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SPECIAL COMPETITIVE STUDIES PROJECT

Space Race in the 21st Century

Assessing China's Challenge to American Leadership

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Executive Summary

China's rapid rise as a space power constitutes a significant and enduring challenge to U.S. leadership in space. In just over two decades, Beijing has transformed its space program from a limited, missile-centric effort into a comprehensive, vertically-integrated enterprise spanning civil, commercial, and military domains. This impressive progress reflects sustained national investment, long planning horizons, and a conviction that space power is integral to economic competitiveness, information dominance, and military effectiveness.

Measured against its accomplishments in space to-date, China is already a formidable competitor, and has matched the United States one-to-one across many of the major milestones that define modern space programs. It operates an independent, permanently crewed space station; maintains global navigation, communications, and Earth-observation constellations of satellites; conducts complex approach operations in orbits, and has executed increasingly sophisticated robotic missions to the Moon, Mars, and near-Earth asteroids. In several areas—most notably robotic lunar exploration and sample return—China has even achieved historic firsts.

In terms of core space capabilities, such as launch, China has developed a broad, indigenous portfolio spanning small-, medium-, and heavy-lift vehicles, enabling missions such as lunar sample return, Mars exploration, and orbital station construction. While Beijing currently trails the United States in super heavy-lift launch and high-cadence reusable systems, these gaps are narrowing. Several Chinese super heavy-lift rockets and reusable launch vehicles are under development, and there is no indication these capabilities will remain out of Beijing's reach.

China has also made rapid progress in in-space servicing, assembly, and manufacturing. Through modular space station construction, debris mitigation missions, refueling experiments, and a growing volume of rendezvous and proximity operations, Beijing has demonstrated increasing sophistication in maneuvering and interacting with objects in orbit. Moreover, the rising frequency and assertiveness of Chinese proximity operations—particularly near foreign satellites—suggest a deliberate effort to operationalize inherently dual-use capabilities with counterspace relevance.

Emerging technologies, particularly advances in artificial intelligence (AI) and quantum, are further sharpening space competition. China is integrating AI into its space architecture to enable autonomous tasking and onboard data processing, while simultaneously leading in space-based quantum communications through demonstrated long-distance quantum key distribution. These technologies promise advantages in information dominance, resilience, and secure command and control.

Looking ahead, China's most consequential ambition is the Moon. Beijing plans a crewed lunar landing by 2030 and a permanent presence in the 2030s. There is a credible possibility China could land humans on the Moon before the United States returns, enabling it to shape future lunar norms and architectures. Ultimately, the central risk to the United States is not sudden displacement, but the gradual erosion of relative advantage if space leadership is not continuously earned.

Introduction

The second half of the 20th century saw the birth of human spaceflight and America's space programs. In less than fifty years, the United States had sent its first satellites and humans into space, dispatched robotic probes to every planet in our solar system, became the first nation to land on Mars, established a crewed space station in Earth orbit, and successfully landed humans on the surface of the Moon. While several factors drove America's space ambitions then, geopolitics was one of the most crucial—the United States was in a competition with the Soviet Union, and space naturally became a new arena for that geopolitical competition. Thus, as the Soviet threat in space waned and then eventually disappeared, the lack of that geopolitical pressure led Washington to significantly reprioritize its national space programs and ambitions.

Now more than two decades into the 21st century, that geopolitical impetus is back in the form of the People's Republic of China (PRC). But two things are different now. First, China is a much more formidable competitor across all means of national power than the Soviets ever were.[1] And second, the broader landscape in space has changed: private sector-led reductions in the cost of launch, the maturation of existing and emergence of several key technologies, and a better understanding of the space environment itself, amongst other factors, are fundamentally changing the role of space for U.S. national security and economic interests beyond what they were in the 20th century—there is now talk of building data centers in orbit, a prospect made possible by advances in reusable launch and energy capture technologies;[2] the coming online of novel space systems, such as fully reusable super heavy-lift rockets, is expected to enable entirely new modes of military logistics and power projection, as exemplified by programs like the Air Force Research Laboratory's Rocket Cargo.[3] While the United States may still be the pre-eminent space power, this changing strategic landscape is a forewarning that our dominant position in space needs to be earned continuously. If China's space enterprise continues to expand and adapt to take advantage of this new strategic context, and does so faster than our space enterprise, we can lose our edge in a domain that is increasingly vital to our national security and economic prosperity.

The purpose of this paper is to characterize the challenge that China poses to U.S. space dominance over the coming decades. To do so, we first provide a historical overview of China's space program and their accomplishments in space to-date. We then turn to an assessment of China's current standing as a space power vis-a-vis the United States, as measured against capabilities that we judge to be most critical and enabling of modern and future space power. Lastly, we provide a brief survey of the goals that China has set for the future of its space program, and compare them against our own ambitions.

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[1] Charles A. Kupchan, A New Cold War Could Be Much Worse Than the One We Remember, The Atlantic (2023).
[2] Angie Lee, How Starcloud Is Bringing Data Centers to Outer Space, NVIDIA (2025).
[3] Rocket Cargo promises point-to-point logistics transfer from anywhere on Earth to anywhere else in less than 90 minutes. That is a brand new military capability made possible due to advances in reusable rocketry. *See* Clayton Swope, The Future of Military Power Is Space Power, Center for Strategic & International Studies (2025).

China's Emergence as a Rival Space Power

The PRC's space program began in the 1950s with the research and development of rocket and ballistic missile technology.[4] Beijing's early efforts were kickstarted via support from Moscow, but the subsequent Sino-Soviet split forced the PRC to pursue more indigenous solutions, and greatly slowed the rate of progress of their program efforts.[5] Nevertheless, by 1970, China managed to independently launch its own satellite into Earth orbit. During the remainder of the 20th century, China marked critical progress in two areas: first, in developing its small- and medium-lift launch capabilities, primarily to build out its growing constellation of communications satellites;[6] and second, in initiating its human spaceflight program in 1993, which culminated in the launch of Yang Liwei in 2003, making China one of only three nations to have ever independently launched a human into space.[7] China's other accomplishments in space this century are many and impressive. Instead of enumerating each, we summarize them in the timeline below.

[4] Gregory Kulacki & Jeffrey G. Lewis, A Place for One's Mat: China's Space Program, 1956–2003, American Academy of Arts & Sciences at 4-14 (2009).
[5] John W. Lewis & Hua Di, China's Ballistic Missile Programs: Technologies, Strategies, Goals, Stanford University's Center for International Security and Cooperation at 7–8 (1992); Andrew S. Erickson, China's space development history: A comparison of the rocket and satellite sectors, Acta Astronautica at 144 (2014).
[6] Gregory Kulacki & Jeffrey G. Lewis, A Place for One's Mat: China's Space Program, 1956–2003, American Academy of Arts & Sciences at 14-19 (2009).
[7] China's human spaceflight program emerged from Project 863, a state-run initiative inspired from America's Strategic Defense Initiative, and which reflected China's growing willingness to invest in major high-technology projects that had no immediate practical payoff but that helped to develop the country's technological base. *See* Gregory Kulacki and Jeffrey G. Lewis, A Place for One's Mat: China's Space Program, 1956–2003, American Academy of Arts & Sciences at 22-24 (2009). See also Gregory Kulacki & Jeffrey G. Lewis, A Place for One's Mat: China's Space Program, 1956–2003, American Academy of Arts & Sciences at 19 (2009).

China's Long March Into Space (2000-2026)

2000-2009

2000: Construction of *BeiDou* navigation constellation begins

2004: Beijing approves Chinese Lunar Exploration Program (CLEP)

2007: *Chang'e-1* enters lunar orbit, becoming China's first Moon mission

2010-2019

2010: *Chang'e-2* enters lunar orbit to prospect landing sites and resources

2010: Beijing approves CHEOS constellation of Earth-imaging satellites

2011: Experimental space station *Tiangong-1* launched into Earth orbit

2013: *Chang'e-3* lands on Moon (first soft-landing)

2016: Experimental space station *Tiangong-2* launched into Earth orbit

2016: World's first quantum communication satellite *Mozi* launched

2019: *Chang'e-4* lands on lunar far side (global first)

2020-2026

2020: Construction of *BeiDou-3* complete, enabling global service

2020: *Chang'e-5* returns samples from the Moon, completing all phases of CLEP

2020: CNSA announces Planetary Exploration of China (PEC) program

2021: *Tianwen-1* orbits, lands, and conducts surface operations of Mars

2022: Construction of permanently crewed *Tiangong* station complete

2024: *Chang'e-6* returns sample from lunar far side (global first)

2025: *Queqiao-2*, *Tiandu 1*, and *Tiandu 2* enter into lunar orbit to support future lunar far side and south pole missions

2025: *Tianwen-2* launched to explore and return samples from near-Earth asteroid

Ultimately, several conclusions emerge from this historical record. The first is that China has built extensive capabilities across all major space program portfolios (e.g., human spaceflight, robotic deep-space exploration, space science and astronomy, and satellite infrastructure). Across most headline milestones that traditionally define leading space powers, China has matched the United States one-to-one and, in some cases, achieved historic firsts of its own (see table below). In other words, viewed purely through its historical track record, China is already a formidable space competitor. Secondly, while the United States was the first mover and retains deep technological heritage across nearly every milestone category, China has demonstrated a remarkably rapid catch-up trajectory, compressing decades of progress into roughly twenty years, with a sustained focus on the Moon.[8]

China, however, still has a few milestones that it has not met. For example, it has never sent astronauts beyond Earth orbit or landed humans on the Moon—an achievement the United States accomplished more than 40 years ago, and one that requires much greater human spaceflight infrastructure, such as super heavy-lift launch capacity.[9]Also, while China did execute a full-stack (i.e. orbiting, landing, and surface exploration) Mars mission on its first attempt, the United States has carried out far more Mars missions, deployed five rovers compared to China's one, and benefits from more than 50 years of Mars operations. The United States also maintains an advantage in the breadth and depth of deep-space exploration efforts, while continuing to dominate space science and astronomy through a small number of exceptional observatories (namely, Hubble and James Webb).

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[8] China arguably leads in robotic lunar exploration (see Table 1)—since Apollo, the United States has only successfully conducted three robotic lander missions on the lunar surface (IM-1, IM-2, and Blue Ghost M1), and none of these missions involved anything more than just landing. Arguably, these kinds of efforts have been backbenched in favor of placing people back on the Moon before China. *See* Andrew Petro, Accelerate U.S. lunar exploration with a robotic sample return campaign, Space News (2025).

[9] Although the United States has not conducted a crewed lunar mission since 1972, both countries appear on track to return astronauts to the Moon this decade, this time with an emphasis on sustained presence.

Survey of Space Program Milestones

Comparison of major milestones achieved between the United States and Chinese Space Program

Category	Major Milestones	U.S.	China	Reference Missions
Human spaceflight	Operation of permanently crewed, Earth-orbiting station	✓	✓	*U.S.*: ISS; *China*: Tiangong
	Crewed Moon landing	✓	✗	*U.S.*: Apollo (1969-1972)
Robotic deep space & planetary exploration	Robotic landing and surface exploration of the Moon	✓	✓	*U.S.*: Surveyor (1966-1968), IM-1 (2024), IM-2 (2025); *China*: Chang'e-3 (2013)
	Robotic landing and surface exploration of lunar far side	✗	✓	*China*: Chang'e-4 (2018)
	Robotic lunar sample return	✗	✓	*China*: Chang'e-5 (2020)
	Robotic lunar far side sample return	✗	✓	*China*: Chang'e-6 (2024)
	Robotic landing and surface exploration of Mars	✓	✓	*U.S.*: Pathfinder (1997), MER (2004), MSL (2012), InSight (2018), Mars 2020 (2020); *China*: Tianwen-1 (2020)
	Outer planet exploration (beyond Mars)	✓	✗	*U.S.*: Pioneer 10 & 11 (1972-1973), Voyager 1 & 2 (1977), Galileo (1989), Cassini–Huygens (1997), New Horizons (2006)
	Asteroid landing and sample return	✓	✗	*U.S.*: NEAR Shoemaker (1996), OSIRIS-REx (2016)
Space science and astronomy	Operation of space telescopes	✓	✓	*U.S.*: Hubble (optical), James Webb Space Telescope (optical), Chandra (X-ray), Fermi (Gamma-ray); *China*: Insight-HXMT (X-ray)
Satellite infrastructure	Operation of a space-based, global navigation and positioning constellation	✓	✓	*U.S.*: GPS; *China*: BeiDou
	Operation of high-resolution, high-frequency Earth-observation constellation	✓	✓	*U.S.*: Maxar, Planet Labs; *China*: Gaofen
	Operation of satellite internet constellation	✓	✓	*U.S.*: Starlink; *China*: Guowang

China's Capabilities as a Modern Space Power

Space Launch & Reusability

The capability for space launch represents the most fundamental constraint on a nation's ability to realize space projects and missions—space launch enables space access, and one's ability (or inability) to access space effectively and affordably is a first-order enabler (or bottleneck). To assess both China's and the U.S.'s respective capabilities at space launch, we start with a survey of some of the major launch vehicles that both countries have in operation and under development. We assess each launch vehicle across four key metrics: payload capacity[10] (a primary measure of capability), cost[11] (measured in the cost to launch one kilogram of payload mass to low Earth orbit), success rate[12] (a measure of reliability), and reusability[13] (the implications of reusability will be discussed further along in this section). On the Chinese side, we look mostly at the Long March family of rockets, as they have been responsible for the majority of Chinese launches to date.[14] There are currently over a dozen variants of operational Long March rockets, so we focus on detailing a select subset as a sufficiently authoritative overview of Chinese launch capability.

[10] Payload capacity is the mass a launch vehicle can send into space in a single launch. Payload capacities vary depending on orbit, but since most missions begin with low Earth orbit (LEO) insertion, we list payload capacities to LEO unless otherwise stated. Also, payload capacities for vehicles with reusable capability are listed for their reusable configuration.
[11] Where cost per kilogram is not available, it is estimated by dividing the total cost per launch by the total payload capacity. We report *cost* rather than *price* per kilogram because our focus is on the underlying costs of designing, manufacturing, and operating a given launch vehicle, not its listed market price, which is more dependent on market influences.
[12] Success rates are calculated by dividing the number of successful launches by the total number of launches. Partial failures are counted as failures, whereas recovery failures (in the case of reusable systems) are not.
[13] A rocket is considered fully reusable if all its stages are reused after launch, is considered partially reusable if one or more stages are expended, and is considered expendable if all stages are expended.
[14] As of 2025, Long March rockets reportedly accounted for more than 86% of China's space launch missions to date. *See* China's latest launch mission marks 600th flight of Long March rockets, Xinhua (2025).

Survey of Chinese Launch Vehicles

Chinese launch vehicles that are either operational or under development, sorted by payload capacity

Vehicle	Class	Manufacturer	Status	Payload Capacity (Est.)	Cost (Est.)	Reliability	Reusability
Kuaizhou-1A	Small-lift	ExPace	Operational	390 kg	N/A	27 launches, 2 failures, 92.6% success rate	Expendable
LM-11	Small-lift	CALT	Operational	700 kg	N/A	18 launches, 0 failures, 100% success rate	Expendable
LM-2D	Medium-lift	SAST	Operational	3,500 kg	$8,571/kg	101 launches, 1 partial failure, 99.0% success rate	Expendable
Zhuque-2E	Medium-lift	LandSpace	Operational	6,000 kg	N/A	3 launches, 1 failure, 66.7% success rate	Expendable
LM-3B/E	Medium-lift	CALT	Operational	11,500 kg	N/A	103 launches, 2 failures, 1 partial failure, 97.1% success rate	Expendable
LM-7A	Medium-lift	CALT	Operational	13,500 kg	N/A	14 launches, 1 failure, 92.6% success rate	Expendable
LM-5/5B	Heavy-lift	CALT	Operational	25,000 kg	N/A	17 launches, 1 failure, 94.1% success rate	Expendable
LM-10	Super heavy-lift	CALT	Under development	70,000 kg	N/A	N/A	Partially reusable
LM-9	Super heavy-lift	CALT	Under development	150,000 kg	N/A	N/A	Fully reusable

Source: Gunter D. Krebs, Launch Vehicles - China, Gunter's Space Page (last accessed February 2026).

Survey of American Launch Vehicles

American launch vehicles that are either operational or under development, sorted by payload capacity

Vehicle	Class	Manufacturer	Status	Payload Capacity (Est.)	Cost (Est.)	Reliability	Reusability
Electron	Small-lift	Rocket Lab	Operational	300 kg	N/A	81 launches, 4 failures, 95.1% success rate	Expendable
Falcon 9 Block 5	Medium-lift	SpaceX	Operational	17,500 kg	$857/kg	534 launches, 1 failure, 99.8% success rate	Partially reusable
Atlas V	Medium-lift	ULA	Operational	18,500 kg	N/A	106 launches, 1 partial failure, 99.1% success rate	Expendable
Terran R	Heavy-lift	Relativity	Under development	23,500 kg	N/A	N/A	Partially reusable
Vulcan Centaur	Heavy-lift	ULA	Operational	27,200 kg	N/A	3 launches, 0 failures, 100% success rate	Expendable
New Glenn 7x2	Heavy-lift	Blue Origin	Operational	45,000 kg	N/A	2 launches, 0 failures, 100% success rate	Partially reusable
Falcon Heavy	Super heavy-lift	SpaceX	Operational	63,800 kg	N/A	11 launches, 0 failures, 100% success rate	Partially reusable
New Glenn 9x2	Super heavy-lift	Blue Origin	Under development	70,000 kg	N/A	N/A	Partially reusable
SLS Block 1	Super heavy-lift	Boeing (primary)	Under development	95,000 kg	N/A	1 launch, 0 failures, 100% success rate	Expendable
Starship	Super heavy-lift	SpaceX	Under development	150,000 kg	N/A	N/A	Fully reusable

Source: Gunter D. Krebs, Launch Vehicles - USA, Gunter’s Space Page (last accessed February 2026).

A survey of both American and Chinese launch vehicles suggests a few things. For one, China has already come a long way in building diverse, indigenous, and reliable launch capability, across small-, medium-, and heavy-lift launch classes. Moreover, China has matured its heavy-lift launch capability, as evidenced by the success of their LM-5 and LM-5B vehicles, as well as their success at executing space missions that require heavy-lift launch capability (e.g., orbital space station construction, lunar sample return missions, lander missions to Mars, etc.). Zhuque-2 was added as part of our survey because it was the first methane-fueled rocket to reach Earth orbit—liquid methane, combined with liquid oxygen, is increasingly becoming the propellant combination of choice since liquid methane is relatively cheap, easy to manufacture, enables reusability, and can be readily manufactured on Mars.[15]

However, China appears to be behind—possibly by several years—in two key capability areas: super heavy-lift and reusability. Super heavy-lift capability is critical for realizing certain kinds of space projects and missions, such as manned missions to the Moon, Mars, and deep space, the construction of a lunar base, etc. To put it simply, any mission that requires sending a significant amount of mass into space in a single launch requires super heavy-lift.[16] America's lead is predicated on the basis that the United States currently has two super heavy-lift rockets in operation while China has none, and that America has a technological heritage that China lacks, with the United States having built and flown its first super heavy-lift rocket in 1967 with the Saturn V.[17] Nevertheless, China currently has two known super heavy-lift launchers under development: the Long March 9 and Long March 10. The Long March 10, which China plans to use for crewed lunar missions, has already undergone extensive testing, and is planned to launch sometime in 2026.[18] Ultimately, there is nothing suggesting that China won't achieve and mature its super heavy-lift launch capability this decade.

Reusable rockets have been a primary driver for the continued reduction in the cost of launch. Here, China appears to lack the kind of low-cost, high-cadence reusable launch capability proffered by the Falcon 9. This kind of capability is critical for realizing projects that rely on sending a large quantity of objects into space—projects such as the construction of orbital megaconstellations like SpaceX's Starlink, or the buildout of orbital data centers. SpaceX has currently placed more than 9,000 Starlink satellites into orbit, and plans to scale that to an excess of 40,000 satellites in order to realize the megaconstellation.[19] That is a *massive* number of satellites, and can only be realized efficiently with a launch vehicle like the Falcon 9.[20] China has plans for their own Starlink-like constellation—the state-backed Guowang megaconstellation project was started in 2022 as a

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[15] Mark D. Klem, LOX/Methane In-Space Propulsion Systems Technology Status and Gaps, National Aeronautics and Space Administration (2017).

[16] If we want permanent manned presence on the Moon, which we've stated as our goal with Artemis and which China has stated as their goal with the International Lunar Research Station, then we will need a super heavy-lift launcher.

[17] There have only ever existed four operational super heavy-lift launchers in history, two of which are retired—the U.S.'s Saturn V (retired), the USSR's Energia (retired), SpaceX's Falcon Heavy, and NASA's Space Launch System (SLS). And though the SLS is often criticized, it is currently the only rocket in the world capable of sending people to the Moon.

[18] Andrew Jones, China to debut reusable Long March 10-derived rocket in first half of 2026, SpaceNews (2025).

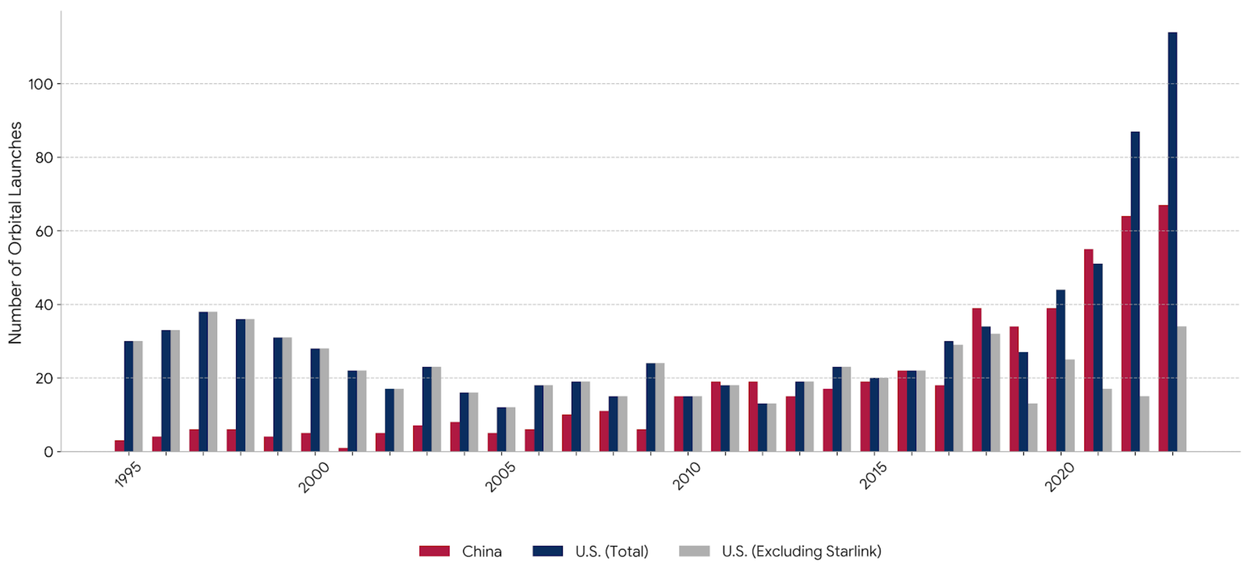
[19] Tereza Pultarova, Starlink satellites: Facts, tracking and impact on astronomy, Space.com (2025).

[20] For reference, as of January 2, 2026, there are little more than 14,000 active satellites in Earth orbit, with Starlink satellites making up about two-thirds of that number. *See* Jonathan McDowell, Satellite statistics: Satellite and Debris Population, Jonathan's Space Report (last accessed 2026).

rival to Starlink, and plans to put 13,000 satellites into orbit by project's end. However, as of December of 2025, the program has only managed to launch 136 satellites into orbit (the figure below further illustrates this lag).[21] This signals that China has the national will to build something akin to Starlink, but currently lacks the technical capability to do so.[22] However, as with super heavy-lift capability, there is nothing to suggest that China will not be able to build a Falcon 9-like system eventually, and China's commercial sector and state-backed enterprises are already making significant efforts in this direction. For example, LandScape attempted to re-land the first-stage of its Zhuque-3 this year; the state-owned Shanghai Academy of Spaceflight Technology (SAST) attempted to do the same with their Long March 12A, while the Long March 10A (which is planned to have a reusable first-stage) is scheduled to launch for the first time in 2026 together with the Long March 10.[23]

Comparison of Orbital Launches Per Year: U.S. Versus China

Orbital launches (U.S. versus China) by year from 1991 onwards. The divergence between U.S. and Chinese launches owes itself mostly to Starlink. It is notable that without Starlink, Chinese launches exceed that of the U.S, though consider that American rockets tend to have higher payload capacity.



Source: Jonathan McDowell, Satellite statistics: Launches, Jonathan's Space Report (last accessed 2026).

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21 Andrew Jones, China hits 90 launches as Guowang deployment continues, SpaceNews (2025).
22 Selam Gebrekidan, This Was Supposed to Be the Year China Started Catching Up With SpaceX, New York Times (2025).
23 Simone McCarthy, et al., Chinese reusable booster explodes during first orbital test, CNN (2025); Andrew Jones, Long March 12A reaches orbit in first reusable launch attempt, but landing fails, SpaceNews (2025).

In-Space Servicing, Assembly, & Manufacturing (ISAM)

In-space servicing, assembly, and manufacturing (ISAM) refers to several capability areas: satellite inspection, refueling, repair, and upgrading, satellite relocation (e.g., orbit raising and de-raising), debris cleanup, in-space manufacturing and assembly, and more. With ISAM capability, satellites designed and deployed with set mission lifetimes could have those lifetimes extended by several years. Instead of designing and deploying exquisite systems with monolithic architectures, ISAM grants manufacturers the ability to deploy smaller and simpler payloads that can autonomously assemble into more complex systems once in orbit. Moreover, ISAM capabilities also underpin future space-based warfighting, and orbital defenses against anti-satellite weapons. It is due to these facts that we are seeing ISAM services emerge as one of the major sectors of the 21st century space economy,[24] and a critical capability for modern space power.

Much of China's growing ISAM capability stems from the logistical demands imposed by their human spaceflight program. Between 2011 and 2021, China completed construction of Tiangong-1 and Tiangong-2 space stations, and performed a series of space rendezvous and docking operations to those stations. Their newly completed Tiangong was built modularly, and was assembled in-orbit using robotic arms.[25] Moreover, as with the International Space Station (ISS), Tiangong requires periodic repositioning and refueling to maintain its orbit due to atmospheric drag. In 2021, China also launched Shijian-21 (SJ-21), an experimental space debris mitigation satellite. SJ-21 went on to successfully rendezvous and dock with the defunct Beidou-2 G2 satellite in geostationary orbit, and towed it to a graveyard orbit 300 kilometers away before returning to its original operational orbit.[26] In 2025, China launched Shijian-25 (SJ-25) to test in-space refueling and mission extension technologies. Both SJ-21 and SJ-25 were later observed to conduct multiple proximity operations together as a precursor to an expected satellite-to-satellite refuelling test.[27]

Beyond this historical record, we can also look at rendezvous and proximity operation (RPO) data as a proxy for measuring China's ISAM capability. RPOs are maneuvers where one satellite does a fly-by or docks with another. These are technically complex undertakings, and require precise guidance, navigation, and control, real-time trajectory optimization, and more, all of which are foundational capabilities for more complex ISAM operations. The figures below plot the yearly number of proximity operations conducted by Chinese satellites against both American satellites and their own satellites.

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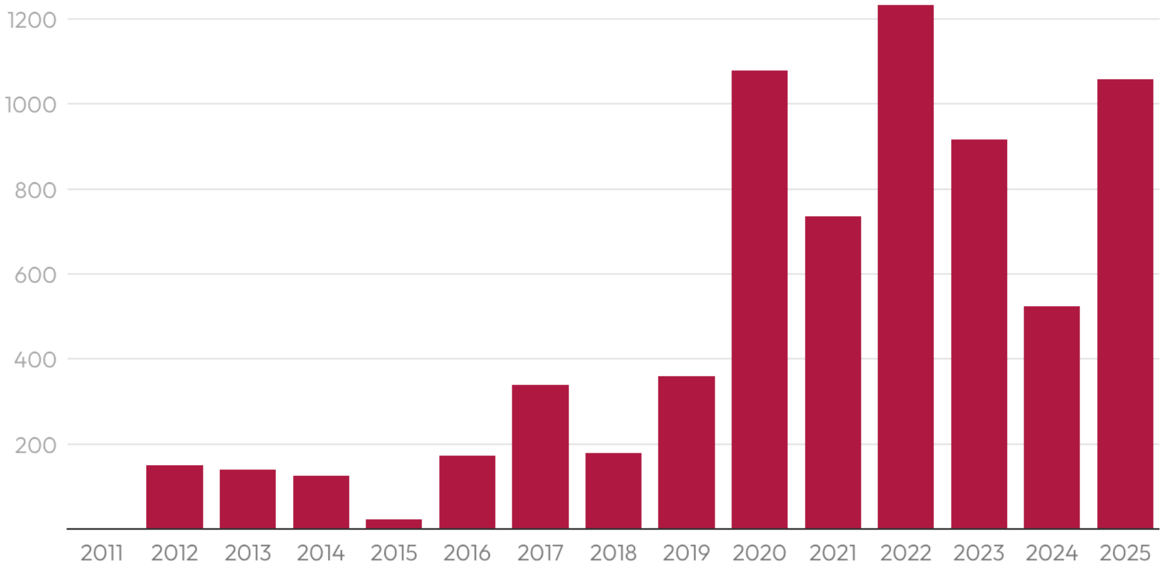
[24] Alizée Acket-Goemaere, et al., Space: The $1.8 Trillion Opportunity for Global Economic Growth, World Economic Forum (2024).
[25] Andrew Jones, On China's new space station, a robotic arm test paves way for future construction, Space.com (2022).
[26] Shi Jian 21 (SJ 21), Gunter's Space Page (last accessed 2026).
[27] Andrew Jones, Chinese spacecraft begin rendezvous and proximity operations in geostationary orbit, SpaceNews (2025).

Rise in Chinese-on-Chinese Satellite Proximity Operations

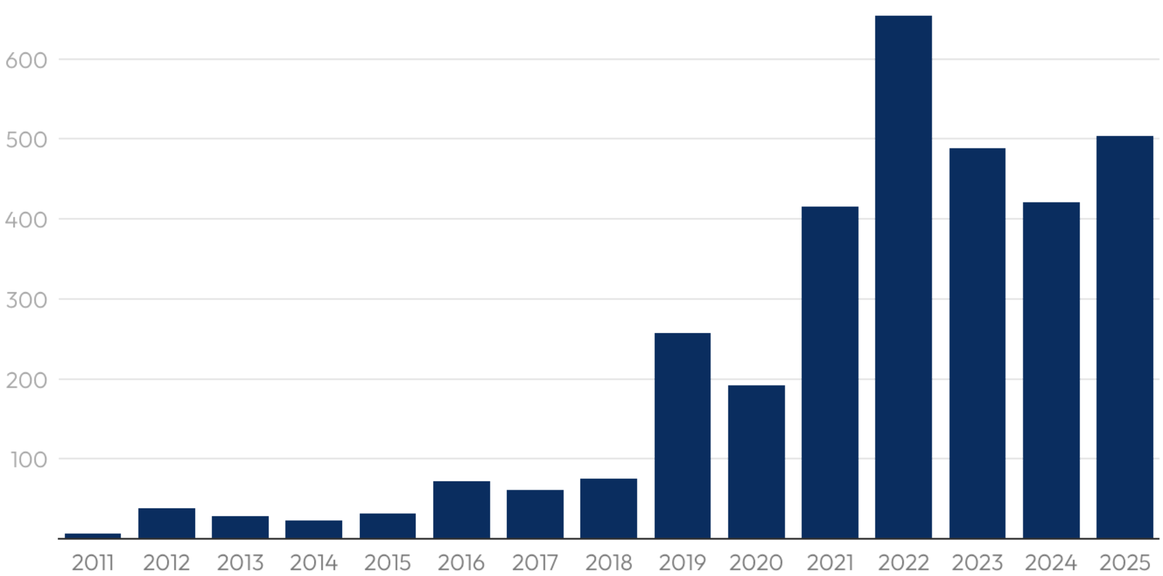
Number of proximity operations performed by Chinese satellites against Chinese satellites.



Source: Rhombus Power's Guardian Platform

Rise in Chinese-on-American Satellite Proximity Operations

Number of proximity operations performed by Chinese satellites against American satellites.



Source: Rhombus Power's Guardian Platform

The data above suggest two things: that the number of RPO operations that China is conducting has greatly trended upwards over the past decade (also implying rapidly increasing ISAM capability), and that China is taking an increasingly aggressive posture towards America's satellites. The precise intentions behind Chinese-on-U.S. proximity operations is not known, but the fact that they are performing them at all, and at an increasing rate, is concerning—since RPO operations could serve as a precursor to malign activities such as the capturing or disabling of a satellite.[28]

The United States has also greatly advanced and matured its ISAM capabilities over the decades. From 2011 onwards, as part of the Robotic Refueling Mission (RRM), NASA conducted a series of demonstrations aboard the ISS to increase the maturity of in-space rocket propellant transfer technologies (robotic refueling hardware, cryogenic fluid storage and transfer, etc.).[29] In 2020, Northrop Grumman's MEV-1 satellite docked with Intelsat 901, repositioned it to its operational geosynchronous orbit, and extended its lifetime by five years via in-orbit stationkeeping. In 2025, MEV-1 moved Intelsat 901 to a graveyard orbit, undocked with it, and relocated for another servicing mission.[30] In 2021, the company Astroscale successfully executed the ELSA-d mission, which demonstrated magnetic capture of client satellites in LEO for future end-of-life servicing and active debris removal missions.[31] NASA's Automated Reconfigurable Mission Adaptive Digital Assembly Systems (ARMADAS) project is developing software and hardware that would allow for the autonomous assembly of functional structures in space like habitats, antennae arrays, and spaceports.[32] NASA's Tendon Actuated Lightweight In-Space Manipulators (TALISMAN) is developing novel actuation systems for the capture of asteroids and space debris.[33] And on the horizon, the Robotic Servicing of Geosynchronous Satellites (RSGS) project aims to enable precision servicing missions in GEO, including inspection, repositioning, and component replacement using robotic payloads.[34]

Ultimately, it is difficult to provide a definitive assessment between the U.S. and China's ISAM capabilities from this data alone, and to state conclusively which nation is ahead. But both the historical record and the RPO data suggest that the United States and China are converging on their ISAM capabilities, and both are actively investing in technologies, projects, and missions that would allow them to execute increasingly complex on-orbit activities. In China's case in particular, the rapid growth in the frequency, sophistication, and assertiveness of their proximity operations—especially against foreign satellites—points to a deliberate effort to normalize

[28] Chris Gordon, China Practicing 'Dogfighting in Space,' US Space Force Says, Air & Space Forces Magazine (2025).
[29] Robotic Refueling Mission, National Aeronautics & Space Administration (last accessed 2026); Robotic Refueling Mission 3 (RRM3), National Aeronautics & Space Administration (last accessed 2026).
[30] Northrop Grumman Achieves First-Ever Undocking Between Two Commercial Spacecraft in Geosynchronous Orbit, Northrop Grumman (last accessed 2026).
[31] Alec J. Cavaciuti, Joseph H. Heying, and Joshua Davis, In-Space Servicing, Assembly, & Manufacturing For The New Space Economy, RAND (2022).
[32] Automated Reconfigurable Mission Adaptive Digital Assembly Systems (ARMADAS), National Aeronautics & Space Administration (2020).
[33] Human Robotic Systems: Tendon Actuated Lightweight In-Space Manipulators (TALISMAN), National Aeronautics & Space Administration (2015).
[34] RSGS: Robotic Servicing of Geosynchronous Satellites, DARPA (last accessed 2026); Servicing operations on satellites in GEO are difficult given how remote they are, but if made feasible, would help reduce the complexity, weight, and cost of these satellites as they'd be designed with fewer backup systems and less fuel capacity.

close-approach behaviors and to operationalize capabilities that are inherently dual-use.[35] And even if many of these activities are nominally benign or experimental, they nonetheless function as live-fire training for higher-end ISAM and counterspace missions.

AI Applications & Quantum in Space

Artificial intelligence (AI) and quantum technologies are increasingly seen as the twin pillars shaping the future of space power. Both enable state and non-state actors to transform space from a domain of observation and exploration into one of autonomous action and secure communication. AI brings cognitive capability to satellites—allowing them to process, interpret, and act on vast streams of data in real time—while quantum technologies promise unhackable communication links and ultra-precise sensing. Together, these technologies are critical because they can determine who achieves information dominance in orbit, ensuring faster decisions, resilient communications, and superior situational awareness.

China is matching–and in some areas possibly surpassing–U.S. initiatives by integrating AI and computing power into its space infrastructure. In May 2025, China launched the first "Three-Body" AI computing constellation satellites, a planned fleet of 2,800 small satellites that will perform in-orbit data processing.[36] The initial 12 satellites carry AI processors (8-billion-parameter models per satellite) capable of 744 trillion operations per second each. Once fully deployed, the network aims for a combined capacity of 1,000 peta-ops (one quintillion operations per second).[37] The project, led by Zhejiang Lab and startup ADA Space, sees the cold vacuum of space as a natural cooling system for an "AI supercomputer" in orbit. By processing imagery and sensor data in space ("edge computing"), China plans to reduce dependence on ground centers and transmit only useful insights to Earth, overcoming bandwidth bottlenecks. Beyond this headline program, China's satellites are increasingly "intelligent." The Beijing-3 Earth observation satellite, for example, uses onboard AI to autonomously plan its imaging schedule and even adjust orientation rapidly to capture large areas – feats that previously required ground control.[38] Chinese remote sensing constellations (e.g. Jilin-1) have demonstrated AI-based tracking of stealth aircraft from orbit.[39] These developments align with Beijing's strategic goal of becoming a first-tier space power. In sum, China is aggressively investing in AI-powered satellite constellations and onboard supercomputing, aiming to achieve information dominance in orbit and lessen the U.S. lead in space-based AI applications.

Meanwhile, U.S. efforts leverage AI to improve satellite operations, data processing, and autonomous decision-making in orbit. The U.S. Space Development Agency (SDA) is fielding constellations of small satellites with onboard processing to enable faster battlefield awareness. For example, SDA's planned Proliferated

[35] We do not have RPO data available on U.S. satellites, so it is unclear what the training practices of American satellites are.
[36] Ben Turner, China is building a constellation of AI supercomputers in space — and just launched the first pieces, Live Science (2025).
[37] Ben Turner, China is building a constellation of AI supercomputers in space — and just launched the first pieces, Live Science (2025).
[38] Beijing-3, eoPortal (2023).
[39] China's new space-borne radar tech can track stealth-moving targets day and night: study, South China Morning Post (2025).

Warfighter Space Architecture (PWSA)–consisting of hundreds of low-Earth orbit satellites–will perform on-orbit data processing for targeting and communications, instead of relaying all data to ground stations.[40] This "edge computing" approach optimizes support for real-time military decision cycles. U.S. defense contractors, like Lockheed Martin, have developed software-defined satellite architectures (e.g. SmartSat) that allow AI applications to be uploaded to orbit, optimizing satellites for new missions.[41] NASA and industry have also demonstrated space-based supercomputing: Hewlett Packard Enterprise's Spaceborne Computer on the International Space Station proved that modern computer hardware can operate in orbit for long durations, enabling advanced analytics and AI in space.[42] In the commercial sector, companies are deploying AI-powered satellites for Earth observation. For instance, Sidus Space's LizzieSat small satellites use a proprietary AI platform to process imagery on-board and deliver "near real-time, AI-powered intelligence" from low Earth orbit.[43] Google and PlanetLab's Suncatcher initiative applies AI-driven modeling to optimize solar collection and adaptive energy management for orbital and surface-based systems, showcasing how machine learning can enhance operational efficiency and sustainability.[44] PlanetLab also integrates computer vision and predictive analytics to process vast streams of Earth observation data, enabling autonomous detection of environmental, agricultural, and security-related changes in near real time.[45] Overall, the U.S. approach emphasizes flexible, upgradable satellites that can leverage AI to autonomously manage data and respond to emerging threats or opportunities.

When it comes to applying quantum technology to space, China is regarded as the world leader and is moving swiftly to operationalize these capabilities. In 2016, China launched Micius (Mozi), the world's first quantum science satellite, and successfully demonstrated space-to-ground quantum key distribution (QKD) and entangled photon transmissions over distances >7,000 km.[46] Building on this, China has established multiple QKD links: for example, in 2025 Chinese scientists announced an ultra-secure quantum communication link between Beijing and South Africa (~12,800 km) enabled by quantum satellites.[47] This marked the first quantum-secure link connecting to the Southern Hemisphere and is part of Beijing's plan to connect BRICS nations with hack-proof communications. Chinese officials have set a goal of a global quantum-encrypted communications service by 2027, supported by a constellation of quantum satellites.[48] Achieving this would give China and its partners a communications network highly resistant to eavesdropping – a significant strategic asset for military and financial data security. In addition to communications, China is researching quantum-enhanced space sensors (sometimes dubbed "quantum radars") that could detect stealth aircraft or otherwise outperform conventional sensors. There are reports that China has even begun limited production of single-photon detectors for quantum radar systems.[49] While such systems are experimental, they underscore China's intent to

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[40] Proliferated Warfighter Space Architecture, Space Development Agency (SDA).
[41] SmartSat-equipped Satellite Uploads New Mission On-Orbit, Lockheed Martin (2024).
[42] HPE Spaceborne Computer, Hewlett Packard Enterprise (last accessed 2025).
[43] LizzieSat, Sidus Space (last accessed 2025).
[44] Meet Project Suncatcher, a research moonshot to scale machine learning compute in space, Google (2025).
[45] Mariah Hauck, How Is AI Used In The Space Industry? Planet Labs (2024).
[46] World's first quantum science experimental satellite "MoZi" launched, Our China Story (2024).
[47] Matt Swayne, China Establishes Quantum-Secure Communication Links With South Africa, Quantum Insider (2025).
[48] Matt Swayne, China Establishes Quantum-Secure Communication Links With South Africa, Quantum Insider (2025).
[49] Marin, Quantum Radar: The Next Frontier of Stealth Detection and Beyond, Post Quantum (2023).

incorporate quantum tech across space applications. Strategically, China's heavy investment in space quantum tech–highlighted in its national science plans–is driven by a desire to leapfrog traditional U.S. advantages in secure communications and sensing. If China fields a quantum secure satellite network first, it will establish a secure channel for its military and diplomatic traffic while potentially blinding others to its communications.

Meanwhile, the United States is in the early stages of deploying quantum technology in space, with a focus on secure communications and precision navigation. NASA, academia, and the U.S. Space Force are conducting experiments to lay the groundwork for future quantum networks. In late 2024, NASA sent a quantum communication experiment (SEAQUE) to the ISS, which tests entanglement-based links in the space radiation environment.[50] This experiment aims to prove technologies for long-distance quantum key distribution and entangled photon exchange—essential steps toward quantum-secured communications. The United States is also exploring quantum-enabled positioning and timing to augment GPS. In 2025, the U.S. Air Force's X-37B spaceplane carried a quantum inertial sensor experiment (using ultracold atom interferometry) to demonstrate ultraprecise navigation in orbit without GPS.[51] These investments reflect U.S. recognition that quantum tech could secure space links and provide strategic redundancy. However, near-term U.S. efforts remain mostly in R&D stages. The United States is prioritizing ground-based quantum networks and small-scale space demos rather than fielding an operational QKD satellite network. Still, partnerships are forming: for example, U.S. agencies are working with companies like Infleqtion (ColdQuanta) and national labs to develop space-qualified quantum clocks and memory for future satellites.[52] In the near-term future, the United States is looking to launch dedicated quantum communications payloads or piggyback them on commercial satellites as technology matures.[53] Strategically, the U.S. intent is to avoid being surprised by quantum-secure communications and to ensure its military and intelligence communications remain secure in a post-quantum world. This includes both developing its own quantum-encrypted links and figuring out how to intercept or mitigate adversary quantum links.

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[50] SEAQUE (Space Entanglement and Annealing QUantum Experiment), National Aeronautics & Space Administration (2024).
[51] Advancing Quantum Sensing for the DoD: From Lab to Orbit Within Months, Defense Innovation Unit (DIU) (2025).
[52] Voyager and Infleqtion Partner to Launch Quantum Era in Space, Infleqtion (2025).
[53] Boeing Launches Satellite to Test Quantum Communications in Space, Quantum Zeitgeist (2024).

An Assessment of China's Space Ambitions

Amongst the most ambitious of China's space goals, and the goal with perhaps the most strategic consequence and concern for the United States, is their plan to establish a permanent presence on the Moon. Beijing intends to conduct a crewed lunar landing by 2030, followed by the construction of a lunar base under the framework of the International Lunar Research Station (ILRS), which is planned to be operational sometime in the 2030s.[54] The first six Chang'e missions (along with China's human spaceflight program) have already granted Beijing much of the prerequisite scientific knowledge required to successfully conduct extended manned expeditions to the lunar surface, and the Chang'e-7 and Chang'e-8 missions (planned to launch in 2026 and 2029, respectively) are explicitly designed to scout and characterize resource-rich regions on the lunar surface, test in-situ resource utilization techniques, as well as power generation, thermal control, communication, and surface mobility systems.[55] Moreover, many of the major infrastructure elements that are required to bring people and base infrastructure to the Moon—namely, a super heavy-lift launcher and a lunar lander—are well under development in China.[56] More generally, China's lunar program—and its space program more broadly—has already demonstrated a long history of setting ambitious and strategic goals decades in advance, methodically building up the capabilities and technical expertise required to achieve them, and then following through on those goals on schedule.

The United States is also planning to return to the Moon in a permanent capacity through NASA's Artemis program, which aims to conduct a crewed lunar landing no earlier than 2027 and progressively establish long-term presence via construction of the Artemis Base Camp—alongside the Lunar Gateway station—through the 2030s.[57] Much of Artemis's core infrastructure, including the Space Launch System (SLS), Orion spacecraft, Human Landing System (HLS), Lunar Gateway, surface rovers, and spacesuits, has already undergone extensive development, but the program faces significant challenges. The SLS is an incredibly expensive system—each launch costs roughly $2.5 billion, and as of 2022, project costs were estimated at $23.8 billion.[58] These are costs associated with just a single element of Artemis (the launch vehicle), and several SLS launches will be required to bring the necessary crew and infrastructure to realize Artemis' ambitions. Artemis may transition to another launch vehicle over the long-term, but we are likely several years away before those systems become fully operational.[59] In addition to high program costs, certain programmatic decisions could also challenge NASA's overall development schedule.[60] To-date, NASA has only selected a single lander to move

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[54] Andrew Jones, China sets out preliminary crewed lunar landing plan, SpaceNews (2023).
[55] Leonard David, Chang'e 7 could search the lunar south pole for water this year, Space.com (2026); Andrew Jones, China outlines Chang'e-8 resource utilization mission to the lunar south pole, SpaceNews (2023).
[56] The LM-10 is scheduled to launch for the first time this year, and China has already conducted systems testing of their Lanyue lunar lander. *See* Kenna Hughes-Castleberry, China's moon lander passes key test, Space.com (2025).
[57] Lunar Gateway is a planned space station that will orbit the Moon to support lunar surface operations; Pallab Ghosh, When does the Nasa Moon mission launch and who are the Artemis II crew?, BBC (2026).
[58] NASA's Transition of the SLS to a Commercial Services Contract, NASA Office of Inspector General (2023); The Cost of SLS and Orion, The Planetary Society (last accessed 2026).
[59] Mike Wall, SpaceX looking into simplified Starship Artemis 3 mission to get astronauts to moon faster, Space.com (2025).
[60] For additional context, Artemis was established in 2017, and originally planned for crewed landings to the Moon by 2024.

onto a full development contract – SpaceX's Starship HLS. Starship HLS—a variant of Starship—appears to be a very capable system, but several years remain before the system becomes fully operational, and it imposes a mission architecture on Artemis which requires capabilities and technologies that have not been demonstrated before (namely, orbital refuelling of the lander in Earth orbit).[61]

Mindful of these dynamics, there is a real possibility that China lands people on the Moon before the United States returns there. If that ends up being the outcome, that could be a considerable strategic setback for the United States. Aside from the expectations that the Moon could service the future Earth-based economy,[62] the Moon is widely regarded as a staging base from which to launch future, further reaching space missions. For example, the Moon contains an abundance of water ice, which can readily be used to make rocket fuel to refuel launch vehicles.[63] The Moon's gravity is one-sixth that of Earth's, making it far easier and less fuel-intensive to access space from there than from Earth. Ultimately, planned Chinese lunar efforts would confer operational and technical advantages that would be difficult for the United States to replicate quickly. Moreover, this could place U.S. firms at a disadvantage as they would find themselves operating within an environment shaped by Chinese technical standards, operational norms, and access arrangements. In this sense, competition over the Moon is more about who defines the architecture within which future activity occurs.

Looking beyond the Moon, the China National Space Administration (CNSA) currently has four deep-space missions planned for the future that are publicly known—Tianwen-2, Tianwen-3, Tianwen-4, a mission to Venus, and a set of manned missions to Mars. The primary goal of Tianwen-2, which was launched in 2025, is to return samples from the near-Earth asteroid 469219 Kamoʻoalewa[64] by 2027. Tianwen-3, which is expected to launch in 2028, is China's mission to return samples from Mars by 2031[65] (a feat which even the United States has yet to achieve). Tianwen-4, scheduled to be launched in 2029, is a planned mission to Jupiter and its moon Callisto, with expected arrival date at the Jovian system in 2035.[66] CNSA's planned mission to Venus aims to return samples from the Venetian atmosphere.[67] And lastly, China has outlined plans to launch its first crewed mission to Mars in 2033, and to begin base construction there. It has notionally set 2035, 2037, 2041, and 2043 as launch dates for follow-on missions.[68]

To be sure, NASA's past and planned deep-space and planetary exploration efforts are also ambitious. However, China appears to be quickly expanding its interplanetary exploration efforts at a time when funding levels for NASA appear somewhat uncertain.[69] Secondly, on top of these missions serving as a forcing function to develop

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[61] Eric Berger, Congress warned that NASA's current plan for Artemis "cannot work", Ars Technica (2025).
[62] Aaron Olson, Lunar Helium-3: Mining Concepts, Extraction Research, and Potential ISRU Synergies, National Aeronautics & Space Administration (2021); Laszlo Keszthelyi, et al., Rare Earth Elements on the Moon, U.S. Geological Survey Astrogeology Science Center (2025).
[63] Neel V. Patelarchive, Here's how we could mine the moon for rocket fuel, MIT Technology Review (2020).
[64] Joey Roulette and Eduardo Baptista, China launches mission to retrieve asteroid samples, Reuters (2025).
[65] Andrew Jones, How China Could Win the Race to Return Rocks from Mars, Scientific American (2025).
[66] Zohaib Afzal, et al., Evaluating the contribution of Tianwen-4 mission to Jupiter's gravity field estimation using inter-satellite tracking, Astronomy & Astrophysics (2025).
[67] Andrew Jones, Venus atmosphere sample return noted in China's long-term space science roadmap, SpaceNews (2024).
[68] Arjun Kharpal, China plans to send its first crewed mission to Mars in 2033 and build a base there, CNBC (2021).
[69] Eric Berger, As NASA faces cuts, China reveals ambitious plans for planetary exploration, Ars Technica (2025).

technologies that will benefit China's broader space efforts (e.g. deep-space networks, advanced propulsion systems, etc.), as has been the case with NASA's efforts, they are likely to spur China's high-technology industries back on Earth.

Conclusion

China's rise as a major space power represents one of the most consequential strategic developments of the early twenty-first century. Over the past two decades, Beijing has transformed its space program from a limited, missile-related effort into a comprehensive, vertically integrated enterprise spanning civil, commercial, and military domains. This evolution has not been accidental nor episodic; it reflects sustained national investment, deliberate planning, and a clear understanding of space as an inseparable part of the continuum of national power. China has already matched the United States across many of the traditional milestones that define advanced spacefaring nations and is rapidly closing gaps in several of the capability areas that will shape future competition in space.

Measured purely in terms of historical achievement, China's record is formidable. It operates an independent, permanently crewed space station; has conducted complex missions to the Moon, Mars, and beyond; and has demonstrated growing sophistication in rendezvous and proximity operations, in-space servicing, and autonomous spaceflight. With emerging technologies—such as AI-enabled satellites and space-based quantum communications—China is not merely catching up, but in some cases setting the pace. These advances matter not because they represent symbolic firsts, but because they enable persistence, resilience, and operational flexibility in space—attributes that increasingly define effective space power.

At the same time, China does not yet enjoy decisive superiority across the full spectrum of space capabilities. The United States retains critical advantages, particularly in reusable launch and super heavy-lift rockets, commercial dynamism, alliance integration, and experience operating large-scale space architectures at high cadence. Likewise, American leadership in commercial space and its integration with national security objectives remains a unique strategic asset.

The central risk for the United States, therefore, is not sudden displacement by China in any single mission set, but gradual loss of overall pre-eminence. As in other aspects of the competition, China's approach benefits from long planning horizons, centralized coordination, and the ability to align industrial policy, technological development, and geopolitical objectives behind unified goals. By contrast, U.S. space efforts are distributed across multiple institutions, incentive structures, and political cycles. Absent deliberate integration and a comprehensive approach, even strong individual programs may fail to translate into sustained leadership across contested regions of the space domain.