration, *CNSA and SNSB Signed Memorandum of Understanding on Space Cooperation*, September 16, 2015; "Swedish Space Agency Halts New Business Helping China Operate Satellites," *Reuters*, September 21, 2020. **Sudan:** "Sudan Launches its First Ever Satellite in Partnership with China," *Al Jazeera*, November 6, 2019. **Tanzania:** Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025. **Thailand:** Ling Xin, "China Doubles Down on Building Telescopes in Thailand to Monitor Earth Using Space Signals," *South China Morning Post*, May 31, 2025; "China Launches 1st Reusable Satellite with Payloads from Thailand & Pakistan," *Satnews*, September 29, 2024; Meia Nouwens, "China's Dual-Use Space Sector Goes Global," *International Institute for Strategic Studies*, July 17, 2025; Andrew Jones, "Thailand Joins China-led ILRS Moon

Base Initiative,” *SpaceNews*, April 5, 2024. **Tunisia:** Jevans Nyabiage, “How China Ties Space Projects in Africa with Climate and Security Priorities,” *South China Morning Post*, November 21, 2023; “BeiDou Navigation Satellite System Centre opens in Tunisia,” *Space in Africa*, April 16, 2018. **Turkey:** “Turkish Imaging Satellite Lifted to Orbit by China,” *SpaceFlight Now*, December 18, 2012; Ling Xin, “Nato Member Turkey Seeks to Join China-Russia Moon Project Instead of US-led Artemis Programme: Reports,” *South China Morning Post*, April 11, 2024. **UAE:** Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025. **United Kingdom:** Jonathan Roll and Oliver Du Bois, “Red-shift: The Acceleration of China’s Commercial and Civil Space Enterprise & The Challenge to America,” *Commercial Space Federation*, September 2025, 8; British National Space Centre, *Memorandum of Understanding Between the United Kingdom Space Agency and the China National Space Administration Regarding Cooperation in the Exploration and Use of outer Space for Peaceful Purposes*, January 14, 2005. **Uzbekistan:** “Uzbekistan, China Ink Host of Cooperation Agreements in Beijing,” *Turkic World*, September 2, 2025. **Venezuela:** “Chinese Satellite Facilities Database,” *Center for Strategic and International Studies*, accessed on October 16, 2025; Stephen Clark, “China successfully launches Earth-imaging satellite for Venezuela,” October 9, 2017; Meia Nouwens, “China’s Dual-Use Space Sector Goes Global,” *International Institute for Strategic Studies*, July 17, 2025; Andrew Jones “Venezuela Signs up to China’s Moon Base Initiative,” *SpaceNews*, July 18, 2023.

98. Guido L. Torres and Laura Delgado López, “Space, Speed, and Sovereignty: Hypersonic Tensions in the Southern Hemisphere,” *Center for Strategic and International Studies*, May 21, 2024

99. Peter Wood, Alex Stone, and Taylor A. Lee, “China’s Ground Segment,” *China Aerospace Studies Institute*, March 1, 2021.

100. Peter Wood, Alex Stone, and Taylor A. Lee, “China’s Ground Segment,” *China Aerospace Studies Institute*, March 1, 2021.

101. Victoria Samson, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 148.

102. Victoria Samson, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 148.

103. Carlo J.V. Caro, “The Patagonian Enigma: China’s Deep Space Station in Argentina,” *Diplomat*, January 8, 2024.

104. Victoria Samson, written response to question for the record for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 149; Carlo J.V. Caro, “The Patagonian Enigma: China’s Deep Space Station in Argentina,” *Diplomat*, January 8, 2024.

105. Matthew P. Funaiole, et al. “Eyes on the Skies: China’s Growing Space Footprint in South America,” *Center for Strategic and International Studies*, October 4, 2022.

106. Peter Wood, Alex Stone, and Taylor A. Lee, “China’s Ground Segment,” *China Aerospace Studies Institute*, March 1, 2021. 5.

107. “Breaking News: China Deploys New Liaowang-1 Space Tracking Ship Capable of Monitoring U.S. Military Satellites and Missile Launches,” *Army Recognition*, April 14, 2025; U.S. Department of Defense, *Military and Security Developments Involving the People’s Republic of China*, 2024.

108. Peter Wood, Alex Stone, and Taylor A. Lee, “China’s Ground Segment,” *China Aerospace Studies Institute*, March 1, 2021, 5.

109. Ken Obuszewski, “Edge Computing Use Cases: Advancing Space Applications,” *VORAGO Technologies*, May 22, 2025.

110. Sikha Haritwal, “LEO Satellite Mega-Constellations: Market Dynamics, Orbital Mechanics, Policy Challenges, and the Future of Global Connectivity,” *Elsevier*, September 24, 2025.

111. Charlie Metcalfe, “On the Ground in Ukraine’s Largest Starlink Repair Shop,” *MIT Technology Review*, August 21, 2025.

112. Alyssa Laffeur, “China’s Space Industry Unpacked: Key Players, Policy, and Private Sector Growth,” *Space Insider*, May 13, 2025. **Launch vehicle manufacturers:** “China Academy of Launch Vehicle Technology (CALT),” *International Astronautical Congress*; “Reducing the Cost of Space Travel with Reusable Launch Vehicles,” *National Security Technology Acceleration*, February 12, 2024; “Blue Origin Overview,” *RocketLaunch.org*. **Satellite manufacturers:** Mark Stokes, Gabriel Alvarado, Emily Weinstein, and Ian Easton, “China’s Space and Counterspace Capabilities and Activities,” *Project 2049* (prepared for the U.S.-China Economic and Security Review Commission), March 30, 2020. 48; “Positioning, Navigation & Timing: GPS III/IIIF

- Satellites,” *Lockheed Martin*; Michael Kan, “SpaceX Hits a Big Milestone for Starlink Satellite Production,” *PC Mag*, June 13, 2025. **Propulsion developers and rocketry firms:** “China has successfully developed the world’s largest thrust solid rocket engine,” *CCTV*, October 20, 2021; “Lockheed Martin, General Dynamics to build their own rocket motors” *Reuters*, August 13, 2024; “Solid Rocket Motors,” *Anduril*. **Subsystems providers:** “China Academy of Space Technology [CAST],” *Federation of American Scientists*; “Communications Satellites,” *Northrop Grumman*; Aimee Emery-Ortiz, “Ball Aerospace’s Groundbreaking ESA Technology Brings Multi-Orbit Capabilities for Better Inflight Experiences,” *Intelsat*, October 3, 2023. **Satellite constellation management:** Stephen Clark, “China’s Guowang megaconstellation is more than another version of Starlink,” *Ars Technica*, August 20, 2025; “Satellite Technology,” *Starlink*; “Powering the Next Era of Earth Intelligence,” *Planet Labs*; “Virtual Satellite Networks,” *Viasat*; Jason Rainbow, “Viasat Developing Small Satellite Constellation Management Service,” *SpaceNews*, August 5, 2024. **Ground control systems and mission management:** “Satellite Ground Systems,” *Chang Guang Satellite Technology Co., Ltd.*; “Proven Turnkey Ground Systems to Meet Your Mission,” *Kratos*; “Satellite Ground Systems,” *General Dynamics*. **Secure data relay:** Andrew Jones, “China Launches New Tianlian Data Relay Satellite to Support Human Spaceflight,” *SpaceNews*, March 26, 2025; “Starlink’s Dual Revolution: The Technological and Strategic Impact of Civilian and Military Satellite Constellations,” *Debug Lies News*, January 19, 2025; “Next-Gen Satellite Technology,” *Capella Space*. **On-orbit services:** Boyu Ma, Zainan Jiang, Yang Liu, et. al., “Advances in Space Robots for On-Orbit Servicing: A Comprehensive Review,” *Wiley Advanced*, April 20, 2023; “NASA’s On-Orbit Servicing, Assembly, and Manufacturing 1 Mission Ready for Spacecraft Build,” *NASA*, May 5, 2021. **Satellite internet:** “Shanghai Spacesail Technologies CO., Ltd.,” *MWC GSMA*; Andrew Jones, “First Launch of Long March 8A Sends Second Group of Guowang Megaconstellation Satellites into Orbit,” *SpaceNews*, February 11, 2025; “Starlink Network Update,” *Starlink*; “Our history,” *Viasat*. **Remote sensing and imaging:** Matthew Bruzzese, “Chang Guang Satellite Technology,” *China Aerospace Studies Institute*, March 2024; “Space Will,” *Sky Brokers*; Tate Nurkin et al., “China’s Remote Sensing,” *OTH Intelligence Group LLC* (prepared for the U.S.-China Economic and Security Review Commission), December 16, 2024, 15, 29; Sandra Erwin, “BlackSky to Launch Next-Gen-Imaging Satellite as it Seeks Market Edge,” *SpaceNews*, February 10, 2025.
113. Yeling Tan, Mark Dallas, and Henry Farrell, “Driven to Self-Reliance: Technological Interdependence and the Chinese Innovation Ecosystem,” *International Studies Quarterly* (Forthcoming, 2025) : 1–54; Mary Hui, “Checking China’s Chokepoints,” *A/symmetric*, September 7, 2024; Khyle Eastin, “A Domain of Great Powers: The Strategic Role of Space in Achieving China’s Dream of National Rejuvenation,” *National Bureau of Asian Research*, May 10, 2024; China’s State Council, *Full Text: China’s Space Program: A 2021 Perspective*, January 28, 2022; Ben Murphy, English translation of “Certain Major Issues for Our National Medium- to Long-Term Economic and Social Development Strategy” (国家中长期经济社会发展战略若干重大问题), *Center for Security and Emerging Technology*, November 10, 2020, 3.
114. Blaine Curcio, “A Rising Chinese Space Sector: Expectations vs Reality,” *Satellite Markets & Research*, June 1, 2022.
115. Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 1, 6.
116. Hema Nadarajah, “China: A Global Power’s Celestial Ambitions,” *Asia Pacific Foundation of Canada*, May 9, 2024; Andrew Jones, “China Sets Out Clear and Independent Long-Term Vision for Space,” *SpaceNews*, December 22, 2022.
117. Blaine Curcio, “Developments in China’s Commercial Space Sector,” *National Bureau of Asian Research*, August 24, 2021.
118. Blaine Curcio, “Developments in China’s Commercial Space Sector,” *National Bureau of Asian Research*, August 24, 2021.
119. “Guiding Opinions of the State Council on Innovating the Investment and Financing Mechanisms in Key Areas and Encouraging Social Investment (Document No. 60),” United Nations, accessed July 7, 2025. <http://www.cpppc.org.cn/zy/994006.jhtml>, 2015; Tereza Pultarova, “China’s Push for a More Commercial Space Industry,” *Via Satellite*, July 24, 2023; Max Zhang and Xiaonan Yang, “China’s Emerging Commercial Space Industry: Current Developments, Legislative Challenges, and Regulatory Solutions,” *Acta Astronautica* (2022).
120. Rob Miltersen, “Chinese Aerospace along the Belt and Road,” *China Aerospace Studies Institute*, June 2020.
121. Fabio Tronchetti and Hao Liu, “The 2019 Notice on Promoting the Systematic and Orderly Development of Commercial Carrier Rockets: The First Step towards

Regulating Private Space Activities in China,” Space Policy 57, (August 2021); China State Administration of Science, Technology, Industry, and National Defense and China Central Military Commission Equipment Development Department, 两部门关于促进商业运载火箭规范有序发展的通知 [Two Departments’ Notice Regarding Promotion of the Regulated and Orderly Development of Commercial Launch Vehicles], May 30, 2019.

122. “聚焦火箭可回收复用 中国商业航天迈入规模化应用新阶段,” China Business News, March 21, 2025; Blaine Curcio, “2020: A Turning Point for Chinese Commercial Space,” Via Satellite.

123. China’s State Council, “Xi Delivers Important Speech at Central Economic Work Conference,” Xinhua, December 14, 2023; Blaine Curcio, “Developments in China’s Commercial Space Sector,” Interview with National Bureau of Asian Research, August 24, 2021.

124. Andrew Jones, “Beijing Government Releases Commercial Space Action Plan,” *SpaceNews*, February 9, 2024.

125. Zhang Weilan, “Wenchang in South China’s Hainan Sets Sight on Becoming a Leading Space Launch Tourism Hub: Official,” *Global Times*, April 17, 2025; Andrew Jones, “Chinese Provinces are Fueling the Country’s Commercial Space Expansion,” *SpaceNews*, January 31, 2025.

126. Joshua Falcon, “Satellite Super factory to Be Built in China,” *Inspenet*, May 20, 2024.

127. Giulia Interesse, “China’s Space Economy: Unlocking Opportunities in Aerospace and Commercial Space Industries,” *China Briefing*, February 4, 2025; Huang Yichang, “China Space Day’ Wuhan’s Commercial Space Industry Leads the Way amid Nationwide Push to Advance Sector,” *CGTN*, April 26, 2024.

128. Blaine Curcio, “Developments in China’s Commercial Space Sector,” Interview with *National Bureau of Asian Research*, August 24, 2021.

129. “Beidou Navigation Program,” China Aerospace Science and Technology Corporation, accessed on October 6, 2025.

130. “Top 10 Space Launch Service Providers in 2024 by Total Launch Count,” *Rocketlaunch.org*, 2025.

131. Alyssa Laffleur, “China’s Space Industry Unpacked: Key Players, Policy, and Private Sector Growth,” *Space Insider*, May 13, 2025.

132. Alyssa Laffleur, “China’s Space Industry Unpacked: Key Players, Policy, and Private Sector Growth,” *Space Insider*, May 13, 2025; “Space Trek,” *Crunchbase*, 2025.

133. Blaine Curcio, “A Rising Chinese Space Sector: Expectations vs Reality,” *Satellite Markets & Research*, June 1, 2022.

134. Denis Kalinin, “China: Private Space Ecosystem of the Rising Superpower,” *Space Ambition*, April 25, 2025.

135. Giulia Interesse, “China’s Space Economy: Unlocking Opportunities in Aerospace and Commercial Space Industries,” *China Briefing*, February 4, 2025; “China’s Commercial Space Industry Gets off the Ground,” *Xinhua*, August 15, 2024; Kang Yin, “最大推力试验增长2倍 商业航天进入快速发展阶段” [Maximum Thrust Tests Have Tripled, Marking Rapid Development of Commercial Spaceflight], *Security Times*, July 1, 2024; China State Administration of Science, Technology, Industry, and National Defense and China Central Military Commission Equipment Development Department, 两部门关于促进商业运载火箭规范有序发展的通知 [Two Departments’ Notice Regarding Promotion of the Regulated and Orderly Development of Commercial Launch Vehicles], May 30, 2019.

136. Denis Kalinin, “China: Private Space Ecosystem of the Rising Superpower,” *Space Ambition*, April 25, 2025; U.S. House of Representatives Select Committee on the Strategic Competition between the United States and the Chinese Communist Party, Gallagher, Krishnamoorthi Probe Sequoia’s PRC High-Tech Investments, Examine Implications of Announced Split, October 18, 2023.

137. Denis Kalinin, “China: Private Space Ecosystem of the Rising Superpower,” *Space Ambition*, April 25, 2025.

138. Yuexia Han et al., “A PIE Analysis of China’s Commercial Space Development,” *Humanities and Social Sciences Communication* 10 (2023).

139. Denis Kalinin, “China: Private Space Ecosystem of the Rising Superpower,” *Space Ambition*, April 25, 2025.

140. Blaine Curcio, “Investment Exits in China’s Space Industry,” *China Space Monitor*, April 30, 2025. Bruce Einhorn and Tonya Garcia, “A Year of Big Misses for Chinese Rocket Companies,” *Bloomberg*, January 8, 2025.

141. Casey Newton and Kevin Roose, “Apple’s Siri-ous Problem + How Starlink Took Over the World + Is A.I. Making Us Dumb?” *New York Times*, March 14, 2025; Jan-Erik Asplund and Marcelo Ballve, “SpaceX,” *Sacra*, January 11, 2025; Matthew Christie, “Crouching Rivals, Not-So-Hidden Dragon: SpaceX and the Future

of Launch Competition—Part 1,” London Economics, September 2024; Ryan Duffy, “Morgan Stanley Note Emphasizes SpaceX’s “Double Flywheel” of Starship, Starlink,” Payload, October 20, 2021.

142. Michael Kan, “SpaceX Offers Rare Peek Inside a Starlink Satellite Factory, Tips ‘Mini Lasers,’” PC Mag, August 26, 2025.

143. “China Advances Scale and Speed of Satellite Manufacturing for Mega-Constellation Push,” Exovera, May 2025, 3.

144. “China Advances Scale and Speed of Satellite Manufacturing for Mega-Constellation Push,” Exovera, May 2025, 5.

145. “China Advances Scale and Speed of Satellite Manufacturing for Mega-Constellation Push,” Exovera, May 2025, 7.

146. Andrew Jones, “First Satellite for Chinese G60 Megaconstellation Rolls Off Assembly Line,” SpaceNews, December 29, 2023.

147. Deng Xiaoci and Tao Mingyang, “Chinese Firm’s Enhanced Version of World’s First Liquid Methane Rocket Nails First Mission This Year, Launching Six Satellites into Orbit,” Global Times, May 17, 2025; Zhang Tong, “China in Bid to Challenge SpaceX by Deploying Maglev Rocket Launch Pad by 2028,” South China Morning Post, March 22, 2025.

148. Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space, April 3, 2025.

149. Eduardo Baptista, “China’s Space Epoch Conducts Key Test for Reusable Rocket Ambitions,” Reuters, May 29, 2025; Blaine Curcio, “Investment Exits in China’s Space Industry,” China Space Monitor, April 30, 2025; Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space, April 3, 2025, 5; Ling Xin, “SpaceX and the 7 Dwarves: Chinese Space Firms Line Up to Enter Reusable Rocket Race,” South China Morning Post, December 12, 2024; “China’s Space Pioneer Raises \$207 Mln to Fund Development of Reusable Rockets,” Reuters, June 6, 2024; Andrew Jones, “China to Debut Large Reusable Rockets in 2025 and 2026,” *SpaceNews*, March 5, 2024.

150. Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space, April 3, 2025, 5.

151. Jonathan McDowell, “Space Activities in 2024,” Jonathan’s Space Report, January 24, 2025, 4, 9; John Holst, “The Ill-Defined Space Spacecraft Deployment Summary: 2024,” Ill-Defined Space, January 10, 2025; John Holst, “The Ill-Defined Space Global Orbital Launch Summary: 2024,” Ill-Defined Space, January 3, 2025.

152. Blaine Curcio, “China Space in 2024: A Year in Review,” China Space Monitor, January 7, 2025.

153. Gunter D. Krebs, “Orbital Launches of 2025,” Gunter’s Space Page, accessed September 25, 2025.; Andrew Jones, “Ceres-1 Rocket Launches 8 Chinese Commercial Satellites,” *SpaceNews*, March 17, 2025.

154. U.S. Space Force, Space Threat Fact Sheet, February 21, 2025.

155. Clarence Leong, “China’s Own Elon Musks Are Racing to Catch Up to SpaceX,” Wall Street Journal, March 23, 2025.

156. Andrew Jones, “China to Debut Large Reusable Rockets in 2025 and 2026,” *SpaceNews*, March 5, 2024.

157. 乔心怡, “对标SpaceX, 中国商业航天走到哪一步了 [How Far Has China’s Commercial Space Exploration Progressed in Comparison to SpaceX?], Yicai, June 12, 2025; Eduardo Baptista, “China’s Space Epoch Conducts Key Test for Reusable Rocket Ambitions,” Reuters, May 29, 2025; Blaine Curcio, “Investment Exits in China’s Space Industry,” China Space Monitor, April 30, 2025; Ling Xin, “SpaceX and the 7 Dwarves: Chinese Space Firms Line Up to Enter Reusable Rocket Race,” South China Morning Post, December 12, 2024; “China’s Space Pioneer Raises \$207 Mln to Fund Development of Reusable Rockets,” Reuters, June 6, 2024; Andrew Jones, “China to Debut Large Reusable Rockets in 2025 and 2026,” *SpaceNews*, March 5, 2024.

158. B. Chance Saltzman, oral testimony for U.S.-China Economic and Security Review Commission, *Hearing on the Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 13.

159. Steven Feldstein, “Why Catching Up to Starlink Is a Priority for Beijing,” Carnegie Endowment for International Peace, September 3, 2024.

160. Blaine Curcio, “China Space in 2024: A Review,” China Space Monitor, January 7, 2025.

161. Andrew Jones, “China’s Guowang Launch Raises Questions about Satellite Purpose and Transparency,” *SpaceNews*, January 7, 2025; Mike Wall, “China Launches 1st Set of Spacecraft for Planned 13,000-Satellite Broadband Constellation (pho-

to),” Space.com, December 18, 2024.; Marc Julienne, “China in the Race to Low Earth Orbit: Perspectives on the Future Internet Constellation Guowang,” IFRI, April 27, 2023.

162. Elsie Chen and Erika Kinetz, “China’s Plan to Stop Elon Musk’s Starlink Includes Submarines That Can Shoot Lasers into Space,” *Fortune*, August 1, 2025; Zeyi Yang, “China’s Effort to Build a Competitor to Starlink Is Off to a Bumpy Start,” *Wired*, May 20, 2025; Zac Aubert, “China Firm Files Plans for 10,000 Satellite Constellation,” *Launch Pad*, May 29, 2024; “CHN2024-67701,” International Telecommunication Union, May 24, 2024.

163. Eduardo Baptista, “China’s Geespace Launches 10 Low-Orbit Satellites, Eyeing Starlink,” *Reuters*, September 5, 2024; Stephen Chen, “China to Start Building 5G Satellite Network to Challenge Elon Musk’s Starlink,” *South China Morning Post*, January 21, 2022.

164. Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 4.

165. Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 5.

166. Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 5.

167. “Xingwang Statistics,” *Jonathan’s Space Pages*, accessed September 25, 2025.

168. “‘上海星’串起 ‘中国链,’”[Shanghai Star Connects the China Chain], *Xinhua*, January 13, 2025.

169. “Qianfan Statistics,” *Jonathan’s Space Pages*, accessed September 25, 2025.

170. “Chinese Space Firm Deploys IoT Satellite Constellation for Global Coverage,” *Xinhua*, September 25, 2025.

171. Stephen Chen, “China to start building 5G satellite network to challenge Elon Musk’s Starlink,” *South China Morning Post*, January 21, 2022.

172. Joe Supan, “Nearly 500 Starlink Satellites Have Incinerated in Earth’s Atmosphere So Far This Year,” *CNET*, July 2, 2025; Zeyi Yang, “China’s Effort to Build a Competitor to Starlink Is Off to a Bumpy Start,” *Wired*, May 20, 2025.

173. “Starlink Statistics,” *Jonathan’s Space Pages*, accessed on September 25, 2025.

174. Joe Supan, “Nearly 500 Starlink Satellites Have Incinerated in Earth’s Atmosphere So Far This Year,” *CNET*, July 2, 2025; Zeyi Yang, “China’s Effort to Build a Competitor to Starlink Is Off to a Bumpy Start,” *Wired*, May 20, 2025; “Over 480 Orbital Launches, 43,000 Satellites Expected by 2032,” *Communications Today*, December 21, 2024; Eduardo Baptista, “China’s Geespace Launches 10 Low-Orbit Satellites, Eyeing Starlink,” *Reuters*, September 5, 2024; Andrew Jones, “Chinese Firm Files Plans for 10,000-Satellite Constellation,” *SpaceNews*, May 27, 2024.

175. Steven Feldstein, “Why Catching Up to Starlink Is a Priority for Beijing,” *Carnegie Endowment for International Peace*, September 3, 2024.

176. Blaine Curcio, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket’s Red Glare: China’s Ambitions to Dominate Space*, April 3, 2025, 4.

177. “Chinese Breakthrough in Laser Data Transmission to Shake Up Telecom Industry,” *Policy Circle Bureau*, March 24, 2025.

178. Laura Heckmann, “Optical Comms Beaming Through Technological Barriers,” *National Defense Magazine*, April 29, 2024.

179. “Chinese Breakthrough in Laser Data Transmission to Shake Up Telecom Industry,” *Policy Circle Bureau*, March 24, 2025.

180. Ling Xin and Zhang Tong, “China Makes World’s First 5G Satellite-to-Phone Video Call. Will It Test US Tiktok Curbs?” *South China Morning Post*, May 20, 2025.

181. Ling Xin and Zhang Tong, “China Makes World’s First 5G Satellite-to-Phone Video Call. Will It Test US Tiktok Curbs?” *South China Morning Post*, May 20, 2025; Luke Pearce and Ben Wood, “What Vodafone’s Historic Satellite Video Call Means for Direct-to-Device Services,” *CCS Insight*, February 6, 2025.

182. Ling Xin and Zhang Tong, “China Makes World’s First 5G Satellite-to-Phone Video Call. Will It Test US Tiktok Curbs?” *South China Morning Post*, May 20, 2025; Luke Pearce and Ben Wood, “What Vodafone’s Historic Satellite Video Call Means for Direct-to-Device Services,” *CCS Insight*, February 6, 2025.

183. Nick Wood, “China Telecom Kicks off International Expansion of Direct-to-Phone Satellite Service,” *Telecoms.com*, May 10, 2024.

184. Kari Bingen, David Gauthier, and Madeleine Chang, “Gold Rush: The 2024 Commercial Remote Sensing Global Rankings,” *Center for Strategic and International Studies*, October 2024.

185. Kari Bingen, David Gauthier, and Madeleine Chang, "Gold Rush: The 2024 Commercial Remote Sensing Global Rankings," *Center for Strategic and International Studies*, October 2024, 1.

186. U.S. Department of the Treasury, *Treasury Imposes Sanctions on More Than 150 Individuals and Entities Supplying Russia's Military-Industrial Base*, December 12, 2023.

187. Humeyra Pamuk, Simon Lewis, and David Brunnstrom, "US Says Chinese Satellite Firm Is Supporting Houthi Attacks on US Interests," *Reuters*, April 17, 2025.

188. Ryan Nelson, Taylor Rhoten, and Brian MacCarthy, "Eastern Stars Rising: The Rise of China's Commercial Space Industry," *War on the Rocks*, July 29, 2025; Zhang Tong, "Chinese Firm Offers High-Performance, Low-Cost Satellites to Belt and Road Countries," *South China Morning Post*, April 19, 2025.

189. Ryan Nelson, Taylor Rhoten, and Brian MacCarthy, "Eastern Stars Rising: The Rise of China's Commercial Space Industry," *War on the Rocks*, July 29, 2025.

190. "USPACE Technology Group to Develop Abu Dhabi Space Eco City Spanning 3 Million Square Meters, Integrate over 1,000 Commercial Aerospace Enterprises Worldwide to Jointly Develop a Global Aerospace Ecological Chain," *USpace*, January 10, 2024.

191. "USPACE Technology Group to Develop Abu Dhabi Space Eco City Spanning 3 Million Square Meters, Integrate over 1,000 Commercial Aerospace Enterprises Worldwide to Jointly Develop a Global Aerospace Ecological Chain," *USpace*, January 10, 2024.

192. "Ministry of Investment of Saudi Arabia Visits USPACE," *USpace*, November 15, 2024; "USPACE Technology Group and EgSA Ink Strategic Partnership Intend to Set Up Aerospace Joint Venture in Cairo, Egypt to Tap the Booming African Space Economy," *USpace*, August 15, 2024.

193. Blaine Curcio, "China's Middle Eastern Space Push," *China Space Monitor*, April 30, 2024; "阿布扎比航天科技城：一家香港上市公司的航天图景," [Abu Dhabi Aerospace City: The Aerospace Landscape of a Hong Kong-Listed Company], *Sohu*, April 11, 2024; "星启宇航成为洲际航天阿布扎比航天城首批合作伙伴," [StarStart Aerospace becomes one of the first partners of Intercontinental Aerospace Abu Dhabi Space City], *Taibo*, February 22, 2024.

194. Blaine Curcio, "China's Middle Eastern Space Push," *China Space Monitor*, April 30, 2024; "穿越者成为阿布扎比航天城全球生态链首批合作伙伴," [Traveler Becomes One of the First Partners in the Global Ecological Chain of Abu Dhabi Space City], *China Financial News Network*, April 8, 2024; "跨界融合——互利共赢——吉旺惠民集团成为阿布扎比航天城全球生态链合作伙伴," [Cross-Border Integration, Mutual Benefit and Win-Win Situation - Jiwang Huimin Group Becomes the Global Ecological Chain Partner of Abu Dhabi Aerospace City], *China Venture Capital Network*, April 8, 2024; "阿布扎比航天城生态链迎来新伙伴：联通航美网络有限公司" [Abu Dhabi Aerospace City's Ecosystem Welcomes a New Partner: China Unicom AirMedia Networks Co., Ltd.], *Phoenix New Media*, March 28, 2024.

195. Yang Xiaotong, "For China and the Middle East, a Space Silk Road Is Written in the Stars," *South China Morning Post*, August 21, 2025; Benjamin Jensen, Erica Longeran, and Kathleen McInnis, "Securing Cyber and Space: How the United States Can Disrupt China's Blockade Plans," *Center for Strategic and International Studies*, March 20, 2025; Blaine Curcio, "China's Middle Eastern Space Push," *China Space Monitor*, April 30, 2024; Deborah Faboade, "China Hands Over the Certificate for Egypt's Assembly, Integration, and Testing Centre (AITC) Project to Egypt," *Space in Africa*, March 4, 2024.

196. Yang Xiaotong, "For China and the Middle East, a Space Silk Road Is Written in the Stars," *South China Morning Post*, August 21, 2025; Benjamin Jensen, Erica Longeran, and Kathleen McInnis, "Securing Cyber and Space: How the United States Can Disrupt China's Blockade Plans," *Center for Strategic and International Studies*, March 20, 2025; Blaine Curcio, "China's Middle Eastern Space Push," *China Space Monitor*, April 30, 2024; "阿布扎比航天城生态链迎来新伙伴：联通航美网络有限公司," [Abu Dhabi Aerospace City's Ecosystem Welcomes a New Partner: China Unicom AirMedia Networks Co., Ltd.], *Phoenix New Media*, March 28, 2024; Deborah Faboade, "China Hands Over the Certificate for Egypt's Assembly, Integration, and Testing Centre (AITC) Project to Egypt," *Space in Africa*, March 4, 2024.

197. Antonia Hmaid and Jeroen Groenewegen-Lau, "China's Long View on Quantum Tech Has the US and EU Playing Catch-Up," *MERICs*, December 12, 2024.

198. Antonia Hmaid and Jeroen Groenewegen-Lau, "China's Long View on Quantum Tech Has the US and EU Playing Catch-Up," *MERICs*, December 12, 2024.

199. Jeremy Hsu, "Quantum Satellite Sets Globe-Spanning Distance Record," *New Scientist*, March 19, 2025; Antonia Hmaid and Jeroen Groenewegen-Lau, "China's

Long View on Quantum Tech Has the US and EU Playing Catch-Up,” *MERICS*, December 12, 2024.

200. Ling Xin, “China’s New Dawn: Pan Jianwei Reveals High-Orbit Quantum Satellite for Global Network,” *South China Morning Post*, June 26, 2025.

201. Simone McCarthy, “China’s secretive space plane has returned to Earth. Its mission? Unknown,” *CNN*, September 12, 2024.

202. Brooke Becher and Abel Rodriguez, “What Are Spaceplanes,” *BuiltIn*, June 11, 2025; Andrew Jones, “China’s Secretive Spaceplane Conducts Proximity Operations with Small Spacecraft,” *SpaceNews*, June 13, 2024.

203. Secretary of the Air Force Public Affairs, “US Space Force Scheduled to Launch Eighth X-37B Mission,” *U.S. Space Force*, July 28, 2025; Simone McCarthy, “China’s Secretive Space Plane Has Returned to Earth. Its Mission? Unknown,” *CNN*, September 12, 2024.

204. John Hollaway, “Spaceplanes: why we need them, why they have failed, and how they can succeed,” *Space Review*, May 13, 2024.

205. Wes Davis, “China begins assembling its supercomputer in space,” *The Verge*, May 18, 2025.

206. Ling Xing, “China launches satellites to start building the world’s first supercomputer in orbit,” *South China Morning Post*, May 15, 2025.

207. “Samuel Greengard, ‘Datacenters Go to Space,’ *Communications of the ACM*, May 14, 2025; Justin Goodwill, Christopher Wilson, and James MacKinnon, “Current AI Technology in Space,” *NASA Goddard*, July 2023.

208. Bayuan Duan et al., “On the Innovation, Design, Construction, and Experiments of OMEGA-Based SSPS Prototype: The Sun-Chasing Project,” *Engineering* 36 (May 2024): 90–101; Edith Mao, “China Urged to Boost Space Solar Power Technology Efforts,” *South China Morning Post*, August 16, 2025.

209. Edith Mao, “China Urged to Boost Space Solar Power Technology Efforts,” *South China Morning Post*, August 16, 2025; Brian Sloboda, “A Glimpse at the Future of Space-Based Solar Power,” *CFC Solutions*, August 11, 2025.

210. Edith Mao, “China Urged to Boost Space Solar Power Technology Efforts,” *South China Morning Post*, August 16, 2025; Brian Sloboda, “A Glimpse at the Future of Space-Based Solar Power,” *CFC Solutions*, August 11, 2025;

Zhang Tong, “China Plans to Build ‘Three Gorges Dam in Space’ to Harness Solar Power,” *South China Morning Post*, January 9, 2025.

211. Zhang Tong, “China Plans to Build ‘Three Gorges Dam in Space’ to Harness Solar Power,” *South China Morning Post*, January 9, 2025; Bayuan Duan et al., “On the Innovation, Design, Construction, and Experiments of OMEGA-Based SSPS Prototype: The Sun-Chasing Project,” *Engineering* 36 (May 2024): 90–101.

212. Zhang Tong, “China Plans to Build ‘Three Gorges Dam in Space’ to Harness Solar Power,” *South China Morning Post*, January 9, 2025.

213. Zhang Tong, “China Plans to Build ‘Three Gorges Dam in Space’ to Harness Solar Power,” *South China Morning Post*, January 9, 2025.

214. Tracey Honney, “China Gives Details of Its Nuclear Space Engine Project,” *Nuclear Engineering International*, April 12, 2024; Stephen Chen, “Starship Rival: Chinese Scientists Build Prototype Engine for Nuclear-Powered Spaceship to Mars,” *South China Morning Post*, March 19, 2024; Chao Liu et al., “Design and R&D of Megawatt Lithium-Cooled Space Nuclear Reactor,” *Scientia Sinica Technologica (CAS)*, February 23, 2024.

215. Tracey Honney, “China Gives Details of Its Nuclear Space Engine Project,” *Nuclear Engineering International*, April 12, 2024; Stephen Chen, “Starship Rival: Chinese Scientists Build Prototype Engine for Nuclear-Powered Spaceship to Mars,” *South China Morning Post*, March 19, 2024; Chao Liu et al., “Design and R&D of Megawatt Lithium-Cooled Space Nuclear Reactor,” *Scientia Sinica Technologica (CAS)*, February 23, 2024.

216. Tracey Honney, “China Gives Details of Its Nuclear Space Engine Project,” *Nuclear Engineering International*, April 12, 2024; Stephen Chen, “Starship Rival: Chinese Scientists Build Prototype Engine for Nuclear-Powered Spaceship to Mars,” *South China Morning Post*, March 19, 2024; Chao Liu et al., “Design and R&D of Megawatt Lithium-Cooled Space Nuclear Reactor,” *Scientia Sinica Technologica (CAS)*, February 23, 2024.

217. Tracey Honney, “China Gives Details of Its Nuclear Space Engine Project,” *Nuclear Engineering International*, April 12, 2024; Stephen Chen, “Starship Rival: Chinese Scientists Build Prototype Engine for Nuclear-Powered Spaceship to Mars,” *South China Morning Post*, March 19, 2024; Chao Liu et al., “Design and R&D of Megawatt Lithium-Cooled Space Nuclear Reactor,” *Scientia Sinica Technologica (CAS)*, February 23, 2024.

218. Tracey Honney, "China Gives Details of Its Nuclear Space Engine Project," *Nuclear Engineering International*, April 12, 2024; Stephen Chen, "Starship Rival: Chinese Scientists Build Prototype Engine for Nuclear-Powered Spaceship to Mars," *South China Morning Post*, March 19, 2024; Chao Liu et al., "Design and R&D of Megawatt Lithium-Cooled Space Nuclear Reactor," *Scientia Sinica Technologica (CAS)*, February 23, 2024.
219. Dean Chang, "China and the New Moon Race," *Space Policy Institute*, November 2024.
220. Huizhong Wu, "A Chinese lunar probe returns to Earth with the world's first samples from the far side of the Moon," *AP News*, June 25, 2024.
221. Andrew Jones, "China Wants 50 Countries Involved in Its ILRS Moon Base," *SpaceNews*, July 23, 2024.
222. Brett Schaefer and Danielle Pletka, "Countering China's Growing Influence at the International Telecommunication Union," *Heritage Foundation*, March 7, 2022.
223. "About International Telecommunication Union (ITU)," *International Telecommunications Union*, accessed August 11, 2025.
224. Brett Schaefer and Danielle Pletka, "Countering China's Growing Influence at the International Telecommunication Union," *Heritage Foundation*, March 7, 2022.
225. Brett Schaefer and Danielle Pletka, "Countering China's Growing Influence at the International Telecommunication Union," *Heritage Foundation*, March 7, 2022.
226. Brett Schaefer and Danielle Pletka, "Countering China's Growing Influence at the International Telecommunication Union," *Heritage Foundation*, March 7, 2022.
227. "Blue Ghost Mission 4," *Firefly Space*, accessed October 3, 2025; "Mars Sample Return," *European Space Agency*, accessed October 3, 2025; NASA, *Escapade*, accessed October 3, 2025; NASA, *Artemis II*, accessed October 3, 2025; Andrew Jones, "China Opens 2028 Mars Sample Return Mission to International Cooperation," *SpaceNews*, March 12, 2025; Andrew Jones, "China Selects International Payloads for Chang'e-8 Lunar South Pole Mission," *SpaceNews*, April 25, 2025; Ling Xin, "China's Moon Ambitions Take Shape with Construction Road Map for Research Station," *South China Morning Post*, April 25, 2023; Victoria Bela, "China's Moon Shot: 2030 Crewed Lunar Mission Tests on Pace, Space Agency Says," *South China Morning Post*, April 23, 2025; China's State Council, "China's Chang'e-7 Mission to Land on Lunar South Pole for Water Ice Search, Report Says," *Xinhua*, February 5, 2025; Abbey A. Donaldson, "NASA Shares Progress toward Early Artemis Moon Missions with Crew," *NASA*, January 9, 2024; "Artemis 4 Astronauts Will Be 1st Crew to Use NASA's Moon-Orbiting Gateway in 2028," *Space*, August 16, 2023; Catherine E. Williams, "Artemis III: NASA's First Human Mission to Lunar South Pole," *NASA*, January 13, 2023; Ashley Strickland, "Why NASA Wants to Return to the Moon before Sending Humans to Mars," *CNN*, November 15, 2022; "China Plans Its First Crewed Mission to Mars in 2033," *Reuters*, June 24, 2021.
228. "A New 'Great Game?': China's Role in International Standards for Emerging Technologies," *Exovera*, August 2022, 3.
229. Brett Schaefer and Danielle Pletka, "Countering China's Growing Influence at the International Telecommunication Union," *Heritage Foundation*, March 7, 2022.
230. NASA, *The Artemis Accords*, accessed August 11, 2025.
231. NASA, *Full Text of the Artemis Accords*.
232. NASA, *The Artemis Accords*, accessed August 11, 2025.
233. U.S. Department of State, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, January 27, 1967; "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," *United Nations Office for Outer Space Affairs*, accessed August 11, 2025.
234. U.S. Department of State, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, January 27, 1967; "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," *United Nations Office for Outer Space Affairs*, accessed August 11, 2025.
235. China's State Council, International Lunar Research Station attracts more partners: CNSA, *Xinhua*, April 24, 2025.
236. Andrew Jones, "China wants 50 countries involved in its ILRS Moon base," *SpaceNews*, July 23, 2024.
237. B. Chance Saltzman, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on The Rocket's Red Glare: China's Ambitions to Dominate Space*, April 3, 2025, 3.

238. Anne Wainscott-Sargent, "The Changing Risk Landscape in LEO vs. GEO: Differences Impact Service, Response, Mitigation and Sustainability," *Kratos*, May 22, 2025.

239. Stephen Clark, "Reusable Rockets Are Here, So Why Is NASA Paying More to Launch Stuff to Space?" *Ars Technica*, April 24, 2025; William Harwood, "SpaceX Rocket Landing Applauded, but Experts Say Implications TBD," *Spaceflight Now*, December 23, 2015.

240. "Miniaturization of Satellite Technology Advancements," *Cadence*, accessed October 6, 2025; Peggy Hollinger, "Has Starlink Already Won the New Space Race?" *FT*, May 22, 2025; Ruth Stilwell, "Aftershocks: Disruptive Growth in Low Earth Orbit Creates New Policy Challenges," *CIGI*, January 2025; "How Surface Technologies Are Making Low-Earth Orbit Satellites Economical," *Keronite*, June 1, 2021.

241. Andrea D'Ottavio and Emma Gatti, "The Missing Rocket: An Economic and Engineering Analysis of the Reusability Dilemma in the European Space Sector," *InterEconomics* 2, 2024; Micah Maidenbergh, "The SpaceX Advantage That Rivals Are Trying to Emulate," *Wall Street Journal*, October 27, 2024.

242. "The rockets are nifty, but it is satellites that make SpaceX valuable," *Economist*, October 17, 2025.

243. Kemal Santja and Mike Hicks, "The Factors Determining LEO Internet Performance," *Cisco—Thousand Eyes*, April 10, 2025; "Low Earth Orbit," *ScienceDirect*, 2023; "Perspectives on LEO Satellites Using Low Earth Orbit Satellites for Internet Access," *Internet Society*, November 2022; Christopher M. Hocking and Melissa K. Griffith, "The Role of Satellites in 5G Networks," *Wilson Center*, October 1, 2021.

244. Kemal Santja and Mike Hicks, "The Factors Determining LEO Internet Performance," *Cisco—Thousand Eyes*, April 10, 2025; Jorge Garcia-Cabeza et al., "Direct-to-Cell: A First Look into Starlink's Direct Satellite-to-Device Radio Access Network through Crowdsourced Measurements," *arXiv*, June 6, 2025; Logan Kugler, "How Laser Communications Are Improving Satellites," *Communications of the ACM*, October 2, 2024; Derek Szopa, "How Starlink's Innovative Mesh Network Principles Can Revolutionize the Logistics Industry," *Supply Chain Brain*, November 2, 2023.

245. Maurizio Arseni, "Inside the UN tech agency role in Musk's space conquest," *Geneva Solutions*, May 1, 2025.

246. Zeyi Yang, "China's Effort to Build a Competitor to Starlink Is Off to a Bumpy Start," *Wired*, May 20, 2025; Akhil Thadani and Makena Young, "Low Orbit, High Stakes All-In on the LEO Broadband Competition," *Center for Strategic and International Studies*, December 14, 2022.

247. Zeyi Yang, "China's Effort to Build a Competitor to Starlink Is Off to a Bumpy Start," *Wired*, May 20, 2025; Maurizio Arseni, "Inside the UN Tech Agency Role in Musk's Space Conquest," *Geneva Solutions*, May 1, 2025; Sydney Nystrom, David Zou, and Peter Garretson, "Thousand Sails: Why Low Earth Orbit Is the Next Frontier for Great Power Competition between the U.S. and China," *American Foreign Policy Council*, February 2025; Akhil Thadani and Makena Young, "Low Orbit, High Stakes All-In on the LEO Broadband Competition," *Center for Strategic and International Studies*, December 14, 2022.

248. Tereza Pultarova, "Starlink Satellites: Facts, Tracking and Impact on Astronomy," *Space.com*, September 25, 2025; "The Global Satellite Market Is Forecast to Become Seven Times Bigger," *Goldman Sachs*, March 5, 2025; Joe Supan, "Inside the Rise of 7,000 Starlink Satellites—and Their Inevitable Downfall," *CNET*, February 15, 2025.