Redshift

The Acceleration of China's Commercial and Civil Space Enterprise & The Challenge to America

A Strategic Report from the Commercial Space Federation

September 2025

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With data support from Orbital Gateway Consulting

Commercial Space Federation (CSF)

The Commercial Space Federation (CSF) is the leading trade association representing the commercial space industry. CSF serves as the industry's voice to policymakers in the U.S. government, international governments and organizations, the media, and the public, advocating for policies that support growth and innovation in the space economy.

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The recommendations advocated for in this report reflect the analysis of the Commercial Space Federation (CSF) and should be understood as its institutional perspective.

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Forward

By: Dean Cheng

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The People's Republic of China (PRC) has paid great attention to space since the beginning of the Space Age. In 1958, Chinese leader Mao Zedong stated "We, too, must work on artificial satellites." But for several decades, China's space aspirations exceeded its industrial and financial grasp. It was not until 1970 that China launched its first satellite, Dongfanghong-1 (which remains in orbit). China launched a number of communications and EO satellites over the next two decades, but its pace of launches and satellite development remained slow.

Since the 1990s, however, China's space program has mushroomed, as the PRC has gained more and more resources, whether financial, industrial, or human, to devote towards aerospace. China was only the third nation to deploy a position, navigation, and timing (PNT) satellite constellation, the Beidou system in the late 1990s and early 2000s. The PRC has one of the largest constellations of weather satellites, a growing suite of EO systems, as well as an extensive array of communications satellites. This will further expand, as the PRC is developing at least three proliferated Low Earth Orbit (pLEO) mega-constellations.

While much of the PRC space effort has focused on systems intended to support China's economic development, the People's Liberation Army (PLA) has benefited from China's growing space capabilities. Its Military Aerospace Force has access to an array of anti-satellite (ASAT) systems, including demonstrated direct ascent ASAT capabilities. Similarly, China's human spaceflight efforts have benefited from robust funding, incorporating a modular space station (the Tiangong), with semi-annual crew rotations. Chinese space scientists meanwhile have access to their own lunar samples, retrieved by Chinese spacecraft, and analyze data from only the second national probes to successfully deploy on Mars.

All of these achievements reflect a Chinese approach that has been systematic and sustained. The Chinese Communist Party (CCP), true to Mao's statement, has hewed to a long-term set of goals for developing indigenous Chinese capabilities, whether in space launch, production of space systems (including satellites, launch vehicles, and the terrestrial equipment necessary to support both), or expanding space services, which now includes satellite communications, EO, and PNT. Its human spaceflight program has similarly benefited from long-term programmatic stability, both in design and funding, unlike the American effort which has seen almost every new administration start anew, while Congress has regularly interceded to alter NASA's funding.

What is worrisome is China's acknowledgement of the importance of innovation and flexibility. Recognizing that large state-owned enterprises (SOEs) like the China Aerospace Science and Technology Corporation (CASC) and the China Aerospace Science and Industry Corporation (CASIC), the long-time cornerstones of China's space industrial complex, were unlikely to provide said innovation and flexibility, the CCP opened the doors in 2014 to more truly commercial companies participating in China's space efforts.

This is in line with the broader CCP recognition that markets are unrivaled in the efficient allocation of resources and responsiveness to supply and demand signals. Thus, the CCP supported the growth of a more genuinely commercial aerospace industrial sector, not only to generate technological innovations, but also innovations in production techniques through greater efficiency and cost reductions. Chinese commercial space companies have scored a variety of major advances, such as methane-powered rockets and reusable launcher designs. The majority of the acknowledged Chinese LEO providers are private companies, rather than SOEs, to generate and exploit advances in mass production, modular satellite and launch vehicle design, and rapid launch cadence.

This is not to suggest that the PRC is pursuing economic liberalization. As with every Chinese organization of any sort, Chinese aerospace firms have "Party committees" staffed by members of the CCP, who have ultimate authority and oversight. The policy of military-civil fusion, and Chinese mobilization laws, means that in the event of crisis or war, the Chinese leadership will be able to access the intellectual property, as well as the equipment, facilities, and personnel, of Chinese aerospace firms, whether commercial or SOE.

Instead, the Chinese willingness to rely on markets and commercial firms rather than SOEs reflects the CCP's recognition of not only the importance of aerospace for the PRC's future, but that a more market-oriented aerospace sector will be more innovative, more efficient, and therefore better able to compete against the United States and the West in this vital domain.

To understand where the PRC, with its diverse space industrial complex, is going, it is important to understand how far they have come. This requires assessing not only China's space efforts, but to measure how well they have done against their own goals. This report from the Commercial Space Federation provides not only a snapshot of current Chinese efforts, but lays out China's programs, as reflected in publications such as the Chinese space white papers. China's growing space capabilities are not only expanding, but are doing so according to long established plans. The Chinese ability to sustain this effort over decades, as reflected in this report, is a warning that the competition in space between the US and the PRC is intensifying with no sign of abating—and no guarantee of who will be the winner.

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Executive Summary

Redshift: The Acceleration of China's Commercial and Civil Space Enterprise & The Challenge to America

A Strategic Report from the Commercial Space Federation

Supported by: BryceTech and Orbital Gateway Consulting *September 2025*

Introduction and Context

This report arrives at a pivotal moment for global space affairs. Over the past decade, China's space enterprise has transformed rapidly, driven by sweeping policy reforms, surging investment, and an intentional merging of commercial, civil, and national security ambitions. The timeliness of this analysis is underscored by China's shift from aspirational planning to tangible achievement—changes that are fundamentally altering the strategic landscape for the United States and its partners. By providing a comprehensive, segment-by-segment assessment of China's space progress and its implications for American interests, this report aims to serve both as a factual record of China's emerging capabilities and as a risk assessment for U.S. industrial competitiveness and national security.

Objectives and Scope

To dissect the rapid evolution of China's commercial and civil space sectors and its implications for American interests, this report uses some guiding questions:

- What official goals, plans, and doctrines drive China's recent pace of investment and innovation?
- What concerted shifts in policy and regulation, funding, and public campaigns has China undertaken to achieve these goals?
- Which tangible achievements have materialized across the various segments of China's space enterprise, whether technological developments, programmatic milestones, or cultivation of new stakeholders, domestic innovation hubs, and international projects?
- How does this alter the risk profile for U.S. commercial and strategic leadership?

After an opening section that provides a holistic overview of China's space ambitions and landscape, the report continues with six sections analyzing China's progress across key areas of the space ecosystem.

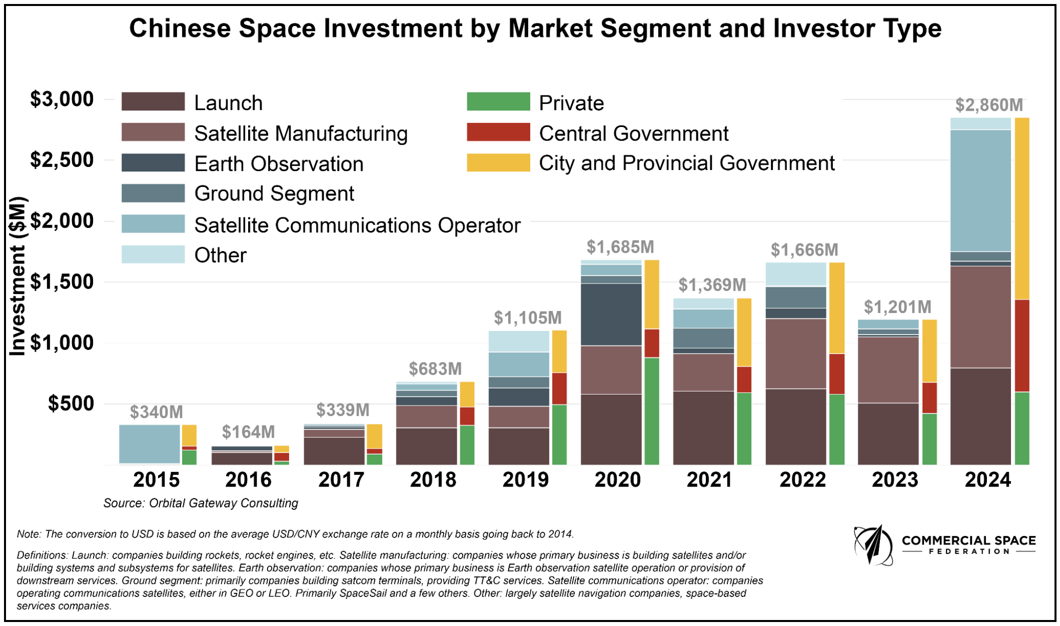
1. Spaceports and Infrastructure
2. Launch and Reentry
3. Remote Sensing (RS) and Space Situational Awareness (SSA)
4. Satellite Communications (Satcom) and Positioning, Navigation, and Timing (PNT)
5. Commercial low Earth orbit (LEO)
6. Space Exploration

Each of these sections begins by examining Beijing's stated ambitions and reforms, evaluates the real-world milestones it has achieved by 2025, and finally details the resulting risks posed to U.S. industry, international competitiveness, and national security. The analysis covers the full scope of China's commercial and civil space enterprise including mapping their international projects and collaborations. The report ends with recommendations distilled from in-depth expert review and the guidance of sector advisory boards, ensuring actionable insights for policymakers and commercial stakeholders seeking to respond to China's accelerating influence in space.

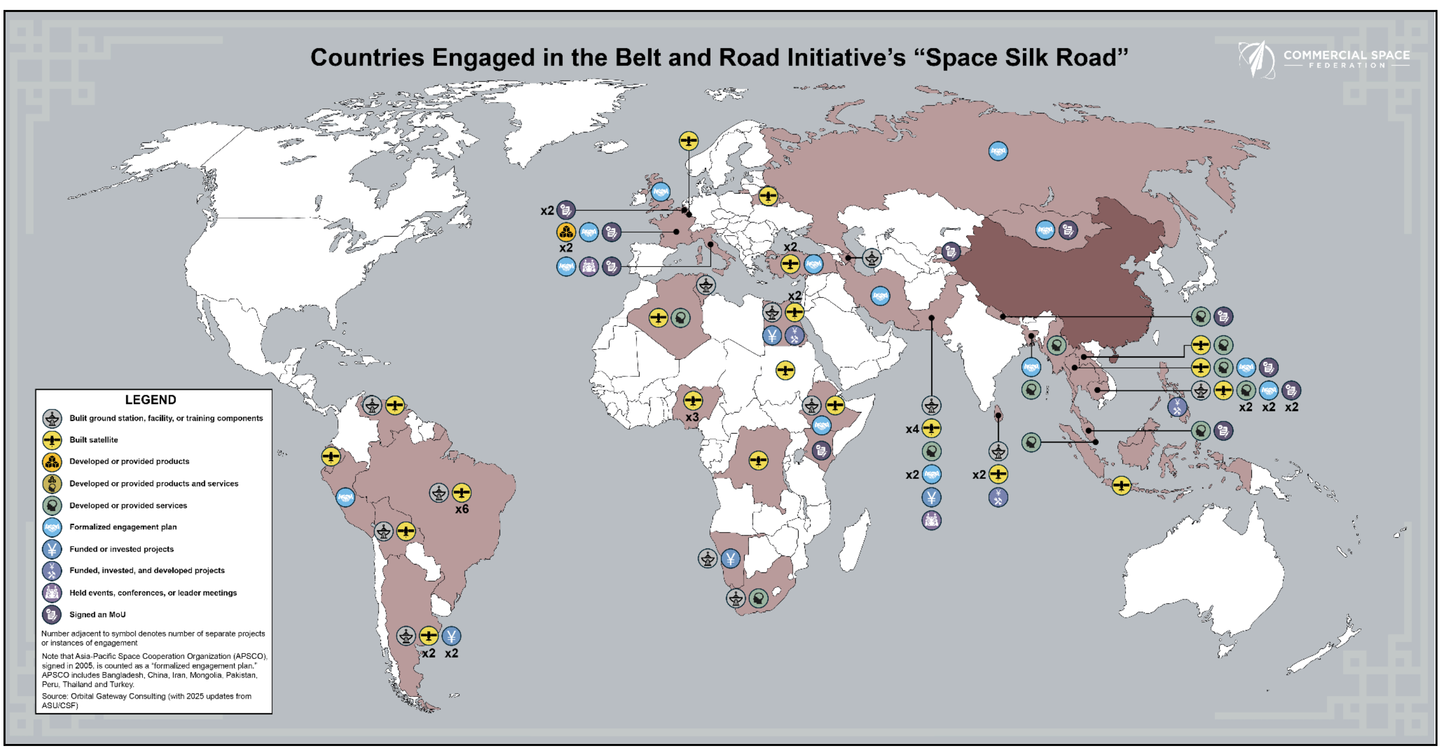
Key Findings

China's decade of steady progress in space is now reshaping the competitive landscape and may soon challenge U.S. leadership and commercial strength. The risks extend beyond technology to markets, partnerships, and governance, signaling a pivotal moment in global space competition. What began as milestone-driven missions has become a state-backed campaign to define norms, capture markets, and build international coalitions across all segments of the space ecosystem.

Key Finding 1: China is using a hybrid growth playbook; ours to innovate, theirs to scale, with striking outcomes.

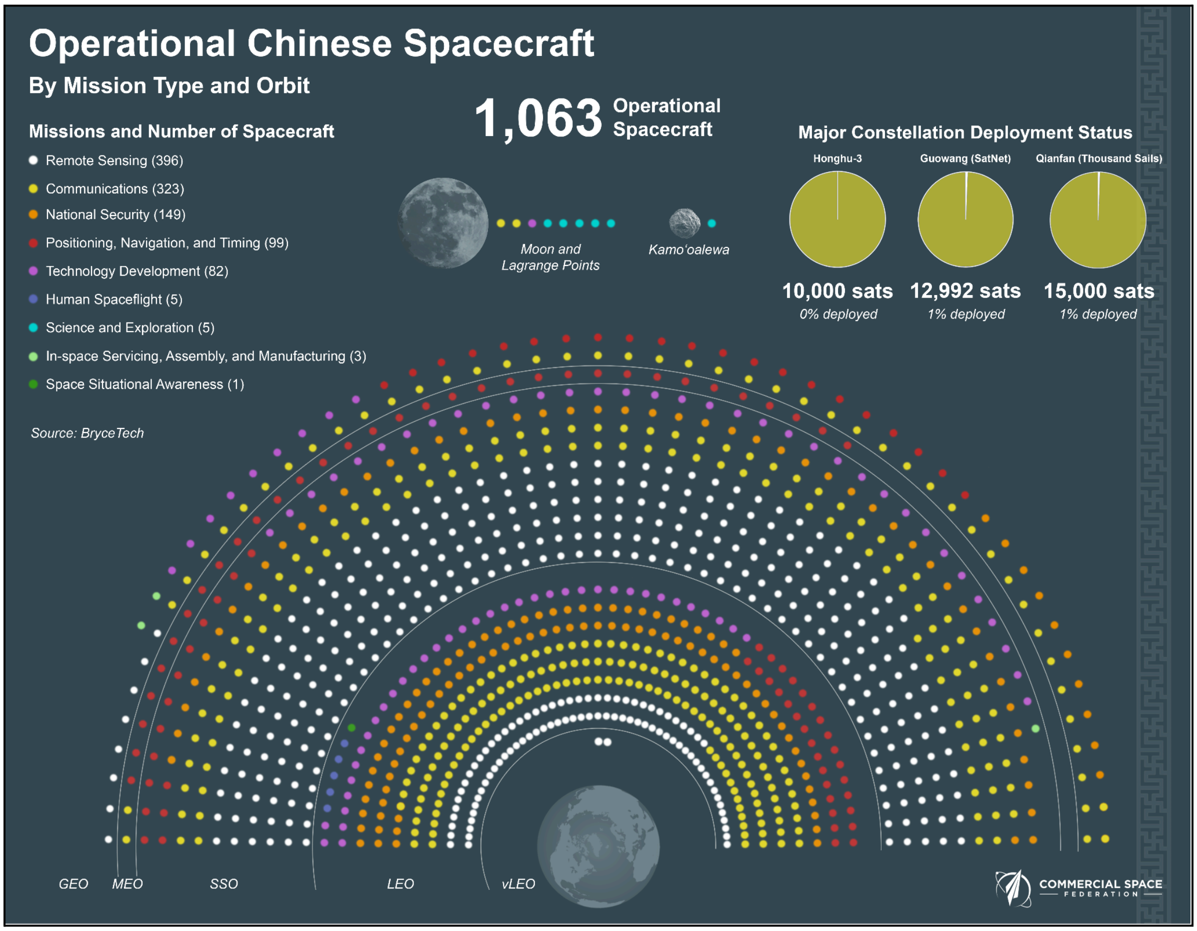


China's space sector has rapidly evolved into a powerhouse that combines long-term state planning with market-driven commercial innovation and regional government support. This transformation is marked by private companies now representing a substantial portion of activity across segments. In China, a private company is a business legally owned by individuals or non-state entities that is profit-driven, engaged in market competition and innovation, but more heavily subject to regulatory oversight and alignment with state policy than U.S. private firms. Enabled by targeted policy shifts like 2014's National Development and Reform Commission "Document 60" and reinforced by their 14th Five-Year Plan and 2021 Space White Paper, China built concentrated regional hubs—Shanghai, Beijing, Chengdu, Xi'an, Guangzhou, Jinan and more—that unite universities, state organizations, and private firms in a "triple helix" of accelerated aerospace growth. Long known for its ability to scale innovations from one to one hundred, China is now learning to pioneer its own breakthroughs "from zero to one". Yet, activity remains tightly overseen by the Chinese Communist Party and subject to military-civil fusion laws, which mandate that even private companies and academic researchers must share technologies and expertise with the military when ordered—allowing authorities to quickly mobilize talent and hardware in a crisis, and underscoring the strategic risks of China's flexible, state-backed innovation model.



Key Finding 2: *The "Space Silk Road" is tethering even more countries to Beijing.*

China's Space Silk Road under its Belt and Road Initiative has prompted over 80 international space diplomacy infrastructure projects in satellite manufacturing, ground stations, launch services, data sharing, and training centers. It is rapidly embedding Chinese state-owned firms and sanctioned entities into the space and communications infrastructure of dozens of countries, often supplemented by preferential loans and long-term maintenance contracts. Beijing's expanding footprint risks leaving countries engaged in these projects vulnerable to debt diplomacy, surveillance, information censorship, and operational encroachment, as seen in instances across South America and Africa. Without urgent U.S. strategic countermeasures and targeted alternative opportunities for infrastructure cooperation and market access, nations across the globe may find their digital and orbital futures tethered to Beijing, eroding American influence and introducing new coercive leverage in international and security domains.



Key Finding 3: *China's infrastructure surge could upend U.S. launch assumptions.*

With six operational spaceports—including new coastal and sea-based launch sites—China is now positioned as a formidable launch competitor, able to support near-simultaneous launch operations with a high frequency cadence and attract international clients with increasingly cost-competitive options. This rising infrastructure is matched by a boom in commercial launch activity; more than a dozen private rocket manufacturers are now active and venture funding in the sector has topped $3 billion since 2020. Manufacturing ecosystems are flourishing in advanced urban clusters nationwide, feeding innovation and regional economic growth, with tens of thousands of satellites planned for future megaconstellations—though fewer than 1% have been launched thus far. Even as China remains behind the United States in realized launch capacity, the momentum is tangible. Meanwhile, elements of the U.S. infrastructure operate in a relative status quo, with viable legacy launch sites but underutilized inland ports and only incremental investments in launch infrastructure. Should China's surge accelerate as many industry leaders predict, the competitive balance could quickly shift, with America's long-assumed launch and orbital dominance facing new and unprecedented pressures.

China Space Activity Hubs

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	Hub	Launch site	Launch Provider Headquarters	Launch Vehicle Manufacturer	TT&C Site	Satellite Headquarters	Satellite Manufacturer	Government Organization	University
1	Beijing-Tangshan-Tianjin Binhai-Xiong'an Hub		4	3	1	2	7	5	4
2	Harbin-Jilin Hub		1			2		1	
3	Haiyang-Jinan-Qingdao Hub	1		4	1		4		
4	Hangzhou-Jiaxing-Jinhua-Nanjing-Quozhou-Shanghai-Shaoxing-Shengzhou-Tai'an-Taizhou-Wuxi-Zhangjiagang Hub		1	9		2	23		5
5	Anqing-Bengbu-Chizhou-Weinan-Wuhu Hub		1	6	1		3		
6	Wuhan Hub			1			2		
7	Changsha-Zhuzhou Hub						3		1
8	Guangzhou-Hong Kong-Shenzhen Hub			1		2	4	1	2
9	Wenchang Hub	1		1			1		
10	Chengdu-Chungu-Deyang-Xichang Hub	1		3			4		1
11	Xi'an Hub		1		1		2		3

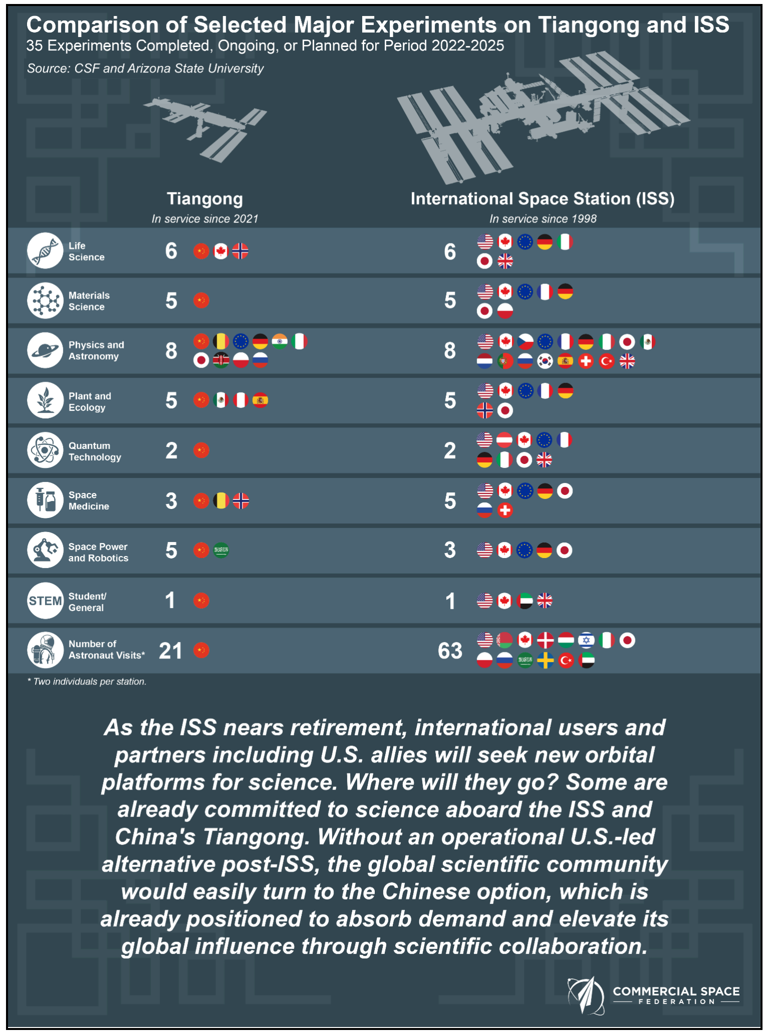
LEGEND

- Launch site
- Launch Provider Headquarters
- Launch Vehicle Manufacturer
- TT&C Site
- Satellite Headquarters
- Satellite Manufacturer
- Government Organization
- University

Sources: Arizona State University and Orbital Gateway Consulting

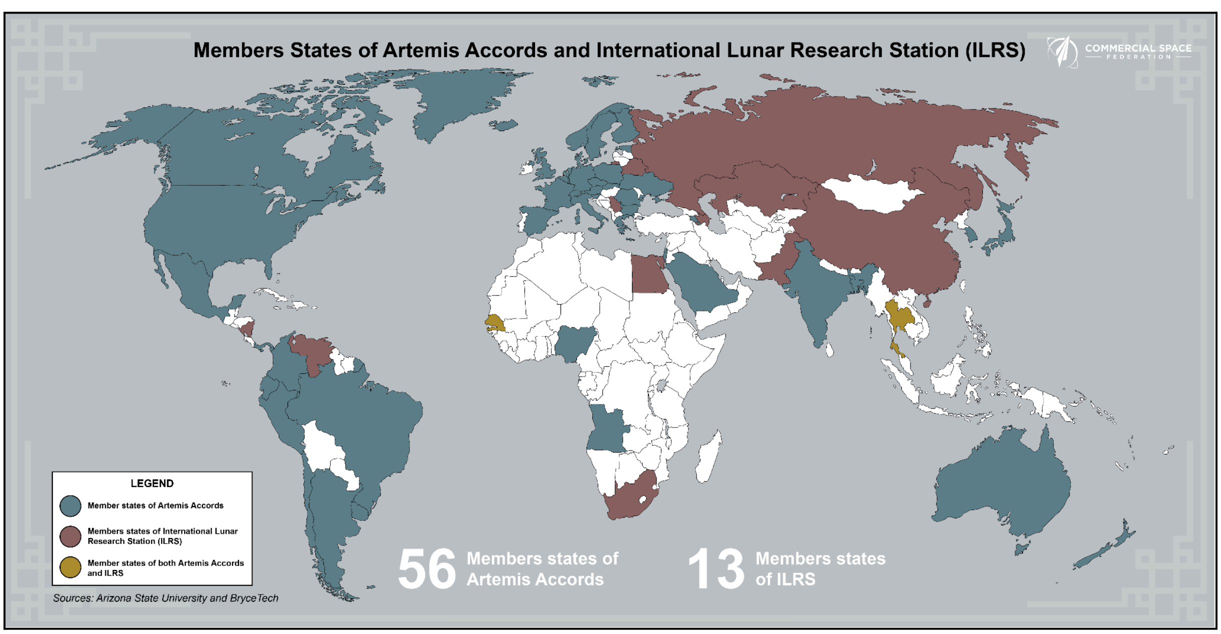
Key Finding 4: *Tiangong is already absorbing orbital science demand.*

As the International Space Station nears retirement, China's Tiangong station is poised to become the primary hub for orbital science, already attracting international participation—including from U.S. allies—and engineered to absorb demand once the ISS is gone. While the ISS currently dominates in experiment volume and global engagement, the absence of a U.S.-led successor would leave the international science community little choice but to turn to China's platform, enabling Beijing to set new norms and expand its influence over orbital space research.



Key Finding 5: *China is hitting all deadlines on their deep space roadmap.*

China's deep space strategy is rapidly converting technical ambition into global influence; by 2030 it aims to land a taikonaut on the Moon, by 2031 return Martian samples to Earth (by the late 2020's by some accounts), and its 2028 Chang'e-8 mission alone will include scientific payloads or involvement from nine countries. China's lunar program is on track toward Phase IV with active preparation for Chang'e 7 & 8 missions including successful pad abort tests of the Mengzhou crew spacecraft, along with key development milestones for the Long March 10 rocket and Lanyue lunar lander. Their Chang'e mission sequence could galvanize further international engagement via the International Lunar Research Station (ILRS), which already includes more than a dozen participant nations. Similarly, China is inviting international payloads and participation on its Tianwen-3 Mars sample mission. This rapid progression, combined with China's proven track record—such as the world's first lunar far-side sample return—signals not just technological ambition but a deliberate bid to redraw partnerships of deep space exploration.



How to Maintain US Leadership

One thing is certain. China is not slowing down but accelerating beyond America's pace in many areas—(*i.e.,* Redshift). They are not deviating from their "Space Dream"—China is living its Apollo, ISS, and commercial space eras all at once, bringing new strategic, economic, and commercial risks for America. As this report concludes, China's space program has matured rapidly—driven by strategic patience and state investment—meeting and often exceeding its goals, reshaping global space power, and posing complex risks to U.S. industry. China remains fully committed to its roadmap and milestones and will use all available resources to become a global leader in space.

Here in the U.S., innovative capabilities developed by our commercial space companies continue to push the boundaries of the possible. However, U.S. companies must deal with an uncertain and sometimes constraining policy, budget, and regulatory landscape that creates obstacles to continued success. Change is needed to unleash the U.S. space industry and further its lead in this new space race. Below, we provide recommended actions for consideration by the U.S. Congress, the White House, and Executive Branch agencies. These recommendations would focus national attention on the U.S. space industry, remove barriers to growth, and drive the investment of time, dollars, and resources needed to stay ahead of China's space ambitions.

Spaceports and Infrastructure:

1) Provide Federal investment in spaceports through grants
2) Streamline Federal and State environmental reviews
3) Reform regulations to enable inland vertical launch and orbital reentry operations

Launch and Re-Entry:

1) Streamline commercial launch/reentry licensing
2) Reform environmental reviews for launch/ reentry operations
3) Provide appropriate resources to improve launch/reentry licensing
4) Reform export controls to increase international collaboration
5) Modernize the management of airspace during launch/reentry operations

Remote Sensing and Space Situational Awareness:

1) Reform U.S. export controls
2) Reform commercial remote sensing licensing
3) The U.S. government should utilize commercial data and services to the maximum extent practicable
4) Support the TraCSS Program and distribute basic SSA data free of charge to the end user

Satellite Communications and Positioning, Navigation, and Timing:

1) Allocate sufficient spectrum for satellite operations
2) Reform Federal spectrum coordination processes
3) Ensure U.S. communication accessibility programs are technology neutral

Commercial LEO

1) Fully utilize the ISS through end of life
2) Foster a smooth transition from ISS to commercial LEO stations and research facilities
3) Continue robust NASA human operations in LEO post-ISS

Space Exploration

1) Fully utilize commercial capabilities to achieve NASA's Moon to Mars Exploration and Science Objectives.
2) Partner with commercial space to enable space science
3) Implement a mission authorization process that facilitates commercial space exploration missions.

Conclusion and Call to Action

China's space ascendancy—propelled by disciplined policy, strategic investment, and sweeping technological gains—has fundamentally redrawn the domain in which global power is contested. As this "Redshift" report makes clear, China's pursuit of its "Space Dream" is deliberate and relentless, merging commercial and civil space ecosystems and fusing terrestrial and orbital infrastructure in ways that directly challenge decades of American industrial, technological, and security leadership. The accelerating integration of Chinese space assets with terrestrial networks, the expanding network of global partnerships, and the rapid advance of "dual-use" systems now constitute not just a competitive threat, but a systemic risk to U.S. interests and the very frameworks that underpin international space norms and regulations.

The world is entering an era of divided space systems and multiplying risk, where the stakes are measured in innovation horizons, supply chain resilience, and new strategic high grounds. The trend line is unmistakable; China is not only racing to catch up—it is setting pace, deregulating, and, at times, redefining what leadership looks like on and above Earth. This new space race will not be won with a single breakthrough or headline achievement, but with sustained commitment, clear-eyed vigilance, and a willingness to adapt over decades. The United States and its partners must act now to invest boldly in resilient space and terrestrial capabilities, expand collaborative alliances, and foster a whole-of-nation innovative, agile ecosystem. Only by doing so can America secure its place at the forefront of the next chapter in the exploration and stewardship of the space domain.

ACTION REQUIRED:
Ensure Congress, industry, and allied partners have the mandate, resources, and strategic clarity to counter and outpace China's momentum. The choice is clear; proactive engagement, or strategic irrelevance in the most consequential domain of the 21st century.

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Glossary of Acronyms:

5G fifth-generation mobile network technology
AfSA African Space Agency
AI artificial intelligence
AIIB Asian Infrastructure Investment Bank
APSCO Asia-Pacific Space Cooperation Organization
ASAT Anti-Satellite
ASEAN Association of Southeast Asian Nations
AST Office of Commercial Space Transportation
ATO Air Traffic Organization
BEAD Broadband Equity, Accessibility, and Deployment
BDS BeiDou Navigation Satellite System
BDSBAS BeiDou Satellite-Based Augmentation System
BITTT Beijing Institute of Tracking and Telecom Technology
BRI Belt and Road Initiative
CALT China Academy of Launch Vehicle Technology
CAS Chinese Academy of Sciences
CASC China Aerospace Science and Technology Corporation
CASIC China Aerospace Science and Industry Corporation
CAST Chinese Academy of Space Technology
CATEX Categorical exclusion
CAVES Cooperative Adventure for Valuing and Exercising human behaviour and performance Skills
CBERS China-Brazil Earth Remote Sensing Satellite
CCP Chinese Communist Party
CDSN China Deep Space Network
CFOSAT China-France Oceanography Satellite
CGST Chang Guang Satellite Technology
CGWIC China Great Wall Industry Corporation
CHEOS China High-resolution Earth Observation System
CLD Commercial LEO destinations
CLEP China's Lunar Exploration Program
CLPS Commercial Lunar Payload Services
CMS Chinese Manned Space Program
CMSA China Manned Space Agency
CNES Centre national d'études spatiales (Fr.), National Center for Space Studies (Eng.)
CNSA China National Space Administration
COPUOS United Nations Committee on the Peaceful Uses of Outer Space
CSDA Commercial Satellite Data Acquisition
CSS Chinese Space Station
CSST Chinese Space Station Telescope
CZ Chang Zheng
DOC Department of Commerce
DOD Department of Defense
DOS Department of State
DOT Department of Transportation
EO Earth Observation
ESA European Space Agency
EU European Union
EVA extravehicular activity
FAA Federal Aviation Administration
FY fiscal year
FYP Five-Year Plans
GDP gross domestic product
GEO Geostationary Earth orbit
GEOSS Group on Earth Observations System of Systems
GNSS Global Navigation Satellite System
GPS Global Positioning Systems
GSO Geosynchronous orbit
GTO Geostationary transfer orbit
IAMCAS Innovation Academy for Microsatellites
IC Intelligence Community
ICAO International Civil Aviation Organization
IEC International Electrotechnical Commission
IGSO Inclined geosynchronous orbit
ILRS International Lunar Research Station
IoT Internet of Things
ISAM in-space servicing, assembly, and manufacturing
ISRO Indian Space Research Organisation
ISS International Space Station
ITAR International Traffic in Arms Regulations
ITU International Telecommunication Union
LEO Low Earth orbit
LM Long March
MEO medium Earth orbit
MIIT Ministry of Industry and Information Technology
MOE mixed-ownership enterprise
MOU memorandum of understanding
NAS National Airspace System
NASA National Aeronautics and Space Administration
NDRC China National Development and Reform Commission
NEO Near Earth Object
NEPA National Environmental Policy Act
NGSO Non-geostationary satellite operators
NOAA National Oceanic & Atmospheric Administration
OSC Office of Space Commerce
OST Outer Space Treaty
PEC Planetary Exploration of China
PLA People's Liberation Army
PLASSF PLA's Strategic Support Force
PNT Position, Navigation, and Timing
PRC People's Republic of China
R&D research and development
RS remote sensing
SAR synthetic aperture radar
SAST Shanghai Academy of Spaceflight Technology
SASTIND State Administration for Science, Technology, and National Defense
SATCOM Satellite communications
SBSP Space-based solar power
SMD Science Mission Directorate
SOE state-owned enterprise
SSA space situational awareness
SSO Sun-synchronous orbit
SSST Shanghai Spacecom Satellite Technology
SOEs State-owned enterprises
SpARC Human Space Flight Occupant Safety Aerospace Rulemaking Committee
STIM Spaceport Transportation Infrastructure Matching
SUPARCO Space and Upper Atmosphere Research Commission of Pakistan
S&T Science and technology
TT&C telemetry, tracking, and control
TraCSS Traffic Coordination System for Space
UN United Nations
UNOOSA United Nations Office for Outer Space Affairs
USML U.S. Munitions List
USSF U.S. Space Force
VLEO Very low Earth orbit

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1. Introduction

This report, "Redshift: The Acceleration of China's Commercial and Civil Space Enterprise & The Challenge to America," arrives at a pivotal moment for global space affairs. Over the past decade, China's space sector has undergone a rapid transformation, marked by sweeping policy reforms, surging investment, and a deliberate fusion of commercial and civil ambitions. The timeliness of this analysis is underscored by the pace at which China has shifted from aspirational planning to tangible achievement, fundamentally altering the competitive and strategic landscape for the United States and its partners.

The purpose of this report is to provide a comprehensive, segment-by-segment assessment of China's space progress and its implications for American interests. Its scope spans the full spectrum of China's space enterprise—from infrastructure and launch to remote sensing (RS), communications, low Earth orbit (LEO) industry, and deep space exploration. The report is designed to serve both as a factual record of how China's stated goals have translated into real-world outcomes and as a risk assessment for U.S. industrial competitiveness and national security.

Our methodology is grounded in a sequenced, evaluative approach. Each section first examines China's official plans and policy pronouncements, then documents the achievements realized by 2025, and finally examines the possible resulting risks to American commercial and strategic interests. This sequence guides the reader logically from intent to impact, providing a clear narrative that connects China's ambitions to the evolving risk landscape faced by the United States.

The report opens with an essential strategic background on the entire Chinese space enterprise and the drivers of China's emergence, including doctrine, regulatory and funding shifts, domestic mobilization, and foreign engagement. It then moves into a detailed similar breakdown and risk assessment across six core segments: 1. spaceports and ground-based infrastructure; 2. launch and reentry; 3. remote sensing (RS) & space situational awareness (SSA); 4. satellite communications (Satcom) and positioning, navigation, & timing (PNT); 5. commercial LEO; and 6. space exploration. Therefore, this report can be leveraged by stakeholders as a whole or by its component segments.

The story that unfolds is twofold: first, a chronicle of China's decade-long track record in signaling and delivering on space ambitions and, second, a sober framing of the risks these achievements now pose to America's leadership and commercial space ecosystem. These findings and the recommendations that follow from the Commercial Space Federation are intended to inform and empower American decision-makers to chart a proactive course in this new era of global space competition.

2. Strategic Landscape

2.1. Plans & Doctrine

2.1.1. Defining Commercial Space

The United States 2010 National Space Policy of the United States defined commercial space activities as “goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers” [001]. That definition, retained by President Donald Trump in his 2020 National Space Policy, highlights the American focus on private-led innovation and involvement within commercial space. Furthermore, the current Trump Administration’s "Enabling Competition in the Commercial Space Industry" Executive Order, issued on August 13, 2025, further reinforces this priority by directing the streamlining of regulatory processes, expediting licensing, and reducing bureaucratic barriers to enable faster growth and innovation for U.S. commercial space operators. The Executive Order aims to secure U.S. leadership by making the U.S. the premier global destination for private space investment and advanced commercial space activities [002].

However, commercial space as defined in the American context differs from how commercial space is understood in China. For the purposes of this report, understanding the defining characteristics of “commercial space” as per China’s business structure is vital. The market structure within China is semi-open and government-guided. In comparison to the competitive and open market structure held by the United States, China maintains something akin to a *quasi-commercial* structure.

Just this year, Chinese authorities introduced the Private Economy Promotion Law (PEPL) which reiterated the definition of “private economy organizations” as for-profit legal persons, unincorporated organizations, and individual household businesses in which Chinese citizens are the actual controllers, thereby formalizing the concept of “people-operated” (minying) ownership as distinct from state-owned and foreign-invested companies. While these private companies can range from small family businesses to large corporations, they are subject to the Chinese government’s regulatory oversight and policy guidance. Both Chinese and U.S. private companies are profit-driven, engaged in market competition, and structured as privately registered enterprises that operate outside of direct government ownership or management. However, it should be emphasized that while both pursue market-oriented business activities and innovation, the fundamental divergence lies in the extent of government involvement, political oversight, and the expectations for alignment with state objectives in China, which contrasts sharply with the higher autonomy characteristic of U.S. private firms [004].

2.1.2. The Space Dream

In November of 2012, Xi Jinping, the General Secretary of the Chinese Communist Party (CCP) within the People’s Republic of China (PRC), promoted the phrase the “Chinese Dream” which focused on the rejuvenation of China with a long-term goal to become a fully developed great power by 2049. In June of 2013, merely three months after assuming office as the President of the PRC, Xi announced that China was ready to take “great steps” towards growing its space exploration following the success of various Chinese manned missions [005]. He further coined the “Space Dream,” a subordinate to the “Chinese Dream”, in which he laid out the importance of

Chinese dominance in the space domain to Chinese rejuvenation and stated that "the Space Dream is an important component of the dream of [becoming] a strong country" [006].

At the time, China was considered a "partial space power" as its growing space capabilities had not evolved into a "comprehensive influence" amid the global sphere [007]. As it became clear that Chinese prominence in the global space sector would be a "critical component" to achieving the Chinese Dream, the CCP spearheaded efforts to advance the country's position in space [006].

Accordingly, in the mid-2010's, Chinese focus expanded on space in all sectors, commercially, militarily, and scientifically. In 2014, China's milestone shift to open the commercial sector through the China National Development and Reform Commission's (NDRC) "The State Council's Guidelines on Investment and Financing Mechanism Encouraging Social Investment in Innovation and Key Areas", commonly known as "Document 60," triggered a rush of new private space companies and investment, designating space as a domain for civil innovation, and spurring Chinese firms to develop new technologies for the space industry [008]. The following year in 2015, China established the Strategic Support Force focusing on space, cyber, and electronic warfare under the People's Liberation Army (PLA) [009]. It has since been reorganized into the further specialized units of the PLA Aerospace Force, PLA Cyberspace Force, and PLA Information Support Force as of April 2024 to streamline command, improve joint operations, and provide modern agility. One year later in 2016, China released its space-focused, recurring 5-year white paper "China's Space Activities in 2016": which updated progress and set out national priorities for space science, technology, infrastructure, and applications [010].

This paved the way for the PRC to release its first national-level, long-term plan for space science in October, 2024. The document, *The Mid-to-Long Term Plan for Space Science Development (2024-2050)*, set the goal for China to become a global leader in space science by 2050, and was coauthored by the China National Space Administration (CNSA), the China Manned Space Agency (CMSA), and the Chinese Academy of Sciences (CAS) [011]. The *Mid-to-Long Term Plan* highlights three phases in which Chinese space supremacy will be reached:

- **Phase One: Up to 2027**
  - Focuses on progressing scientific research and science development to advance China's international standing and impact in space science
  - Aims to implement 5-8 space science missions; 2-3 large missions achieving landmark results
- **Phase Two: 2028-2035**
  - Focuses on obtaining a top global ranking with key research areas to become one of the world's most innovative countries
  - Seeks to have China be among the top nations for strategic and leading talent, providing the nation a comparative advantage in space science talent
  - Aims to implement 15 space science missions, including 4-5 large missions that will explore scientific frontiers
- **Phase Three: 2036-2050**
  - Focuses on becoming an international leader in key areas and a major power for space science
  - Seeks to lead global space science advancements, and a hub of global space science
  - Aims to implement 30 space science missions

This plan demonstrates the expansion of Chinese ambition for space power and is accompanied by recurring white papers released every five years to illustrate the progress of the Chinese space program towards achieving those goals. China has progressed from establishing rudimentary space capabilities in the early 2000s to currently focusing on advanced projects such as deep space exploration and ensuring "space asset security, commercial launch sites, and building up its space stations" to improve Chinese space defense alongside advancing space exploration [011].

The *14th Five-Year Plan (FYP) for Economic and Social Development and Long-range Objectives Through the Year 2035 of the People's Republic of China*, passed by the Chinese parliament in March 2021, is the most recent recurring report of goals to strengthen the national economy from 2021-2025. Additionally, the FYP includes a section on long-range objectives for 2035, which differentiates it from previous plans. The FYP includes multiple mentions of science and technology (S&T) development and innovation relevant to the space industry including manned spaceflight, lunar exploration, aerospace technology, deep space exploration and research, ground-based space infrastructure, BeiDou industrialization and commercialization, quantum technology, fifth-generation (5G) deployment, and a space infrastructure system that features communications, navigation and RS. Notably, the FYP stresses the deepening of military-civilian S&T collaboration and innovation for varying fields—including the aerospace sector [012]. Per the figure below, the time period between 2012-2024 has resulted in massive doctrinal and policy shifts with direct implications and impact for Chinese aerospace domestically and internationally.

Figure 1: Timeline of Policy & Doctrine Shifts

Source: ASU/CSF

Year	Policy & Doctrine Shift	Impact in Simple Terms
2012	"China Dream" campaign	Raised the status of space as a symbol of national pride and global ambition.
2013	Belt and Road Initiative (BRI) launched	Expanded China's economic and strategic influence by developing infrastructure, trade, and connectivity across Asia, Africa, Europe, & beyond
2014	NDRC issued "Document 60".	Triggered a rush of new private space companies and investment.
2014	Space Information Corridor (SIC), also known as the Space Silk Road, is initiated	Initiated as the space component of the BRI, integrates satellite networks with BRI regions, providing RS/comms/satnav for participants. Also builds overseas ground stations/space centers to link to China.
2015	PLA Strategic Support Force (PLASSF) founded	Militarized and centralized China's space and cyber operations for national defense.
2016	Space White Paper (China's 4th space-specific FYP)	Stated plans for deep space, satellites, civil-military fusion, international cooperation, and strengthening space infrastructure & innovation
2021	14th FYP	Outlined clear milestones for achievements up to 2035, giving industry clear direction.
2022	Known as the 2021 Space White Paper: A Perspective (China's 5th space FYP)	First time openly voiced space leadership ambition, drive toward self-sufficiency, and positioning commercial space development and private innovation as imperative.
2024	"Mid-to-Long Term Plan for Space Science Development" (phased to 2027 >2035 >2050)	Set phased S&T innovation goals, guiding research and investment.
2024	National plenary sessions make space a "strategic emerging sector"	Made space a government priority for national security and economic growth, anchoring resources and focus.
2024	PLASSF reorganized into 3 separate focused units	Now PLA Aerospace Force, PLA Cyberspace Force, and PLA Information Support Force; Specialized and empowers the units further
2049	Critical Target: to be a "Fully developed Great power" (this is the centenary of PRC)	Space capability seen as essential pillar of global power status; all major programs, space included, align to this target.

2.2. Regulatory & Funding Shifts

2.2.1. Inflection Points

There are a number of important regulatory and funding inflection points that China induced in the last decade or so. In 2014, China officially opened the space sector to private capital by designating space a domain for civil innovation, leading Chinese companies to develop technology for the space sector. At the end of 2020, China reportedly had over 160 commercial space companies, with at least 25 actively developing new launch vehicles, marking unprecedented growth for the nation's space sector in areas such as satellite manufacturing, propulsion, and launch [013]. From there, investment only grew. Estimates from Orbital Gateway Consulting data suggest China's commercial aerospace sector saw significant investment jumps in 2018, 2019, 2020, 2022, and 2024. In 2015, just after the inflection point, investment from all funding sources into the commercial sector totaled $340 million. As seen in Figure 3, by 2020 it increased nearly five-fold to $1.685 billion, and just last year in 2024 nearly doubled again at $2.860 billion [014].

During the 2024 *Two Sessions*, the annual plenary sessions of the National People's Congress and the National Committee of the Chinese People's Political Consultative Conference, the PRC officially classified commercial space as a "strategic emerging sector" which incentivized local governments to provide industrial support to the space sector [015]. Targeted funding, infrastructure investments, and tax incentives have since been used to support private and state-owned enterprises (SOEs) in the space industry to support and expand Chinese advancements in space. The investment data reflects city and provincial governments fulfilling that call with over 50 percent of all funding into the commercial sector coming from local governments last year and so far in 2025. Furthermore, Orbital Gateway Consulting data shows that through the entire decadal boom, local government investment in China has always comprised at least 30 percent of total funding, with the smallest historical proportional funding source being the central government. These trends are illustrated in Figure 2 [014].

2.2.2. Innovation Drivers

The majority of space-related policy documents and speeches produced by the Chinese government maintain the following themes as means to drive innovation: space sector self-reliance, diplomacy, international leadership and prestige, and overcoming space-environmental challenges through technological and scientific advancements [016].

Notably, the Chinese military plays "a key role in driving space development" and innovation, as "space power in CCP thinking cannot be separated from military power"[017] [006]. The inherent dual-use nature of space technology combined with President Xi's emphasis on space as additional means to achieve military modernization further incentivizes Chinese innovation within the space sector as an accessory to militaristic advancement. This is demonstrated in the PLA's 2013 *Science of Military Strategy*, its 2020 *Science of Military Strategy*, and China's 2019 Defense White Paper, all highlighting the space domain as being the next domain of modern warfare. This was also echoed by Wu Yansheng, President and Chairman of the state-owned China Aerospace Science and Technology Corporation (CASC), which is the primary contractor of China's space program, stating in 2022 that CASC's work in outer space will aid in achieving China's "chief responsibility of strengthening [its] military" [018].

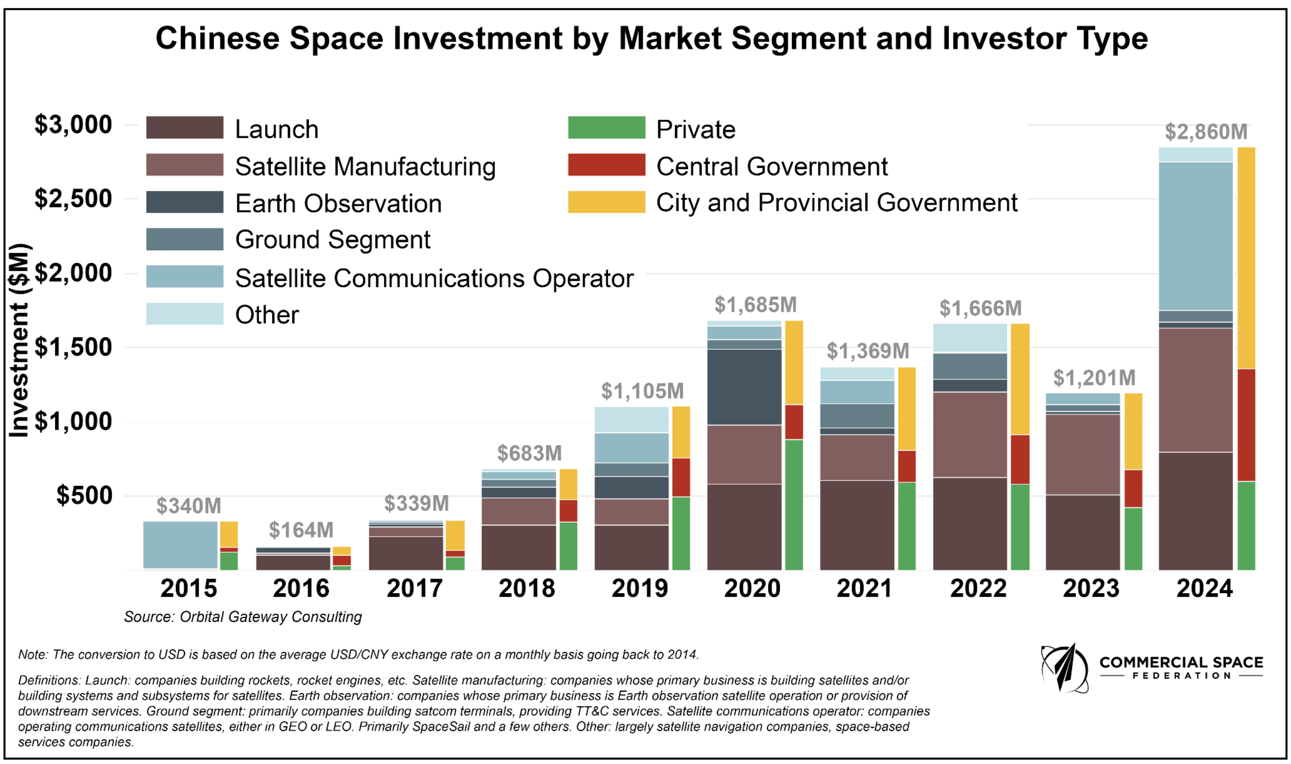
2.2.3. Investment Trends

China's aerospace market is experiencing expansion as a direct result of government-backed initiatives to increase investments in defense, satellite technology, and civil aviation [015]. In 2014, approximately 54% of funding for the Chinese space industry derived from private funding sources, with central government sources and city and provincial government sources accounting for 22 percent each. In 2024, 53 percent of funding came from city and provincial government sources, 26 percent from central government sources, and 21 percent from private sources [014], indicating a growth in the perceived importance of the Chinese space industry from a local government perspective. Per Orbital Gateway Consulting's distinctions above, we can understand investment into the Chinese space industry as going into six different segments or verticals:

1. **Launch** — Companies building rockets and rocket engines.
2. **Satellite Manufacturing** — Companies building satellites, satellite systems, or subsystems.
3. **Earth Observation (EO)** — Companies operating EO satellites or providing downstream services.
4. **Ground Segment** — Companies building satcom terminals or providing TT&C services.
5. **Satellite Communications operator** — Companies operating communications satellites
6. **Other** — Primarily Companies providing satellite navigation services or space-based services.

Figure 2: Chinese Commercial Space Investment by Market Segment and Investor Type

Source: Orbital Gateway Consulting



In 2024, the sector which received the most funding was the Satellite Communications Operator sector at $1.001 billion, a significant increase from the $85.71 million investment in 2023. Launch and Satellite Manufacturing received high funding as well, both having been the top-two funded sectors from 2021-2023 [014]. As China seeks to expand its space economy and maintain a global lead on space technology, strong investments from the government and private funders into the aerospace market are likely to continue.

2.3. Domestic Affairs

2.3.1. Distribution & Innovation Hubs

China’s aerospace and commercial space sectors are regionally concentrated in economically strategic areas, where development is shaped by an integrated ecosystem of local governments, universities, SOEs, and private firms. This reflects a “triple helix” model of innovation—uniting academic excellence, industrial capacity, and state policy to accelerate space-sector growth.

One commercial Chinese company, ADA Space “Three-Body Computing Constellation” is a vivid example of the triple helix model, bringing together government (Zhejiang Lab, run by the province), academia (Zhejiang University), and joint industry support (Alibaba, HiStarlink's laser comms terminals, Emposat's TT&C services, Soonion's navigation and payload products) to develop in-space computing and laser communication capabilities. This consortium recently launched the first 12 of a planned 2,800 satellites, enabling real-time EO data processing and downlink. Per figure 3, some of the largest Chinese innovation hubs within the space sector are as follows [020].

Civil

Beijing: Beijing is the epicenter of aerospace development within China, acting as the nation’s space policy, technology and intellectual hub. It is home to the CNSA, which coordinates most government-led space programs within China, and the CASC. Beijing is prioritizing space S&T research, spearheading the growth of China’s aerospace sector. Within Beijing, two distinct geographic clusters have historically anchored the country’s space activities. In the northwest, CAST, or CASC’s 5th Academy, focuses on building satellites, crewed spacecraft, and operating astronaut training facilities. In the southeast, China Academy of Launch Vehicle Technology (CALT), or CASC’s 1st Academy, is the primary center for rocket development.

Shanghai: Shanghai focuses primarily on the development of space vehicles and satellite communications and RS. It is home to the Shanghai Academy of Spaceflight Technology (SAST), a subsidiary of CASC that supports satellite development and technologies and integrates the Long March (LM) 2, 4, 6, and 8 rockets [021].

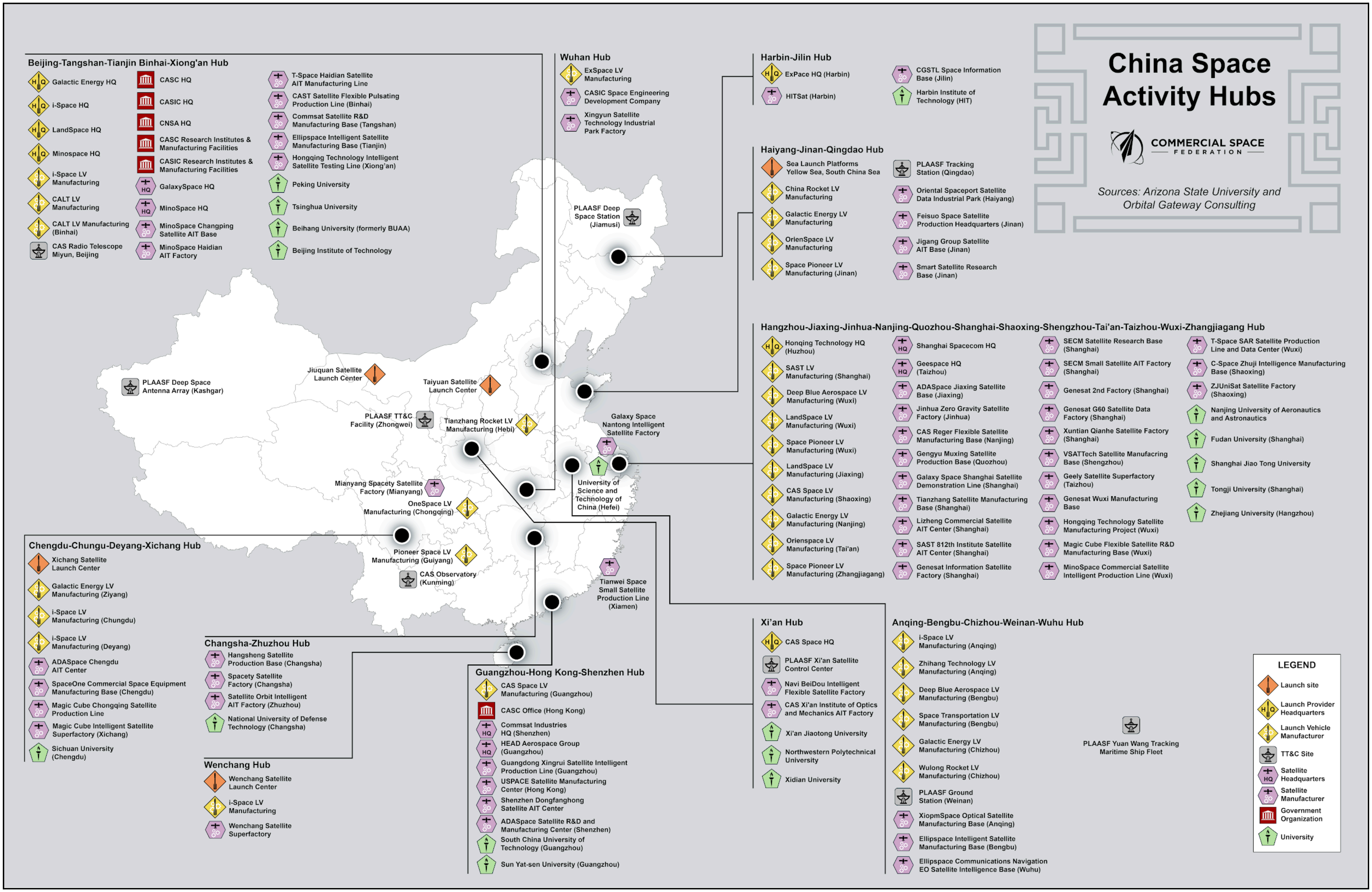
Xi’an: A center of space research and development, Xi’an is recognized as one of the primary aerospace hubs of China [022]. It is home to both the Xi'an Satellite Control Center, the primary satellite control facility of China and the CAST Xi'an Institute of Space Radio Technology, a subsidiary of CAST within CASC [023]. This Institute is the primary satellite payload provider in China and supports the majority of Chinese satcom satellite missions [024]. Xi’an is also a center for rocket development, being home to CASC 4th and 6th Academies of Solid and Liquid Propulsion Technologies, respectively.

Private

Beijing: Beijing is home to approximately 200 commercial space companies by some reports, primarily within the Haidian District. It is the goal of Haidian to develop a space ecosystem of ¥100 billion CNY ($13.9 billion USD) [015]. Leading Chinese state-backed firms such as China SatNet are located around Beijing. A similar commercial sector spatial divide is emerging in Beijing to the civil divide; many private rocket companies are clustering in the southeast near CALT, while satellite manufacturers are gravitating toward the northwest near CAST.

Figure 3: Summary Map of Chinese Space Activity Hubs

Source: ASU/CSF and Orbital Gateway Consulting (manufacturers data)



Shanghai: Shanghai's dedicated commercial space action plan is focused on the integration of private-sector satellite development as well as future launch vehicle development. Its Jiangsu province is focusing on commercial space as a future industry, encouraging tax incentives for growth.

Wenchang: Wenchang, within the Hainan province, is home to the Wenchang Spaceport and China's first commercial spacecraft launch site. It aims to assist in accelerating rocket and satellite industries, while also promoting "the establishment of commercial space development regulations" for trade ports in China [025]. Wenchang is quickly becoming a commercial space hub and seeks to continue its growth.

Wuxi: Wuxi is attracting commercial space development. With the implementation of new policies on June 13, 2024, to "foster commercial space, focusing on commercial rockets, satellite manufacturing and space applications," private companies such as MinoSpace, HiStarlink, AZSpace and Orienspace are potentially transforming Wuxi to a hub for "advanced satellite technology and manufacturing" [026].

Industrial Base

Xi'an: Xi'an is home to the Xi'an National Civil Aviation Aerospace Industrial Base, centered around an industrial aerospace planning strategy which is focused on three aerospace industrial zones and ten industrial parks. In 2023, the Industrial Base introduced 260 unique enterprises with varying characteristics to support the commercialization of scientific and technological developments [027].

Chengdu: Chengdu is an emerging hub for satellite components. It is home to Aotian Technology's manufacturing base for commercial satellite components, with a focus on electric propulsion and orbit maintenance systems. Chengdu's satellite internet and application industries generated approximately 17.3 billion renminbi (RMB, approximately $2.4 billion) in 2023, an increase of over 50% in just one year [028].

Academic

Beijing: Beijing is an academic center, home to a multitude of academic institutions with focuses on space research. Some inclusions are Tsinghua University and Peking University, both C9 schools that are an approximation to American Ivy League universities. Top aerospace-oriented schools Beihang University (formerly BUAA) and Beijing Institute of Tracking and Telemetry Technology (BITTT) are also in the metropolitan area. CAST also resides in Beijing, the leading force in China's space industry, and has a multitude of subsidiaries such as the Beijing Institute of Space Mechanics and Electricity and the Institute of Remote Sensing Satellites [029].

Shanghai & Wider Metro Area: Fudan University and Shanghai Jiao Tong University are both in the C9 League, with Shanghai Jiao Tong also having a major aerospace program. Meanwhile Nanjing University, University of Science and Technology of China (Hefei), and Zhejiang University (Hangzhou) are all C9 League schools in the provinces just west of Shanghai.

Harbin: Harbin Institute of Technology, in the country's northeast is a C9 League university and highly aerospace-focused. A leading center for engineering talent and aerospace innovation, Harbin is nationally recognized for its cutting-edge scientific and technical programs [030].

Xi'an: Residing in the Northwestern province of Shaanxi, Xi'an Jiaotong University and Northwestern Polytechnical University are premier research institutions, renowned for aerospace engineering and just 12 km apart, forming a strategic academic cluster adjacent to China's national TT&C center.

CASC vs. CASIC

China's space ecosystem features a growing institutional competition between two major SOEs: the CASC and the China Aerospace Science and Industry Corporation (CASIC). Both entities, fully owned by the state, operate across overlapping domains in space and defense industries [031].

CASIC has been channeling resources into developing regional aerospace hubs outside Beijing, notably the Wuhan National Aerospace Industry Base. This move is seen as a commercial strategy to benefit from lower costs and a less congested regulatory environment compared to the capital [032]. Wuhan's base, initiated in 2017, has achieved an annual production capacity of up to 50 rockets and has built the backbone of an industry supply chain encompassing satellites, rockets, cloud platforms, and aerospace materials.

In terms of workforce, CASIC employs over 150,000 individuals focusing on aeronautics and military technologies, while CASC has a slightly larger workforce at 180,000 individuals emphasizing space launch and satellite programs [033]. Historically, these two organizations were part of the same structure until their separation in 1999 aimed at fostering internal competition. Despite this rivalry, CASC and CASIC often collaborate on various projects within and beyond the space sector.

2.3.2. Dual Use Technology

Space technology almost always has military and civilian applications, regardless of the nation from which they originate [034]. The inherent dual-use nature of space capabilities is reflected in the bulk of Chinese space operations. The Chinese BeiDou Navigation system, for example, demonstrates the “overlapping military-civilian nature of China’s space programs.” While it does have a large commercial and civil value, its creation was intended to avoid dependence on the U.S. military-operated Global Positioning System (GPS) [035]. China has continued advancing its direct-ascent anti-satellite (ASAT) capabilities—having conducted multiple tests since the widely condemned 2007 satellite destruction—while now focusing on non-destructive demonstrations and dual-use satellite operations, including sophisticated on-orbit maneuvers and technology tests that could serve both civilian and counterspace missions. Compared to traditional kinetic-kill ASAT weapons, co-orbital ASATs offer operational advantages: they minimize space debris, lower the risk of uncontrolled escalation, and can often be presented as benign or dual-use assets, making them harder to attribute or constrain [034] [035].

Doctrinal sentiment implying a focus on outer space as the future of Chinese warfare, combined with space-based systems being utilized for militaristic purposes indicates some level of militaristic adversarial nature from China’s space program. As the geopolitical climate has become increasingly competitive, particularly between China and the United States, international concern about China’s progress in developing such dual-use capabilities is not unexpected.

While it would be incorrect to say every space activity undertaken by China has militaristic intent, it is not unreasonable to assume that *some* of them do. This can further be understood in the context of the PLA having announced in 2024 a “major reorganization that elevates the importance of space, cyber, and information capabilities and creates three new forces under the more direct control of top military leadership, led by Xi” [036]. Some spacecraft within the Tongxin Jishu Shiyan satellite series have been presumed to have missions acting as a cover for military purposes [037]. Similarly, the Shijian (meaning “practice”) satellite series, while seemingly engaging in purely civilian activities, are likely employing disguised military satellites as well, as indicated by their secrecy, payload sizes, and orbital characteristics [035]. In fact, all of China’s satellite launch centers are controlled by the Chinese military and are part of the PLA’s Aerospace Force organizational structure.

2.3.3. Public Perception

Historically, China's space program has been heavily focused on influencing perceptions, both of its citizens and of the rest of the world [038]. Prestige and power obtained through meeting space-related objectives produces national pride alongside international status. Correspondingly, in alignment with the wide expansion of space activities, China seeks to maintain a positive perception of its financial investments into the aerospace sector for its citizens. Methods of doing so include the celebration of taikonauts as heroes through parades and consistent features in Chinese media, as well as the creation of China Space Day as a national holiday to celebrate the Chinese space program [039] [040] [041].

The general consensus of the Chinese population indicates a high level of public support for state-led space endeavors. In a 2020 study undertaken by the U.S. Air War College, stratified sampling was used to match the demographic of the Chinese online population through an online survey [042]. Participants were asked about their views on if human spaceflight, lunar missions, and Mars missions were worth the current investments. The results for each category demonstrated that despite the steep costs of the aerospace sectors, an overwhelming majority of Chinese citizens support China's space endeavors.

Figure 4: Comparative Similar Public Polls on Support of Space Endeavors

*Source A: Poll of Chinese Citizens (U.S. Air War College, via *novel technique; 2020)* [042]

Source B: Poll of Americans (CBS News/YouGov; June 2025) [043]

(A) Are the costs of our human spaceflight program justified?		**(B)** Does the U.S. Space Program contribute to national pride & patriotism?	
They are justified	**68.2%**	A lot	**29%**
They are not justified	11.34%	Some	**44%**
No opinion	20.24%	Not much / None	27%
		Does the U.S. Space Program contribute to scientific advances for all Americans?	
		A lot	**33%**
		Some	**44%**
		Not much / None	23%
Do you support sending a taikonaut to the moon?		Do you support the U.S. sending astronauts to the moon again?	
Yes	**94.94%**	Favor	**67%**
No	5.061%	Oppose	33%
Is our lunar program a good investment?			
A good investment	**78.61%**		
Not a good investment	9.717%		
No answer	11.67%		
Is our Mars program a good investment?		Do you support the U.S. sending astronauts to explore Mars?	
A good investment	**75.78%**	Favor	**65%**
Not a good investment	11.74%	Oppose	35%
No answer	12.48%		

Furthermore, when asked to rank on a scale of 1-5, with 1 being completely disagree and 5 being completely agree, if it is essential for China to become a leader in space, the participants showed a similarly high level of support. Approximately 37 percent of participants selected 4, and 50 percent selected 5, leaving only 13 percent of participants choosing between 1-3. While not all encompassing, this study demonstrates a trend of Chinese citizens having a favorable opinion of state-led space initiatives. The inclination towards China's advancement into becoming a space-leader implies “considerable support” could be found by the Chinese population for further investments into the aerospace sector to obtain and maintain such dominance.

These results, portrayed in the above table sourced from the U.S. Air War College, CBS News, and YouGov, demonstrates a larger percentage of support for the Chinese national space program by Chinese citizens in comparison to that of American citizens for the American national space program. While both groups surveyed showcase a higher percentage of support for their respective nations, Chinese support for investment into human spaceflight, lunar, and Martian programs is higher than that of Americans. This indicates state-led Chinese actions in outer space are a larger source of pride for Chinese citizens

2.4. Foreign Affairs

2.4.1. Diplomatic Power

The geopolitical divide between the ideological "west" (the U.S. and its allies) and "east" (China and its allies) in relation to space has never been deeper. Russia has strengthened its space-related cooperation with China due to both nations opposing an "American-led world order" in space [044]. This indicates a clear shift in the way space is viewed internationally and showcases increasing tensions between two different ideological sides.

Further demonstrating this divide is the Chinese-led 2021 Memorandum of Understanding (MOU) regarding Cooperation for the Construction of the International Lunar Research Station (ILRS), in which Russia and China jointly declared their intent to build a fully operational research station on the Moon by 2035. Although the Artemis Accords are grounded in the principles of the Outer Space Treaty (OST), which China has ratified, Chinese authorities have opted not to join, citing concerns that provisions—such as those regarding resource extraction and safety zones—may expand beyond the Treaty's existing framework and unduly favor U.S. governance approaches. Chinese state media frequently vilifies the Accords as a vehicle for American hegemonic leadership in space and have therefore prioritized alternative initiatives like the ILRS. In partnership with Russia, the MOU has now been signed by 11 other nations as of June 2025: Venezuela, Belarus, Pakistan, Azerbaijan, South Africa, Egypt, Nicaragua, Thailand, Serbia, Kazakhstan, and Senegal [045].

Furthermore, China has been able to capitalize on the U.S.'s inability to commit financial assistance to developing nations' space enterprises, priming these developing nations for "opaque and predatory Chinese dealings that undermine the sovereignty of host nations." This leaves the door open for China to engage in international cooperation with Latin American, Asian, and African nations, commonly through the provision of launch services and the aiding of satellite development [046]. For example, China paid for $6 million out of the $8 million required to construct Ethiopia's first satellite, which China then launched in 2019 [047]. China has also constructed a militaristic space facility in Argentina [048] [049].

China's role as a key supporter of developing nations seeking access to space clearly serves its own geopolitical interests. Countries that gain space capabilities through China may be more likely to align with its strategic goals in space.

2.4.2. The Belt and Road Initiative (BRI)

Chinese investment in international space projects is emblematic of a broader strategy developed by China to build out infrastructure for developing nations across the globe under their Belt and Road Initiative (BRI). In 2013, Xi announced the BRI, sometimes known as the New Silk Road. BRI is a global infrastructure strategy employed by China to broaden its economic and political influence through development and investment initiatives. The criteria for what qualifies as an official BRI project is unclear. With no defined standard for BRI projects, the ambiguity allows for initially unrelated projects to be claimed as part of the BRI following their completion. The "loose, ever-expanding nature" of the BRI allows for it to be all-encompassing when need be, and overexaggerated in scope [050]. Notably, projects started before the launch of the BRI in 2013 are commonly counted as BRI projects today. For instance, the Laos-China railway, intended to create a link between Vientiane, capital of Laos and the Yunnan province's capital Kunming, was launched in 2011. The project was derived from a 1990s plan to connect all mainland Southeast Asian countries with China by railway, but has been retroactively associated with the BRI [051].

By definition, the BRI is a "tool of strategic ambiguity," intentionally left undefined to create a structure in which China can claim any project as being within the BRI [052]. With 147 nations signed onto or indicating interest in BRI projects as of February 2023, it is clear that the Chinese sphere of influence is growing, with the initiative impacting roughly two-thirds of the human population [053] [054]. This growth of influence provides China with political leverage. Often, Chinese contracts signed with foreign governments position Chinese lenders as "preferred creditors" and give lenders discretion to cancel loans or demand full loan repayment ahead of an initially planned schedule [053]. As BRI countries engage in contracts with Chinese lenders for technological and development initiatives, the limitations given to the borrower countries may encourage Chinese policy influence to be projected onto borrowers.

2.4.3. The Space Information Corridor (SIC): The "Space Silk Road"

In tandem with the China Great Wall Industry Corporation (CGWIC), the BRI is being utilized to promote Chinese space cooperation with other nations in order to build "a new world space order" [055]. In 2015, China added the "Space Information Corridor" (SIC) to the BRI, also known as the "Space Silk Road", which consists of Chinese space exports, such as RS, satellite communications, and navigation applications. While the initiatives of the Space Silk Road are loosely defined, a 2016 white paper produced by China's Information Office of the State Council defines the vision of China's space industry as being used to "build China into a space power" and "provide strong support for the realization of the Chinese Dream of the renewal of the Chinese nation" among other goals [010].

What is the Space Silk Road? — The SIC, or Space Silk Road,is Beijing's orbital extension of the BRI, echoing the CCP's strategy to export surplus capacity, proliferate technical standards, and deepen foreign reliance on Chinese infrastructure. It intersects core U.S. national security concerns; expanding commercial space activity, diplomatic and tech alignment with China, and long-term geoeconomic rivalry. As global systems enter the Fourth Industrial Revolution, driven by seamless real-time data exchange, China's bundling of satellite exports with proprietary software and ground systems could be tightening its grip on the digital future of developing nations.

The SIC mirrors the BRI's broad objectives of advancing cooperation, aligning national strategies, leveraging complementary strengths, and fostering coordinated development. Its more targeted "four-in-one" model seeks to unify sensing, transmission, knowledge, and utility across digital and orbital platforms. Chinese officials emphasize cooperation across policy, infrastructure, and applications, creating pathways for state-backed firms to export excess capacity into foreign markets.

What Assets are Involved? — Chinese satellite constellation coverage already thoroughly spans the Eastern Hemisphere, and Beijing actively promotes both access to their services and sales of systems to BRI nations. This dual offering extends to RS systems like Fengyun and Gaofen that deliver meteorological and agricultural data, while China exports satellites such as Pakistan's PRSS-1 and Venezuela's VRSS-2. China's BeiDou navigation system, now boasting over 45 satellites—more than GPS, GLONASS, or Galileo—is a cornerstone of China's outreach in many countries including Algeria, Pakistan, and Cambodia [056]. Beyond scale, China's edge lies in affordability and bundled service access, positioning it as a compelling partner for emerging space users. Commercial companies are leading some of the efforts now in 2025 with nascent broadband megaconstallation operator, SpaceSail, signing MOUs with Brazil, Malaysia, and Thailand, and setting up a subsidiary in Kazakhstan. Meanwhile, in-space computing company, ADA Space, recently welcomed delegations from UAE and Malaysia to China to discuss partnership and utilization of ADA Space's in-space computing constellation [057].

What Mechanics are Involved in Projects? — China has become one of the world's largest launchers of space technology. From 1990 to June 2023, China launched approximately 77 satellites for foreign customers and delivered 17 satellites on-orbit to foreign customers due to its "dedicated space export promotion agency, generous financing, and clear political and regulatory support" [055]. While China does not directly ship completed satellites from China to other nations to be launched on foreign rockets, their deliverance of satellites on-orbit is of great note in building diplomatic relations with other nations.

Chinese space launches and deliveries have been managed by the CASC subsidiary, CGWIC, since 1980. Based in Beijing, it is the "sole commercial organization authorized by the Chinese government to provide commercial launch services, satellite systems and to carry out space technology cooperation" [058]. Operationally, CGWIC is the point of contact for the buyer of specific space goods through interactions with Chinese organizations as needed to fulfill contract requirements. Unlike other exporters, the CGWIC is permitted through the government to represent any Chinese entity relevant to space exports, increasing its negotiation power. As of 2007, services sold by the CGWIC include: Launch services, Ground infrastructure, Satellites, Training, Financing, Operations support, and Insurance [055]. Through the CGWIC, China has become a major satellite deliverer and launching state around the globe. The nation's ascension in this realm can largely be attributed to three major factors [055]:

1. The CGWIC promotes Chinese space products through overseas offices
2. The CGWIC claims "no obstacles" in receiving governmental approval of exports
3. The Chinese government offers preferential financing, including loans and grants

Nations which purchase space capabilities from China may develop a technical reliance on China, in which China will remain involved in the maintenance and operations of sold satellites and/or by which China's provision of space services could be discontinued if customer nations do not comply with Chinese interests. When China delivers satellites, it also delivers ground stations built by the BITTT or installs new infrastructure at existing satellite ground stations. Following a satellite launch, CAST engineers operate the delivered satellite to ensure functionality and are expected to return controls to local operators. However, CAST engineers often remain in these ground stations as China offers operational support services due to the following reasons [055]:

1. To provide operational support services for the expected lifespan of the launched satellites
2. To provide ground station repairs
3. To train local engineers to conduct satellite operations

What Operators are Involved? — Over 80 projects have been linked or bundled into the SIC since 2000, concentrated in South and Southeast Asia, Africa, and Latin America. Many have been highly successful, primarily satellite manufacturing deals involving major Chinese SOEs like CALT and CAST, often arranged through CGWIC [059]. Some past projects have stalled or failed. But numerous projects small and large remain ongoing, involving countries like Pakistan and Egypt, plus scattered partnerships in Argentina, South Africa, and Turkey. Brazil and Cambodia rank among the most active participants according to Orbital Gateway Consulting data from 2022.

The scope of a project's official inclusion under SIC appears elastic—by some accounts even encompassing North American entities under affiliated project listings [059]. Thus, some actors may not recognize their involvement on a project as falling into this SIC umbrella. One account reportedly involved a Singapore subsidiary of a U.S.-based firm that interacted with Chinese startup Emposat (known at the time as Satellite Herd) around data-security-as-a-service [059] [060]. Emposat, as an example, has been active since 2016 and is a

Figure 5: Chinese-exported Satellites Involving Follow-on Ground Stations & Engineers

Source: Georgetown University/China Aerospace Studies Institute [055]

Country	Satellite	City
Algeria	ALCOMSAT-1	Bouchaoui
Algeria	ALCOMSAT-1	Boughezoul
Belarus	Belintersat-1	Minsk
Bolivia	TKSAT-1	La Paz
Bolivia	TKSAT-1	La Guardia
Ethiopia	ET-Smart-RSS	Addis Ababa
Indonesia	Palapa-N1	Jakarta
Indonesia	Palapa-N1	Surabaya
Indonesia	Palapa-N1	Medan
Laos	Laosat-1	Vientiane
Nigeria	NIGCOMSAT-1, 1R	Abuja
Pakistan	PAKSAT-1R	Lahore
Pakistan	PAKSAT-1R	Karachi
Pakistan	PRSS	Karachi
Pakistan	PRSS	Islamabad
Venezuela	VENESAT, VRSS	Bamari
Venezuela	VENESAT	Luepa

venture-backed company rather than a state-owned entity. Perspective on a number of these SIC projects has been illuminated by Orbital Gateway Consulting data that suggests most SIC-linked clients are national governments or agencies lacking their own satellite capabilities, though some commercial firms and academic institutions also appear. Notably, seven such projects—including launches and ground stations—were completed during the COVID-19 pandemic [059] .

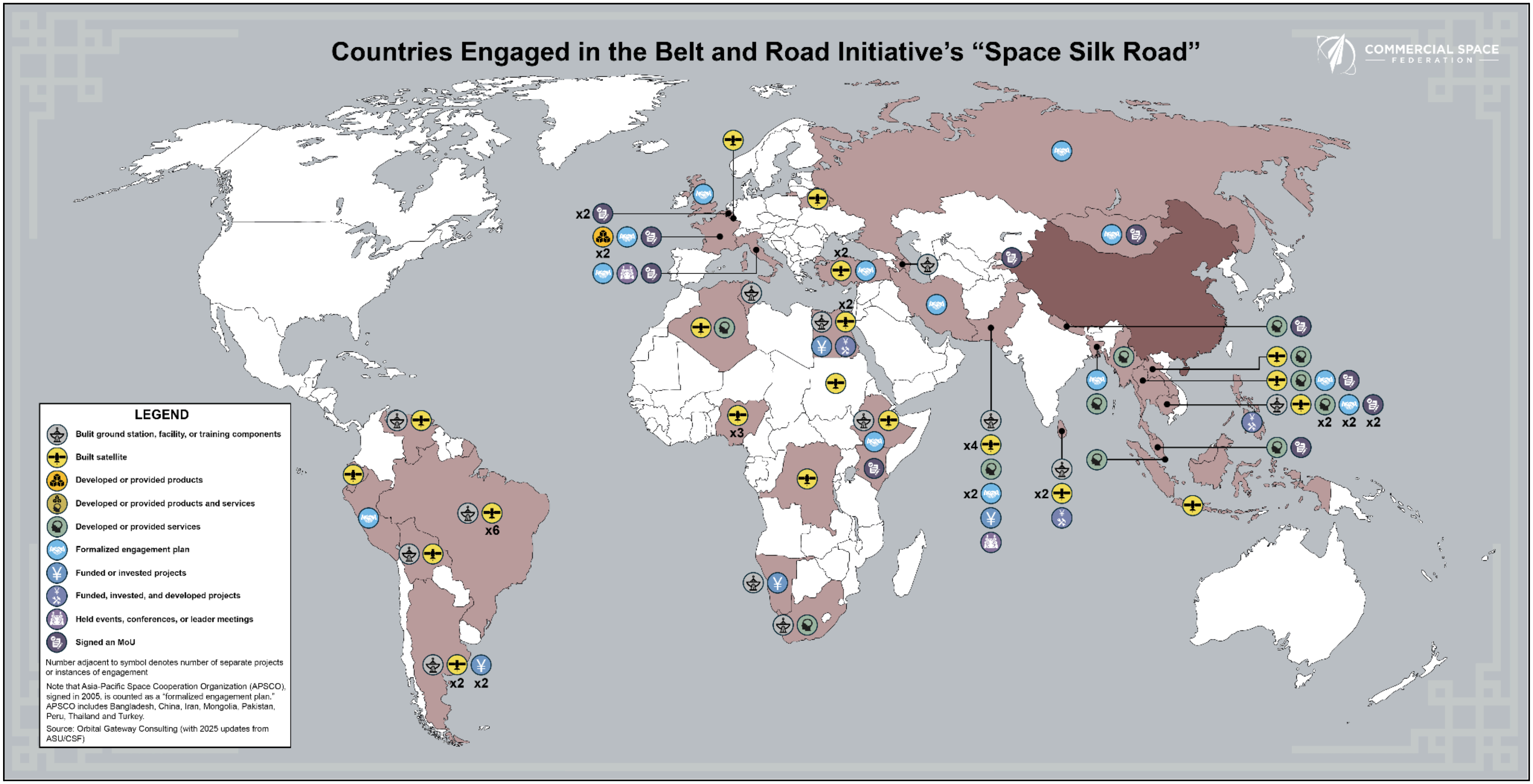
Orbital Gateway Consulting's analysis confirms that China is investing heavily in tech infrastructure across BRI nations, with SIC-linked telecom projects extending into Western Europe and South America [059]. While multilateralism is often invoked in Chinese rhetoric, all SIC activities have been bilateral, led by Chinese SOEs or other entities offering turnkey systems. Multiple projects have failed or been left incomplete, and the strategic value of a few of those operational remains ambiguous [059]. A central concern is dependency: recipient nations often risk long-term reliance on China for system maintenance and updates. Of the 35 or more Chinese firms tied to SIC exports, ten were under U.S. sanctions as recent as 2022—including ZTE, Huawei, and multiple CASC and CASIC subsidiaries—highlighting the PLA affiliations and political risks embedded in these partnerships.

What Supporting Entities are Involved? — China's space outreach is supported not only by its SOEs but also by institutions like the Asia-Pacific Space Cooperation Organization (APSCO) and the Asian Infrastructure Investment Bank (AIIB). Though APSCO presents itself as an international body—with members such as Iran, Peru, and Mongolia, and observers including Mexico—its relevance is unclear with no meaningful web presence or landing page for some time. More consequential is the AIIB, where China holds a 30 percent voting stake and effective veto power. While the AIIB presents itself as a multilateral institution with senior level international staff and membership, former insiders have alleged it still operates under implicit CCP control [061]. About a third of AIIB loans support BRI-linked projects. Complementing this, the Silk Road Fund operates as a state-owned equity investor, with notable stakes in energy ventures across Africa and Pakistan.

China's 14th FYP emphasizes reframing the BRI to counter criticism of exploitative or opaque practices. This narrative shift extends to the space sector as well. SIC-related projects are poised to grow as Beijing streamlines directives for commercial and state-owned space actors and better aligns infrastructure with emerging demand. For partner nations, however, the central risk remains: entrenching Chinese political and technical

Figure 6: Countries Engaged in the Belt and Road Initiatives's "Space Silk Road"

Source: Orbital Gateway Consulting (with 2022-2025 updates from ASU/CSF) [059]



systems in national infrastructure over the long term and vulnerability to China's industrial overcapacity

Select Project Updates — As of mid-2023, 147 countries had joined China's BRI, including nearly all of Sub-Saharan Africa and 18 European Union (EU) member states. Yet the depth and timing of participation—especially in space-sector projects under the SIC—remain poorly defined. AEI's China Global Investment Tracker lists eight space-related BRI investments under their portal since 2013 (searchable with "aero", "space", "launch", and other keywords). The countries involved are Argentina twice, Nigeria, South Korea, France, Thailand, Luxembourg, and Bolivia and the listed investor/builder are all military-linked SOE's; CASC, CASIC, or CAS. While limited public detail on outcomes is provided, each project tracks expectedly to BRI activities in technology or transport sectors and is categorized as either investment or construction [062]. Fragmented data and opaque reporting hinder strategic assessment, especially in cases like Nigeria's stalled satellite project. U.S. policymakers would benefit from a dedicated mechanism to systematically track and analyze China's space infrastructure diplomacy under the BRI-SIC/Space Silk Road framework.

Pakistan's space ambitions have increasingly converged with China's, driven by limited domestic capabilities and strategic proximity. Still, under the Space and Upper Atmosphere Research Commission of Pakistan (SUPARCO), they hope to establish self-reliance in satellite development [063]. With China and India far ahead, Pakistan has leaned heavily on Beijing, formalizing new space cooperation agreements at the 2019 Belt and Road Forum. Islamabad has committed to continuing satellite procurement and launches through China's CGWIC, as evidenced recently in 2024 by Pakistan's launch of its first high-throughput satellite, PakSat-MM1R [064]. This partnership with China has cultivated internal expertise but also drawn domestic criticism reflecting a trend of infrastructure dependency within the BRI.

Egypt's Space City, now fully operational and the new headquarters of the African Space Agency (AfSA), has positioned Egypt at the forefront of African space science, research, and continental policy, with continued support from Chinese partnerships and international collaboration [065]. The 123-acre campus includes satellite assembly, integration, and testing facilities, technical training centers, and a technology zone for space-related companies, supporting both national satellite manufacturing and regional capacity building [066].

Venezuela became the first Latin American nation to contract CGWIC to develop and launch its telecom satellite, Venesat-1 (Simón Bolívar-1), in 2008—a $406 million project that not only included the satellite itself but also the construction of major ground control stations at Capitán Manuel Ríos Aerospace Base in El Sombrero, Guárico and a second located in either Luepa or Fort Manikuyá according to different sources [067] [068] [069]. These ground facilities were instrumental in providing operational control and communications, while a parallel technology transfer program trained up to 15 Venezuelan personnel in China. Cooperation has continued with more recent satellite builds including imaging satellites VRSS-1 in 2012 and VRSS-2 in 2017 [069].

SIC's Image Management — To enhance the appeal of its BRI-SIC efforts, China has hosted a series of international events—from the Fengyun Satellite User Conference to the UN-China Forum on Space Solutions—framing space collaboration as a global public good. Recent trends could indicate a pivot from hard infrastructure to softer economic expansionist tools like technical training, regional agreements, and software integration. While less visible, this approach poses deeper strategic risks; embedding Chinese platforms in national systems can limit sovereign control and constrain independent space development in partner nations.

3. Segment Analysis & Risks to America

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3.1. Spaceports & Infrastructure

"Now is the critical time for space infrastructure to expand…"

– 2025, Yang Mengfei, senior CASC official

3.1.1. What were China's goals?
Spaceports & Infrastructure

A decade ago, China set forth an ambitious plan for spaceports and infrastructure, as detailed in its 2016 Space White Paper and reinforced in subsequent policy documents. At the core of this vision was the expansion and modernization of launch sites, ground stations, and TT&C networks, with a focus on supporting a broad spectrum of missions and building out the industrial and R&D backbone for space activities. The inauguration of the Wenchang Launch Site in June 2016, described as a new-generation, environmentally friendly facility, and the renovation of Jiuquan, Taiyuan, and Xichang, established a launch network covering both coastal and inland regions, high and low altitudes, and diverse orbital trajectories to support manned, scientific, and commercial missions [010].

Simultaneously, China expanded its ground station network, integrating land, ocean, and meteorological satellite data, and improved TT&C infrastructure with new relay satellites and tracking ships. The Tianlian-1 series enabled global networking, while deep space TT&C stations were brought online, supporting increasingly complex and distant missions. These upgrades allowed China to complete TT&C missions for the Shenzhou, Tiangong, and Chang'e series, and to establish a multi-function TT&C network integrating space, marine, and ground elements [010].

Looking to the decade ahead, China's plans called for adaptive improvements to launch sites, enhanced reliability, IT integration, and greater complementarity between facilities. The goal was to create a launch system characterized by "rational division of labor, mutual support, and security, while also opening sites to commercial and international use". By 2021, these objectives had largely been realized, with new commercial launch pads, operational sea launch capabilities, and a more integrated information network. The TT&C system was set to become more unified, efficient, and globally connected, with a focus on supporting high-intensity, diversified missions and expanding international cooperation, particularly with the European Space Agency (ESA) [070]. These efforts collectively aimed to position China as a leader in global space infrastructure and operations.

3.1.2. How did China shift?
Spaceports & Infrastructure

Policy Shifts

China's spaceports and infrastructure have undergone major transformation propelled by targeted policy reforms and strategic planning. In 2014, NDRC Document 60 opened the sector to private investment, enabling provincial governments to fund commercial space infrastructure and catalyzing significant private sector participation [016]. The 2015 National Civil Space Infrastructure Medium- and Long-Term Development Plan (2015-2025) prioritized a market-driven, government-guided approach, accelerating the modernization and expansion of national infrastructure [071].

These steps aligned with the 14th FYP (2021–2025), which emphasized technological self-reliance and the integration of civilian and military sectors, further strengthening China's innovation and industrial capabilities [012] [072]. The 2021 Space White Paper reinforced this commitment, highlighting the country's drive to advance domestic technology and industrial strength.

Regarding the space ground segment subsector, deregulation of smaller user terminals occurred in earlier years, but the TT&C market has still expanded significantly since 2014. By 2022, at least twelve commercial TT&C

companies had emerged, reflecting the broader trend of commercial growth and innovation in China's space infrastructure [073].

Campaign Shifts

China's domestic public campaign initiatives have combined high-profile national efforts—such as the annual "Space Day" launched in 2016 to foster public support, inspire scientific curiosity, and showcase achievements through nationwide exhibitions, lectures, and outreach. Furthermore, targeted local government action plans in major cities like Beijing and Shanghai, have seen authorities introduce dedicated policies, financial incentives, and infrastructure programs to accelerate commercial aerospace development and attract talent [016] [074] [075] [076] [077].

Investment Shifts

To better understand Chinese investment trends into the space ecosystem, comparative data from Novaspace (formally Euroconsult) and Orbital Gateway Consulting are examined over the last decade. The year range of 2015-2024 is bounded so as to keep full year data sets and track developments from the first full fiscal year since Document 60 induced a commercial shift. Novaspace's data provides the big picture of overall Chinese government expenditures into their national space programs, specifically the programs of the civil and military sectors. Orbital Gateway Consulting's data provides a parallel and more nuanced look at all funding going into the commercial sector with breakdowns by funding source (central government, city/provincial government, private funder) and segment divided into the six categories below [014]:

- Launch — Companies building rockets and rocket engines.
- Satellite Manufacturing — Companies building satellites, satellite systems, or subsystems.
- EO — Companies primarily operating EO satellites or providing downstream services.
- Ground Segment — Companies building satcom terminals or providing TT&C services.
- Satellite Communications operator — Companies operating communications satellites
- Other — Primarily Companies providing satellite navigation services or space-based services.

Table 1: China Space Funding (with Ground Segment Call-out)

China Space Investment *Ground* *(in Millions USD)*	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total 2015-2024**
Estimated Government Expenditures into Full Civil & Military Sector --- *Source: Novaspace annual Government Space Programs Report*											
China	*4,210.00*	4,909.00	*5,300.00*	5,833.00	*7,300.00*	8,852.00	10,286.00	11,935.00	14,152.00	19,886.00	**92,663.00**
Total Commercial Sector Funding by Source --- *Source: Orbital Gateway Consulting*											
Private	$122.31	$37.59	$94.34	$327.22	$493.12	$876.29	$595.78	$578.00	$423.68	$599.26	**$4,147.57**
Central Government	$35.75	$66.04	$44.73	$145.57	$261.39	$238.63	$211.22	$336.23	$256.25	$754.75	**$2,350.57**
City & Provincial Government	$181.90	$60.71	$199.50	$209.71	$350.52	$569.70	$561.94	$752.22	$520.79	$1,505.65	**$4,912.65**
Year subtotal	$339.96	$164.34	$338.57	$682.50	$1,105.04	$1,684.62	$1,368.95	$1,666.45	$1,200.71	$2,859.66	**$11,410.79**
Commercial Sub-Segment Funding --- *Source: Orbital Gateway Consulting*											
Ground Segment	$0.28	$4.78	$14.41	$51.85	$90.58	$69.61	$159.98	$173.66	$40.36	$74.14	**$679.65**
	Ground Segment: Companies primarily building satcom terminals or providing TT&C services.										

Over the decade since China opened its space market in late 2014, cumulative government investment into the combined civil and military space sectors has reached somewhere between $85-95 billion USD according to yearly estimates made public by Novaspace's annual Government Space Programs Report [078], with year-on-year trend upward from $4.9 billion in 2016 to nearly $20 billion in 2024. This highlights the state's steady prioritization of space as a strategic domain and its willingness to devote resources at scale. Meanwhile, total investment into the commercial space sector from all levels of government and private sources grew to $11.4 billion from 2015 to 2024, reflecting rising market participation [014].

The data also illustrate how targeted segments have evolved since industry opening. For example, investment in commercial ground segment companies—focused on building satcom terminals and TT&C services—remained modest in absolute terms, with $5 million invested in 2016, increasing to $70 million in 2020, and cresting at $74 million by 2024 for a decadal total of $680 million. This trend indicates a gradual, but steady, emergence of ground segment capabilities within the broader commercial space ecosystem, with persistent growth driven by expanding demand for robust satellite communications and command infrastructure [014].

3.1.3. What has China achieved?

Spaceports & Infrastructure

New Technologies, Installations, & Programs

Legacy Spaceports — For decades, China relied on three inland launch sites—Jiuquan, Taiyuan, and Xichang—which together supported nearly 390 launches. The Xichang site in particular has posed public safety concerns through the years due to its proximity to populated areas. Notable incidents, such as the catastrophic Intelsat 708 launch failure at Xichang in the 1990s, underscored these hazards and highlighted the limitations of China's early infrastructure [079].

Newer Spaceports — To address these issues and expand its capabilities, China established new coastal and commercial launch sites. The Wenchang Space Launch Site, opened in 2016 on Hainan Island, enabled safer and more versatile launches from a larger array of heavy lift vehicles, while the Yellow Sea sea-based platform and the Wenchang Commercial Space Launch Site—operational since late 2024—marked China's first dedicated commercial facility [080] [081]. Today, with six operational launch sites and remote landing zones in Inner Mongolia, China's infrastructure modernization demonstrates its ability to execute on ambitious plans and positions it as a formidable global competitor, raising the risk profile for U.S. commercial and strategic interests [082].

Telemetry, Tracking, & Command (TT&C) — China's TT&C capabilities have advanced significantly, enabling complex missions like the Chang'e 4 lunar far side landing and Tianwen-1 Mars rover deployment [083]. The country now operates a global TT&C network with ground stations in Asia, Africa, and South America, and is developing integrated ground-based and space-based TT&C systems to better support its growing fleet of commercial satellites [049] [070]. China's TT&C infrastructure is anchored by the Xi'an Satellite Control Center, which directs a widespread network of domestic ground stations—including key nodes in Xinjiang—and core tracking facilities across China. This terrestrial network is augmented by a fleet of Yuan Wang-class tracking ships, able to provide TT&C coverage at sea for space launches and deep-space missions, and by the geostationary Tianlian relay satellite constellation that enables near-continuous communication with spacecraft beyond terrestrial line-of-sight [084] [085]. Together, these assets allow China to conduct complex deep-space and crewed missions, while also supporting the growing demands of commercial satellite operators through global reach and high network redundancy.

Commercial TT&C — With rising demand beginning to challenge capacity of the Xi'an Satellite Control Center—especially after loss of access to Swedish and Australian ground stations—China has seen a surge in commercial TT&C providers. New ground stations in cities like Meishan, Sichuan, now offer higher capacity and advanced features to support commercial constellations, while companies such as Tianlian TT&C, Space Wisdom, Satchain, and Emposat are increasingly handling overflow and international service deals [086] [073]. This commercialization trend is expected to accelerate as global satellite operators seek more flexible, cost-effective ground station access in the Asia-Pacific [087].

New Stakeholders & Hubs

Provincial Hubs: Talent, Manufacturing, & Public Support — China's commercial space sector is propelled in part by regional government support, including government-provided land, tax breaks, and other incentives to attract both SOEs and private firms [088] [089]. For example, ExPace moved to Wuhan with significant local support, while LandSpace, a leading private launch company, established its factory in Huzhou, Zhejiang province, benefiting from favorable conditions [090].

Many of these private ventures were founded by graduates from top aerospace programs such as Tsinghua University and by former SOE engineers seeking to innovate outside the traditional system. Employment in the sector has surged; first-generation launch startups (founded around 2014) have doubled their workforce, while newer companies (from 2016 onward) have tripled in size [091]. Graduates from C9 universities (Tsinghua, Beihang, Northwestern Polytechnical among them) and top aerospace programs increasingly fuel commercial ventures in provincial hubs like Beijing, Shanghai, Chengdu, Wuxi, Xi'an, and Changsha, creating accelerating innovation clusters [092]. The 2021 Space White Paper explicitly outlines this strategy of strengthening an open industrial system with "systems integrators, specialized contractors, market suppliers, and public service providers" while building intelligent production lines to bridge research and commercial output [070].

Manufacturing efforts are showing growth in various regions of China, as indicated in Figure 3 in the second chapter of this report. Satellite manufacturing has a sizable footprint in Wuhan, Taizhou, Beijing, Shanghai, and other cities, especially in districts like Haidian and Pudong that host multiple operational factories. Data from Orbital Gateway Consulting indicates numerous other locations including Wuxi, Wenchang, and Chengdu are planning further satellite manufacturing capacity in the near future. Similarly, rocket factories are distributed across China but show significant operational presence in Anqing, Wuxi, and Beijing, particularly in Daxing and nearby Tianjin Binhai. Furthermore, over a dozen additional rocket factories are either in development or planning stages across various regions of China [093].

Concurrently, China cultivates public enthusiasm through curated space narratives. National and regional governments have built immersive museums (e.g., Beijing Spaceflight Museum, Shanghai Astronomy Museum) and space-themed parks [094]. Annual Space Day celebrations (April 24), World Space Week, and Science and Technology Week events frame achievements as evidence of CCP-led "national rejuvenation" [095] [096]. This deliberate narrative could reinforce social consent for centralized governance by linking technological progress to regime legitimacy, expanding the Overton Window for state control while fostering patriotic pride.

New International Engagement

Overseas Tracking Stations — China has established a global network of overseas tracking and data-receiving stations to support its space program, with key facilities in Kenya (Malindi), Namibia (Swakopmund), South Africa, Bolivia, and Argentina, as well as stations in Thailand and Indonesia [097]. Some of these ground stations were jointly operated with countries that are traditional U.S. partners, such as France, Sweden, and Australia, though recent geopolitical tensions have led Sweden and Australia to end or not renew their contracts with China [098].

Overseas Business — Internationally, China positions itself as open to foreign satellite clients, aiming to expand its global commercial launch footprint. Notable collaborations include Denmark's GomSpace at point contracting with LandSpace for satellite launch services and the Wenchang Commercial Space Launch Site enhancing accessibility for international customers [099]. Foreign companies often face restrictions on investing in sensitive sectors due to China's "Negative Lists," but recent 2024 and 2025 editions alongside a 2022 "Encouraged Foreign Investment Industries Catalogue" have invited foreign investment into some Chinese space segments [100].

3.1.4. What risks does America face?

Spaceports & Infrastructure

The United States leads the global space launch sector with numerous Federal Aviation Administration (FAA)-licensed vertical and horizontal launch sites, profitable companies, and established regulatory frameworks [104]. However, China's state-subsidized expansion of spaceports and infrastructure—marked by cost-competitive launch facilities, dual-use technology proliferation, and strategic global partnerships—demands urgent U.S. countermeasures. Without accelerated innovation and allied infrastructure cooperation, America could risk ceding orbital access dominance and enabling coercive leverage against global space networks. As launch sites and calendars become increasingly crowded, expanded launch capacity and improved cadence will be instrumental to maintaining U.S. global leadership [105].

Segment-Specific Risks to American Industry

1. **Cost Underutilization Pressure**
   China's state-funded coastal spaceports (e.g., Wenchang) exploit location advantages to offer accessible, competitive launch options, potentially undercutting the U.S.commercial launch market. This pricing pressure could threaten the viability of U.S. launch startups and erode market share.

2. **IP and Dual-Use Technology Leakage**
   As the Hainan province seeks to attract global partners and streamline commercial aerospace operations, ventures like the National Technology Transfer Hainan Center (or Hainan Center) there is a risk of easier transfer of sensitive technologies to Chinese entities [106].

3. **TT&C Standards Fragmentation & Surveillance Access**
   Chinese ground station networks and interconnected Global Navigation Satellite System (GNSS) receivers now exist across a significant portion of South America, Africa, and Asia. Worries over this include possible displacement of U.S.-developed operational protocols, espionage, data theft, and cyber attacks [097].

National Strategic Risks

1. **Surveillance and Signals Intelligence Vulnerabilities**
   China's tracking stations in Namibia and Bolivia could intercept U.S. satellite telemetry via dual-use signals intelligence capabilities, compromising space domain awareness during conflicts.

2. **Supply Chain Weaponization**
   China's strong hold on rare-earth minerals and propulsion components could allow strategic throttling of U.S. space infrastructure development, as seen in China's 2024 shift on rare earth element export restrictions.

3.2. Launch & Reentry

"The sea spaceport alone aims to support 100 launches per year starting from 2027."

– Chinese officials at the Haiyang Oriental Maritime Spaceport

3.2.1. What were China's goals?
Launch & Reentry

In 2016, China's plans for its Launch & Reentry segment reflected a clear ambition to modernize and expand its space transportation capabilities. The 2016 Space White Paper highlighted the growing effectiveness of the LM carrier rocket series, which by late 2016 had completed 86 launches with a 97.67 percent success rate. This period saw the debut of the LM 5, China's most capable rocket to date, featuring a 5-meter diameter fairing and a payload capacity of 25 tons to LEO, marking a significant leap in launch vehicle technology. Other notable achievements included the maiden flights of the LM 6 and 7—powered by newly developed 120-ton liquid oxygen and kerosene engines—and the solid-fuel LM 11, all of which diversified and strengthened China's launch portfolio [010].

Looking ahead, China's 10-year outlook focused on developing non-toxic, pollution-free, and more reliable medium-lift launch vehicles, as well as advancing heavy-lift rocket technology and reusable space transport systems. The official plan called for breakthroughs in high-thrust engines, new upper-stage technologies, and cost-effective launch solutions, with the goal of eventually activating a heavy-lift launch vehicle project. By the mid-2020s, the emphasis shifted to further expanding the launch vehicle family with new-generation rockets, accelerating heavy-lift R&D, and conducting test flights for reusable systems. China also committed to developing advanced propulsion and upper stage technologies to increase the efficiency and frequency of space entry and reentry, supporting a rapidly growing demand for regular launches [010] [070].

3.2.2. How did China shift?
Launch & Reentry

Policy Shifts

China's launch sector transformation has benefited the past decade from deliberate policy shifts and public campaigns accelerating technological development. The 2014 policy opening private investment catalyzed a wave of commercial startups the following year, with over 50 startups emerging to challenge SOEs and over a dozen launch-focused companies [071] [107]. This was reinforced by the 14th FYP (2021-2025), which prioritized technological self-reliance and military-civil fusion—directing resources toward next-gen launch vehicles while integrating civilian innovations into defense applications [012] [072].

The State Administration for Science, Technology and Industry for National Defense (SASTIND) became the operational engine of this strategy, regulating launch activities while driving military-civil integration [108] [109]. The 2021 Space White Paper further targeted R&D for non-toxic, heavy-lift rockets, explicitly aiming to phase out older toxic propellants [110].

Campaign Shifts

Complementing these policies, cities like Beijing, Shanghai, and Wuhan established "space industry parks" and "spaceport cities" in 2024, clustering manufacturing, testing, and launch operations to attract talent and accelerate innovation [111]. This integrated approach—policy reform, strategic funding, and geographic clustering—has positioned China's launch sector for sustained technological advancement and global competitiveness.

Investment Shifts

Similar to this report's "Spaceports & Infrastructure" section, we can glean Chinese investment trends in the space ecosystem with comparative data from Novaspace (formerly Euroconsult) and Orbital Gateway Consulting from the past decade. The period of 2015–2024 is chosen to ensure complete annual data sets and to follow developments beginning with the first full fiscal year after Document 60 triggered a commercial transition. Novaspace's data presents the broad view of total Chinese government spending on national space programs, specifically those in the civil and military sectors. Orbital Gateway Consulting's data offers a complementary and more detailed perspective on all funding directed into the commercial sector, with breakdowns by funding source (central government, city/provincial government, private funder) and by segment divided into six categories (Launch, Satellite Manufacturing, EO, Ground Segment, Satellite Communications, and Satellite Navigation Services/Space-based Services) [014].

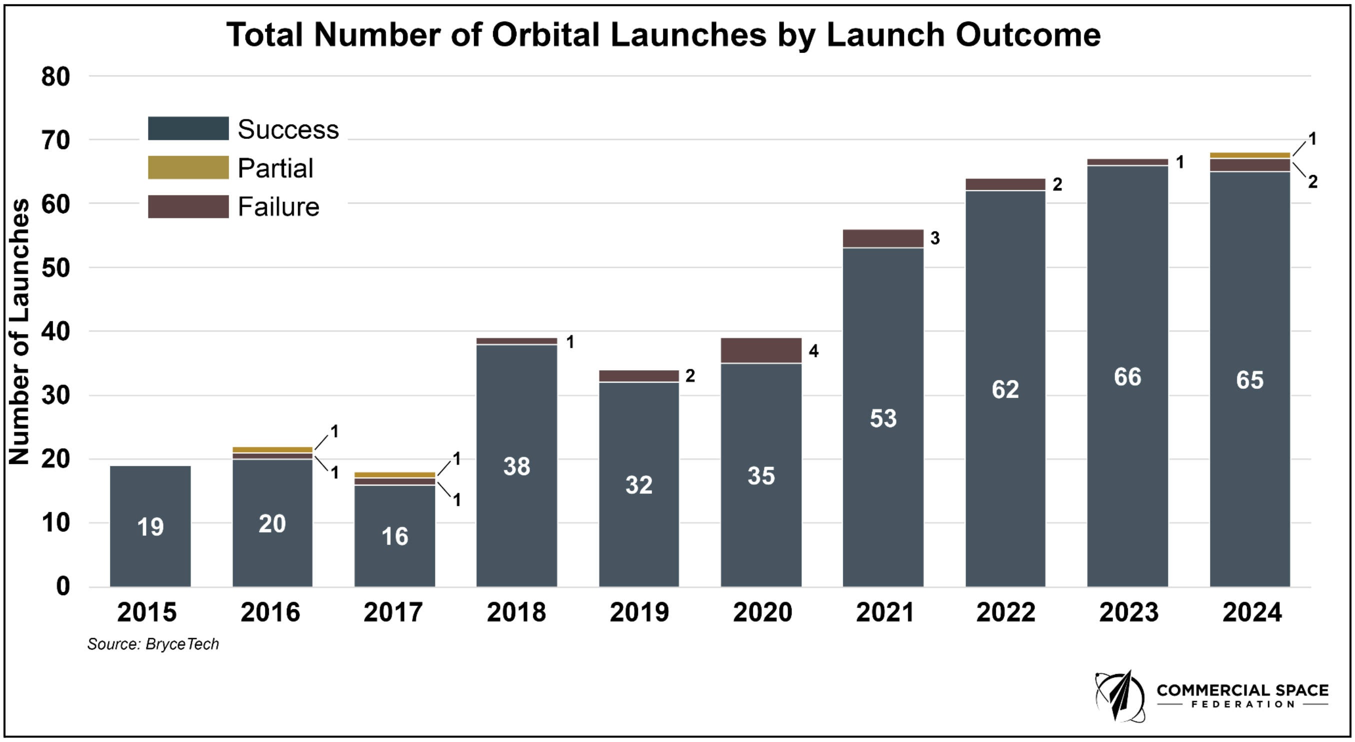
According to Novaspace, aggregate government investment into China's civil and military space programs reached approximately $85-95 billion USD over the past decade, with annual overall expenditures increasing from $4.9 billion in 2016 to $19.9 billion by 2024 [078]. In parallel, Orbital Gateway data shows all-source investment in the commercial space sector—including central, provincial, and private funds—grew rapidly, rising from $164 million in 2016 to just under $2.9 billion by 2024 and totaling $11.4 billion USD for the decade, underscoring the expanding role of non-traditional actors and market-driven activity in shaping China's trajectory [014].

Focusing on the launch segment specifically, total cumulative commercial investment into launch from all sources was $4.06 billion USD during 2015–2024, with annual funding scaling from $102 million in 2016 to $798 million in 2024—significantly surpassing early years and indicating accelerating industry maturation. These figures place the launch sector as one of the foremost beneficiaries within the commercial space landscape, attracting over a third of all private and government capital across all commercial market segments [014]. A number of high profile companies have developed out of this segment's consistent funding climate including LandSpace, iSpace, Galactic Energy, and Deep Blue Aerospace.

Table 3: China Space Funding (with Launch Segment Call-out)

China Space Investment *Launch* *(in Millions USD)*	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total 2015-2024
Estimated Government Expenditures into Full Civil & Military Sector --- *Source: Novaspace annual Government Space Programs Report*											
China	*4,210.00*	4,909.00	*5,300.00*	5,833.00	*7,300.00*	8,852.00	10,286.00	11,935.00	14,152.00	19,886.00	**92,663.00**
Total Commercial Sector Funding by Source --- *Source: Orbital Gateway Consulting*											
Private	$122.31	$37.59	$94.34	$327.22	$493.12	$876.29	$595.78	$578.00	$423.68	$599.26	**$4,147.57**
Central Government	$35.75	$66.04	$44.73	$145.57	$261.39	$238.63	$211.22	$336.23	$256.25	$754.75	**$2,350.57**
City & Provincial Government	$181.90	$60.71	$199.50	$209.71	$350.52	$569.70	$561.94	$752.22	$520.79	$1,505.65	**$4,912.65**
Year subtotal	$339.96	$164.34	$338.57	$682.50	$1,105.04	$1,684.62	$1,368.95	$1,666.45	$1,200.71	$2,859.66	**$11,410.79**
Commercial Sub-Segment Funding --- *Source: Orbital Gateway Consulting*											
Launch Segment	$4.84	$101.84	$224.12	$303.08	$306.16	$579.44	$609.23	$623.96	$507.50	$798.28	**$4,058.43**
	Launch Segment: Companies primarily building rockets and rocket engines.										

Figure 7: Total Number of Orbital Launches by Launch Outcome
Source: BryceTech



3.2.3. What has China achieved?
Launch & Reentry

New Technologies, Installations, & Programs

Chang Zheng (CZ) / LM Launch Vehicles **—** China is increasingly active in their launch segment, having launched more rockets than the U.S. in both 2018 and 2019 [112]. Today, China has a wide family of launch vehicles for space. This primary carrier group is called Chang Zheng (CZ) in China and are anglicized and internationally promoted as LM rockets. The name "Long March" refers to the CCP's grueling 1930s civil war retreat across thousands of miles.

Light Vehicles — The smallest active members of the CZ family are the CZ-6 and CZ-11, designed for LEO delivery and developed by subsidiaries of state-owned CASC [113]. Both vehicles are regularly used for launching small satellites. The CZ-11 is capable of launching from sea-based platforms, while the CZ-6 is often used for institutional and university missions [114].

Medium Vehicles — For intermediate payloads to LEO, sun-synchronous orbit (SSO), and geostationary transfer orbit (GTO), China employs the CZ-2C/D/F, CZ-3A, CZ-4B/C, and CZ-8 launch vehicles, all manufactured by CASC subsidiaries CALT or SAST, with payload capacities ranging from approximately 3,500 to 8,400 kg to LEO [115]. Among these, the CZ-2F served as the launch vehicle for China's first crewed spaceflight in 2003 that carried Yang Liwei into orbit, and has since been used for multiple crewed missions and space station components. The other rockets in this category primarily launch satellites, with the CZ-3 family notably deploying BeiDou navigation satellites into orbit [116]. The CZ-8 began operations in 2020, and plans to feature a reusable fist stage with vertical landing similar to the Falcon 9.

***Heavy & Super Heavy Vehicles* —** Rounding out the heavy-lift end of the CZ launch vehicle family are the CZ-5 and CZ-7, providing transport ranging from approximately 5,500 kg to GTO (CZ-3B) up to 25,000 kg to LEO or 8,200 kg to trans-lunar injection (TLI) in the case of the CZ-5. The CZ-3 series launched the Chang'e lunar probes, several BeiDou navigation satellites, and numerous spacecraft to geosynchronous Earth orbit (GSO). The CZ-5 and CZ-7 are intended to support crewed Shenzhou missions, deliver space station modules, and facilitate lunar and interplanetary missions.

***Public Hazards* —** Early-generation LM rockets (CZ-2, 3, and 4) relied on highly toxic hydrazine and nitrogen tetroxide, while newer CZ-5, 6, and 7 models use LOX and kerosene. Rockets in both categories continue to pose public hazards. This is underscored by debris from LM 3B boosters crashing and exploding near populated areas in 2019, 2023, and 2025 [117] [118] [119]. The heavy lift LM 5 has similarly worried the international community when China allowed uncontrolled reentry of boosters on three different occasions in 2020, 2021, and 2022 [120] [121]. Uncontrolled reentry has been pointed out as a troubling characteristic of the LM 5B's design without elements to control descent as most orbital-class rockets include. Though these episodes ended with the boosters landing safely in the ocean, China also did not share trajectory information in some cases with the broader community to predict landing zones and reduce risk [122].

New Stakeholders & Hubs

Commercial Launch Vehicles — Since China opened its launch sector to private capital in 2014, its commercial launch ecosystem has rapidly diversified and matured. Today, more than a dozen private providers compete alongside state-built LM rockets, with active small-lift vehicles—such as Smart Dragon 1 (Chinarocket), iSpace's Hyperbola, ExPace's Kuaizhou-1A, and Galactic Energy's Ceres-1, which set reliability benchmarks with successful sea launches [123]. Most early vehicles were solid-fueled and expendable, but the industry's focus has decisively leaned in on now developing larger, reusable, liquid-propellant rockets to lower costs and compete for megaconstellation contracts [124].

LandSpace has emerged as a technological leader, launching the world's first methalox rocket to orbit and securing $123 million from the National Manufacturing Transformation and Upgrading Fund to develop its Zhuque series of reusable launchers [125] [126]. Other notable players include CAS Space, which is advancing the Kinetica-2 for cargo launches; Astronstone, developing a stainless-steel, Starship-style rocket with "chopstick" recovery; and OneSpace, which pioneered China's first private rocket launch [127] [128] [129]. OneSpace was an example of a company, like many, that was courted by different Chinese municipalities, leading to a broad national footprint; R&D developments in Beijing, a manufacturing and assembly base in Chongqing in the southwest, and a testing location in the Jiangxi province closer to the eastern coast [130].

Venture and state-linked capital have poured into the sector—over $6 billion since 2020—split between industrial funds and private venture capital, with companies such as Space Pioneer, Galactic Energy, Deep Blue Aerospace, Orienspace, Jiuzhou Yunjian, ExPace, and LandSpace all securing major funding rounds [131]. This funding model aligns commercial innovation with national strategic goals, including rapid-launch capabilities, reusable tech, and support for China's megaconstellation ambitions. As recent evidence of China's vibrant launch landscape, May and June 2025 saw four successful commercial missions succeed: Galactic Energy's 19th Ceres-1 launch, Landspace's Zhuque-2E sending up six Spacety satellites as the world's first liquid methalox rocket to orbit, CAS Space's ZK-1A delivering six satellites, and Space Epoch's Yuanxingzhe-1 completing a test flight with controlled sea landing [020]. Looking ahead, industry leaders expect an explosive growth period for commercial launches starting in 2026, as private rocket launches are projected to exceed 10 annually and total launches possibly topping 150 by 2030 [132].

Rocket Manufacturing — As stated in this report's prior section, space manufacturing activity is expanding across many parts of China, with rocket production facilities showing substantial presence in metro areas including Beijing, Wuxi and Anqing near Shanghai, Chengdu, and the Shandong province. Additionally, more than a dozen new rocket factories are currently planned or under development in various regions nationwide [093].

New International Engagement

China is one of the world's leading launch providers, operating an extensive global launch business through the CASC subsidiary CGWIC. From 1990 to June 2023, CGWIC oversaw the launch of approximately 77 satellites for foreign customers and provided on-orbit delivery of an additional 17 satellites—demonstrating China's export promotion strategy, generous financing, and regulatory support [055]. China has not regularly sent finished satellites abroad to be launched by other nations, instead providing turnkey launch or on-orbit delivery services as a tool for diplomatic engagement. CGWIC is authorized to represent all relevant Chinese space entities in negotiating and fulfilling these contracts, expanding its flexibility relative to possible competitors. Its services include launch provision, ground infrastructure, operations support, and insurance, reinforcing China's position as a major global launch state [055] [058].

Despite this mentality to refrain from offshoring launch of domestic Chinese satellites to a another country, there are early 2025 reports of China offering Brazil a batch of J-10CE fighter jets in exchange for access to the equatorial Alcântara Space Launch Centre, a move likely aimed at enabling launches by Chinese megaconstellation operators and capitalizing on Alcântara's premier orbital position [133] [134]. The J-10CE proposal was ultimately declined as Brazil maintained its focus on their current fighter jet program and has faced budget constraints. However, this news came in the same season as separate reports of Brazil courting Chinese satellite launch and broadband firms, continuing to seek broader international partners as it refocuses on its space industry [135].

3.2.4. What risks does America face?

Launch & Reentry

China's rapid progress in launch and reentry—driven by progressive reusable rocket innovation, a surge in private launch startups, and the prospect of aggressive price competition—poses a direct challenge to U.S. commercial launch providers and the broader American space enterprise. Without targeted U.S. investment in next-generation launch systems, IP protection, and industrial base resilience, as well as significant reforms to launch and reentry licensing and regulations, America could risk losing its leadership in global launch markets and trailing technologically in strategic options to orbit.

Segment-Specific Risks to American Industry

1. **Aggressive Price Competition from Reusable Launch Vehicles**
   Chinese firms like LandSpace, iSpace, and CASC are fielding new generations of reusable rockets (e.g., Zhuque-3, Hyperbola-2, CZ-8R), which are expected to drive per-launch costs down and attract commercial satellite operators worldwide. This threatens to undercut U.S. providers' pricing models and erode market share, especially in the small- and medium-lift sectors [082] [125].

2. **Rapid Scaling of Private Launch Startups**
   Since 2014, China's policy reforms have enabled a proliferation of private launch companies, many founded by former SOE engineers and top university graduates. These firms benefit from direct provincial

government support and access to state-of-the-art manufacturing hubs, accelerating their ability to compete for international launch contracts.

National Strategic Risks

1. **Loss of Global Launch Market Share**
   China's goal to capture a significant share of the global commercial launch market—especially for BRI partners and emerging space nations—threatens U.S. leadership in space access and could shift the center of gravity for launch innovation and standards away from the U.S. [124]. U.S. policymakers would benefit from a dedicated and persistent mechanism to systematically track and analyze China's space infrastructure diplomacy under the BRI-SIC framework.

2. **Military-Civil Fusion and Dual-Use Launch Capability**
   Many of China's commercial launch advances are explicitly dual-use, supporting both civil and military rapid-response satellite deployment. This blurs the line between commercial and military space, complicating U.S. efforts to monitor and respond to greatly accelerated Chinese launch activities with potential security implications [108].

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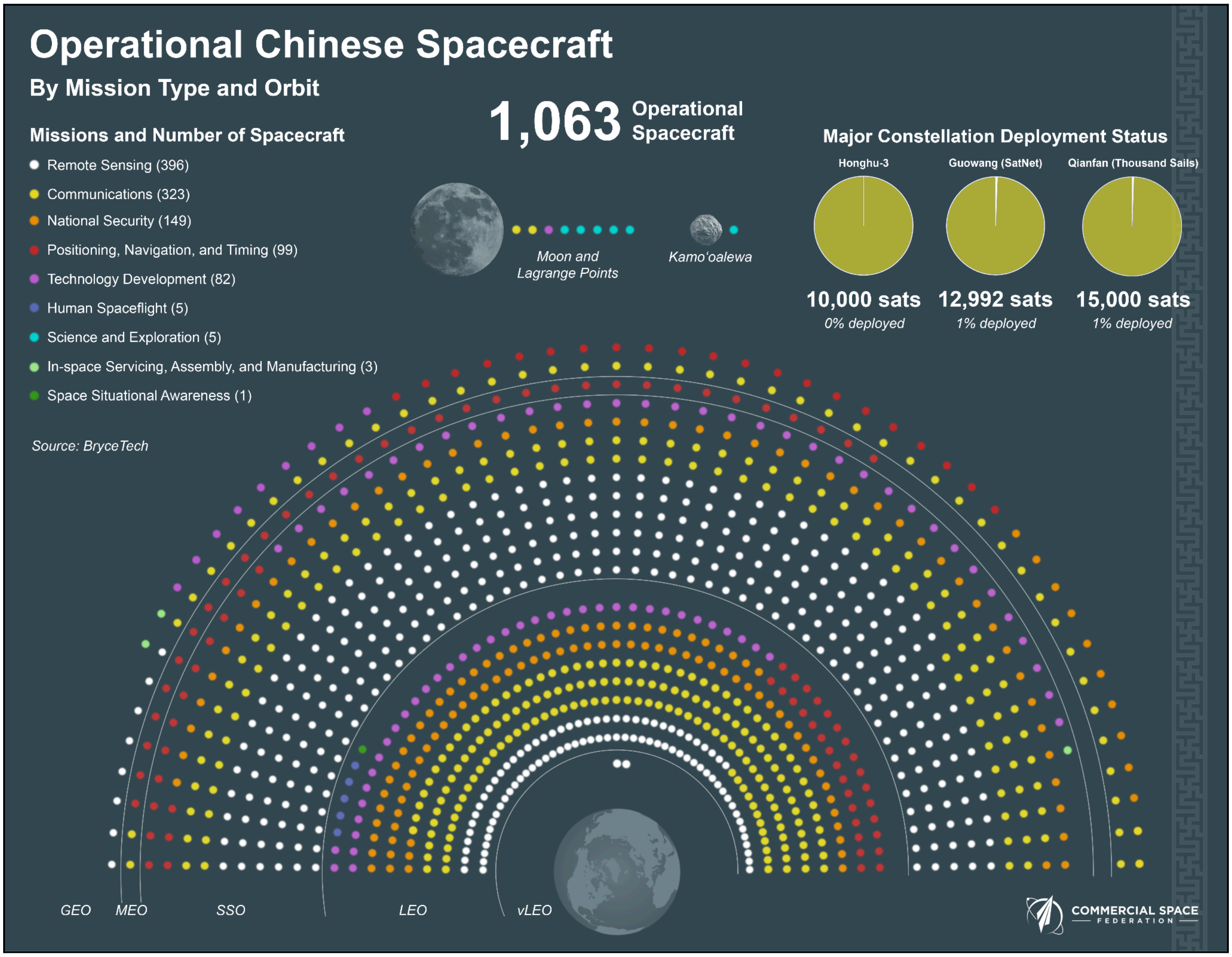
3.3. Remote Sensing (RS) & Space Situational Awareness (SSA)

"The VLEO communications and sensing integrated constellation, taking the natural advantages of shorter distance, low latency, and low path loss… is small but excellent, fast and intelligent, and requires a large quantity of satellites, but is cheap."

– 2023, Zhang Nan, CASIC Chief Designer

Figure 8: Operational Chinese Spacecraft by Mission Type & Orbit
(Satellites, Station modules, Cargo/Crew ships, Orbiters, Landers, & Probes) *Source: BryceTech*



3.3.1. What were China's goals?

RS & SSA

China's plans for the RS & Space Situational Awareness (SSA) segment are outlined in the 2016 Space White Paper, emphasizing the rapid expansion and technological improvement of its EO and SSA capabilities. By 2016, China had significantly advanced its family of EO satellites—including the Fengyun, Haiyang, Ziyuan, Gaofen, and Yaogan series—enabling high-resolution, multi-spectral, and all-weather monitoring of land, ocean, and atmospheric conditions. The operationalization of the Gaofen-2 and Gaofen-3 satellites, with sub-meter optical and meter-level synthetic aperture radar (SAR) imaging, and the launch of the Jilin-1 commercial high-resolution satellite, marked a leap in both state and commercial imaging capabilities. China also deployed small satellite constellations for environment and disaster monitoring, and successfully tested rapid-response launch systems like Kuaizhou, enhancing its emergency space response [010].

In parallel, China prioritized SSA capabilities, establishing regular monitoring and early warning operations for space debris, improving standards and mitigation protocols, and deploying new detection technologies.

Upper-stage passivation and post-mission disposal of spacecraft became routine, while advances in protection design were applied to safeguard assets in orbit [010].

Looking to the decade ahead, China's strategy called for a robust, integrated space infrastructure system, with a focus on developing and networking multi-functional satellites for land, ocean, and atmospheric observation. Plans included launching high-resolution optical and radar satellites, atmospheric LiDAR capabilities, carbon monitoring, and new ocean color sensors, as well as building out global ground station networks and data-sharing platforms. By 2021, the ambition expanded to include geostationary microwave monitoring and advanced water resource satellites, aiming for comprehensive, efficient global observation and rapid data services [070] [136].

For SSA, China planned to enhance standardization, expand its debris monitoring and cataloging, and develop early warning and emergency response platforms. The 2021/2022 white paper highlighted efforts to build a near-Earth object (NEO) defense system and strengthen in-space disaster backup and information protection,. These measures were designed to ensure the safety, stability, and resilience of China's growing space system and to position the country as a global leader in both RS and space environment management [070] [137].

3.3.2. How did China shift?
RS & SSA

Policy Shifts

China's RS and SSA policies have evolved significantly since 2015, driven by strategic civil-military integration and global market expansion. The 2015 National Civil Space Infrastructure Plan established RS as a core pillar, accelerating commercial participation in non-Earth imaging and SSA services, with mixed-ownership enterprises (MOE) entering the market around 2016 [071]. By 2023, new regulations mandated civil-military fusion in RS data sharing, enhancing dual-use capabilities while centralizing data control [111]. The 2021 Space White Paper further promoted enterprise access to government R&D facilities and major projects, though intellectual property rights remain ambiguously defined, potentially limiting innovation incentives [138].

Campaign Shifts

On the initiative front, the Jilin-1 commercial satellite constellation emerged as a flagship program, expanding to over 130 international clients by 2025 and providing high-resolution imagery for agriculture, disaster monitoring, and urban planning [111]. Concurrently, China launched a national RS data platform in 2023, aggregating resources from 30+ satellites and establishing BRICS and Belt and Road data-sharing centers to support global partners, particularly in disaster-prone regions [139]. These efforts align with China's broader strategy to dominate strategic RS markets, advance military reconnaissance capabilities, and leverage infrastructure like the "Belt-and-Road Spatial Information Corridor" for geopolitical influence [140].

China's integrated space-ground network, anchored by five major remote sensing satellite ground stations and 38 large-diameter antennas, enables real-time data reception and disaster monitoring across the country and much of Asia [141]. These locations include Miyun near Beijing; Kashgar in the Xinjiang Uygur Autonomous Region; Sanya on the southern Hainan island; Lijiang in southwest China; and Mohe in the far north. This infrastructure supports both public and commercial applications and underpins China's ambition to shape global RS markets, challenging U.S. leadership and raising new economic and security risks for American interests [142] [143].

Investment Shifts

China's RS and SSA investment landscape evolved quickly over the past decade, driven by both government strategy and an influx of private capital. Government investment remains significant but unclear, with central policy prioritizing RS to boost competitiveness, digitalization, public services, and military modernization [144] [140]. The state has supported flagship projects like the Jilin-1 and SAR constellations, while also building out an advanced ground station network that processes data from over 76 satellites and manages more than 600 terabytes of EO data [141] [145].

Once again, data from Novaspace and Orbital Gateway Consulting will be leveraged here to provide quantitative analysis of Chinese space investment trends in the decade after sector reforms, combining a top-level government expenditure view with detailed numbers on breakdowns of commercial funding sources and segment allocations. For this section of the report, two specific verticals will be examined: EO (companies primarily operating EO satellites or providing downstream services) and Satellite Manufacturing (companies building satellites, satellite systems, or subsystems) [014].

As highlighted in prior sections, total government investment in China's civil and military space sectors reached approximately $85-95 billion by some accounts over the decade, while commercial space investment hit $11.4 billion, both showing strong growth from 2016 to 2024 according to Novaspace and Orbital Gateway Consulting benchmarks [078]. Within the commercial sector, EO/RS companies—those focused on operating EO satellites and providing downstream analytics—attracted a cumulative $994 million from 2015 to 2024, peaking sharply to $506 million in 2020 before returning to more modest levels in subsequent years [014].

In parallel, commercial satellite manufacturing received a staggering $3.1 billion in investment over the same period, a figure that expanded markedly from only $15 million in 2016 to $401 million about a half decade later. In 2024 investment rose to $832 million, notching the second biggest year of funding for any segment, behind only the satcom megaconstellation surge in the same year. Combined, the EO/RS operator/service providers and satellite manufacturers accounted for $4.1 billion in commercial investment resources since market opening, underscoring the strategic priority and rising market confidence in these foundational pillars of the Chinese space ecosystem [014].

Table 5: China Space Funding (with Earth Observation and Satellite Manufacturing Segment Call-outs)

China Space Investment *EO and Satellite Manufacturing* *(in Millions USD)*	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total 2015-2024
Estimated Government Expenditures into Full Civil & Military Sector --- *Source: Novaspace annual Government Space Programs Report*											
China	*4,210.00*	4,909.00	*5,300.00*	5,833.00	*7,300.00*	8,852.00	10,286.00	11,935.00	14,152.00	19,886.00	**92,663.00**
Investment into Commercial Sector by Source --- *Source: Orbital Gateway Consulting*											
Private	$122.31	$37.59	$94.34	$327.22	$493.12	$876.29	$595.78	$578.00	$423.68	$599.26	**$4,147.57**
Central Government	$35.75	$66.04	$44.73	$145.57	$261.39	$238.63	$211.22	$336.23	$256.25	$754.75	**$2,350.57**
City & Provincial Government	$181.90	$60.71	$199.50	$209.71	$350.52	$569.70	$561.94	$752.22	$520.79	$1,505.65	**$4,912.65**
Year subtotal	$339.96	$164.34	$338.57	$682.50	$1,105.04	$1,684.62	$1,368.95	$1,666.45	$1,200.71	$2,859.66	**$11,410.79**
Investment into Commercial Sub-Segment --- *Source: Orbital Gateway Consulting*											
Earth Observation segment	$4.19	$35.37	$20.81	$73.00	$147.97	$506.35	$46.92	$88.43	$22.14	$44.83	**$990.01**
Satellite Manufacturing segment	$0.81	$15.15	$66.10	$184.08	$176.99	$400.70	$304.62	$576.31	$544.00	$832.07	**$3,100.82**
Dual segment subtotal	$5.00	$50.51	$86.91	$257.08	$324.96	$907.05	$351.54	$664.74	$566.14	$876.90	**$4,090.83**

Earth Observation — Companies primarily operating EO satellites or providing downstream services.
Satellite Manufacturing — Companies building satellites, satellite systems, or subsystems.

3.3.3. What has China achieved?
RS & SSA

New Technologies, Installations, & Programs

RS Satellites — China's Made in China 2025 initiative has prioritized aerospace equipment and satellite telecommunications as critical sectors, driving the country to field over 300 RS satellites across at least nine major constellations. The select constellations and spacecraft listed below span land, sea, and atmospheric observation, reflecting China's ambition to lead in diverse RS capabilities [146].

Jilin-1 — This approximately 130-satellite constellation in LEO, operated by Chang Guang Satellite Technology (CGST), is the world's largest commercial remote-sensing constellation. Its mission is super-high-definition imaging for disaster warnings, ocean protection, and forestry. First launched in 2015, it demonstrated laser communications in June 2023 [147] [148].

Fengyun (FY) Series — China's main weather satellite family, with polar, geostationary Earth orbit (GEO), and SSO satellites, provides meteorological data, disaster risk reduction, and supports aviation, forestry, hydrology, and agriculture. The system has supported disaster mitigation in over 121 countries and serves national defense purposes [149] [150].

Gaofen China High-resolution Earth Observation System (CHEOS) Program (international) — This high-resolution EO constellation (14+ satellites in SSO plus 18 others) supports environmental protection, agriculture, and meteorology, with data shared internationally, including with BRICS and Roscosmos [151]. Gaofen 3-02 launched in November 2021.

Haiyang (HY) Series — An 8+ satellite LEO constellation for ocean monitoring, providing data on wind, sea levels, and temperatures for environmental protection. HY-1C/D have been operational since 2020 [152] [153].

Yaogan Series — With at least 18 satellites in LEO, Yaogan is widely analyzed as a military reconnaissance constellation (ELINT/SAR) focused on Pacific surveillance. Triplet launches have occurred since 2010, with the network completed in 2023 [154] [155].

Beijing-3C — This four-satellite optical EO constellation in SSO, launched in May 2024 and operated by Twenty First Century Aerospace Technology Co. Ltd (21AT), delivers 0.5-meter panchromatic and 2-meter multispectral imagery for land management, agriculture, ecological monitoring, and urban planning. Built by the China Academy of Space Technology, Beijing-3C is fully operational and returned its first images within a day of launch [156] [157].

Hongtu/PIESAT/Nuwa — This commercial X-band interferometric synthetic aperture radar (InSAR) constellation, operated by PIESAT Information Technology Co., Ltd, includes Hongtu-1 (PIESAT-1) launched in March 2023 and PIESAT-2 satellites launched in late 2024, all in SSO. Designed for high-precision terrain mapping, disaster monitoring, and resource management, the constellation is operational and expanding toward a planned 16 satellites [158] [159] [160].

Ziyuan China-Brazil Earth Remote Sensing Satellite (CBERS) Series (international) — This Earth resources monitoring constellation, developed with Brazil, consists of 10+ satellites in SSO. CBERS-04A, launched in December 2019, supports agriculture and deforestation tracking [161] [162].

TanSat — This LEO satellite, launched in 2016, monitors global carbon flux for climate research, sharing data via the Group on EOs [163].

Zhangheng-1 — A LEO ionospheric observation satellite, it scouts for seismo-electromagnetic signals that may foretell earthquakes [164].

Huanjing Jianzai-2A/2B — These SSO satellites are dedicated to disaster response and environmental monitoring [165].

CFOSAT (international) — The China-France Oceanography Satellite, launched in 2018, provides oceanographic data and exemplifies international partnership [166].

VRSS-2 / PRSS-1 (international) — Venezuelan and Pakistani resource monitoring satellites, respectively, developed in partnership with China [167] [168].

Future VLEO Constellation — China announced plans for a 300-satellite very low Earth orbit (VLEO) constellation by 2030, aiming for continuous global imaging coverage [169].

RS Commercial and Public Applications — China's rapidly advancing RS sector is driving a surge in both commercial and public service applications. Private firms are leveraging high-accuracy mapping, full-dimensional imaging, and advanced data processing to compete for large-scale geospatial contracts, with new uses emerging in insurance claims, real estate registration, and application software [170]. On the public side, RS satellites now underpin disaster mitigation, crisis response, weather forecasting, and climate monitoring efforts across China [171]. During the COVID-19 pandemic, satellite data was used for geolocation tracking, population monitoring, and logistics coordination, although this also spurred debate about expanded state surveillance under public health mandates [172]. As commercial and state-driven uses of RS multiply, China is positioning itself as a global leader in both the technology and its broad societal applications.

SSA Technologies & Approaches — China's approach to SSA is distinct from Western models, emphasizing autonomous LEO-based satellites over traditional networks of radars and telescopes due to limited global sensor access [173]. Western SSA models primarily rely on globally distributed ground-based radars and optical telescopes, integrated through networks like the U.S. Space Surveillance Network, to monitor, track, and share information on objects in orbit [174]. Chinese SSA is broadly defined as encompassing satellite-to-object scanning, tracking, cataloging, information fusion, intention determination, and maneuver decision processes. Recent advances include the Shijian-21 and Shijian-25 satellites maneuvering in GEO for on-orbit resupply and refueling demonstrations [175].

China is also expanding its SSA infrastructure beyond Earth orbit, with a particular focus on cislunar space. In June 2025, China announced three new lunar SSA projects: an expansion of the Chang'e Lunar Exploration Program, a low lunar orbit RS satellite with SAR, and a lunar far-side radio telescope for deep space tracking [176]. These efforts build on China's deployment of small satellites in specialized lunar orbits, such as those supporting the Queqiao relay network, which tested communications, navigation, and multi-orbital asset deployment for cislunar infrastructure [177]. This integrated, multi-orbit approach could lend itself to enhancing China's ability to monitor lunar activity and secure its ambitions in the Moon's vicinity.

New Stakeholders & Hubs

RS Provincial Clusters — China has transitioned significantly from replicating foreign technology to fostering indigenous innovations, and its innovation landscape for advanced industries—including commercial space—is increasingly shaped by dynamic provincial clusters that blend government, industry, and academic resources

[178]. In the northeast, the region encompassing Changchun, Harbin, and Jilin is home to CGST, a spinoff from the CAS that collaborates closely with the Harbin Institute of Technology and the Jilin industrial park. As of April 2025, CGST's Jilin-1 constellation comprises 117 satellites, with plans to reach 300 satellites by the end of the year, significantly enhancing global RS capabilities [179]. Cities like Shanghai have launched targeted action plans—such as the 2023 three-year initiative to advance commercial space and spatial information industries—to foster economies of scale, accelerate breakthroughs in reusable launch vehicles, and support integrated satellite manufacturing and application incubators [076]. Meanwhile, the Shenzhen-Hong Kong-Guangzhou cluster continues to rank second globally in the World Intellectual Property Organization's Global Innovation Index, reflecting its robust output in patents and scientific publications [180]. Shenzhen's Huaqiangbei market, once a hub for electronics trading, has evolved into a global center for technology prototyping, component sourcing, and rapid commercialization, fueling the city's gross domestic product (GDP) and global supply chain influence [181]. While it remains to be seen if any single Chinese cluster will rival the impact of Silicon Valley, the rapid growth of these innovation zones signals the potential for dramatic shifts in the global satellite and launch industries if similar acceleration occurs.

Satellite Manufacturing-- China is rapidly expanding its satellite manufacturing, with satellite production hubs firmly established in cities such as Wuhan, Taizhou, Beijing, and Shanghai, and especially in key districts like Haidian and Pudong which host clusters of operational factories. Other cities, including Wuxi, Wenchang, and Chengdu, are actively planning new satellite manufacturing capacity, aiming to support both government and commercial space initiatives [093]. A standout example is the Geespace satellite "superfactory" in Taizhou, Zhejiang Province. This facility leverages intelligent automation to assemble a new satellite in just 28 days, increasing output tenfold while driving down costs [182].

New International Engagement

International RS Applications for Natural Disasters & Climate — Beijing has leveraged its satellite infrastructure to provide emergency monitoring for events like the 2018 Laos dam collapse and Cyclone Idai in Mozambique [183]. It also contributes data to global frameworks like GEO/Group on Earth Observations System of Systems (GEOSS) and participates in the Space for Climate Observatory with France, Sweden, and others under the United Nations Office for Outer Space Affairs' (UNOOSA) informal coordination, alongside partners such as the ESA, the National Centre for Space Studies of France (CNES), the National Oceanic & Atmospheric Administration (NOAA), and Indian Space Research Organisation (ISRO) [184] [185]. Alongside these efforts, China has boosted its EO capacity to support developing countries' space programs in the Global South [186]. It has recently launched a second seismo-electromagnetic satellite in partnership with European collaborators, further expanding its international role in Earth science [187]. While official rhetoric highlights environmental stewardship, ambiguity in China's climate plans—such as the absence of concrete emissions targets—raises questions about whether strategy or sustainability is the primary driver [188]. Still, China's vulnerability to climate impacts makes serious engagement a logical national interest.

China's Collision Concerns — As China's presence in space grows, it is increasingly vocal about the need for domain management and non-weaponization. In 2021, China's Tiangong space station conducted what they described as evasive maneuvers on two occasions to avoid potential collisions with SpaceX's Starlink satellites, prompting Beijing to file a formal complaint with the United Nations (UN) and cite OST violations [189] [190]. In response, China expressed a desire to establish formal communication mechanisms with the United States to enhance space safety and prevent future incidents [191]. Although a U.S.-China space hotline was set up in 2015 to facilitate such exchanges, recent events suggest that these initiatives have not been effectively implemented [192]. Furthermore, these incidents highlight the urgent need for improved bilateral communication protocols as the proliferation of satellites in LEO increases the risk of collision and operational conflict [193].

3.3.4. What risks does America face?

RS & SSA

China's advancements in RS and SSA demonstrate a strategic integration of civil-military capabilities, expanding global influence through commercial constellations and infrastructure. These developments could challenge U.S. technological leadership and market dominance while raising dual-use security concerns.

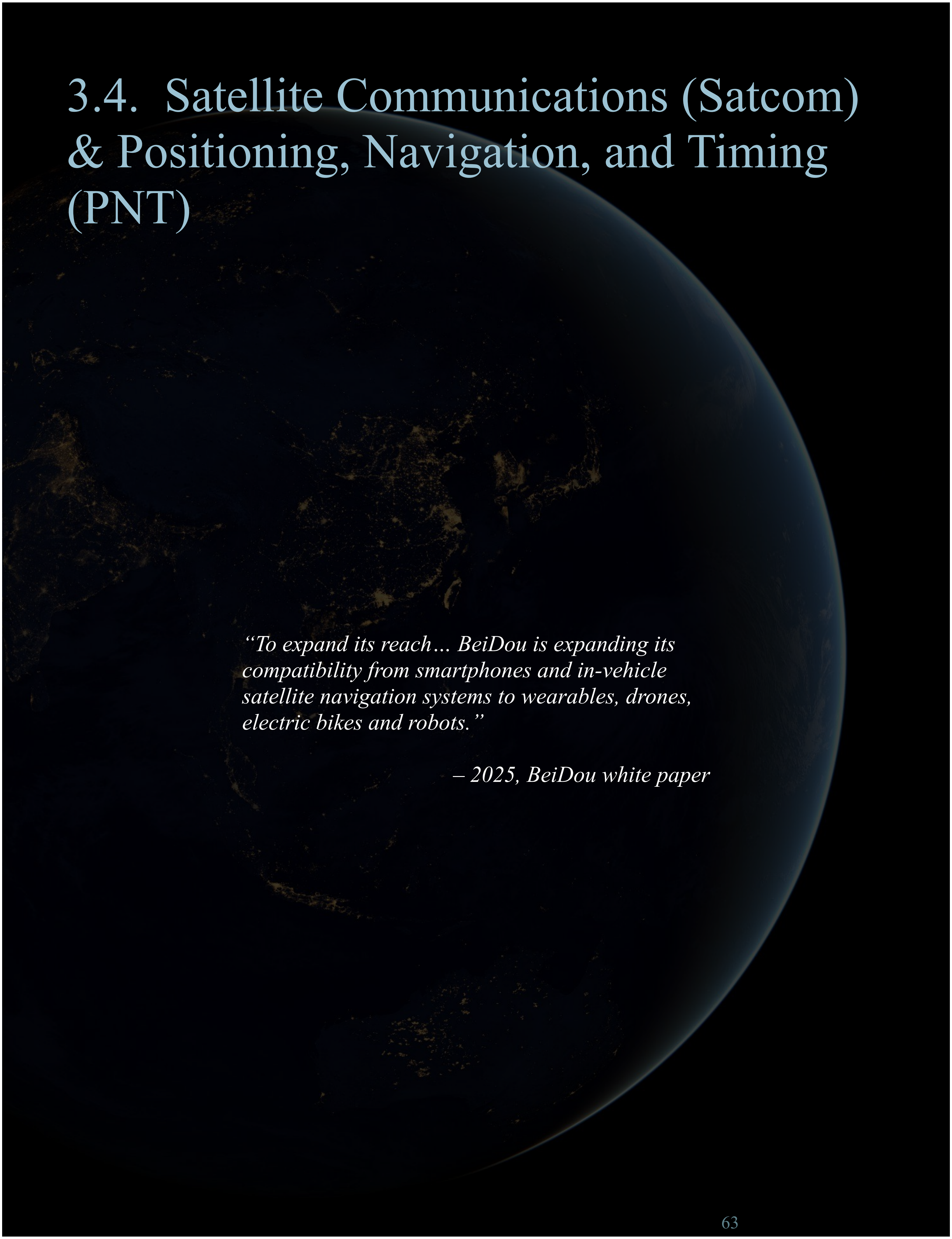
Segment-Specific Risks to American Industry

1. **Market erosion from commercial constellations**
   China's Jilin-1—the world's largest commercial sub-meter remote-sensing constellation with approximately 130 satellites—could undercut U.S. firms by offering high-resolution imagery at lower costs to international clients, threatening U.S. revenue streams in applications around agriculture, disaster monitoring, and urban planning.
2. **Data standard dominance via global platforms**
   China's national RS data platform aggregates resources from 30+ satellites and establishes BRICS/Belt and Road data-sharing centers, promoting Chinese technical standards internationally and potentially marginalizing U.S. geospatial data protocols [139].
3. **Supply chain vulnerabilities**
   China's dominant position on critical mineral mining and processing/refining could create dependency risks for U.S. satellite and aerospace component manufacturers reliant on rare-earth elements and advanced alloys [195].

National Strategic Risks

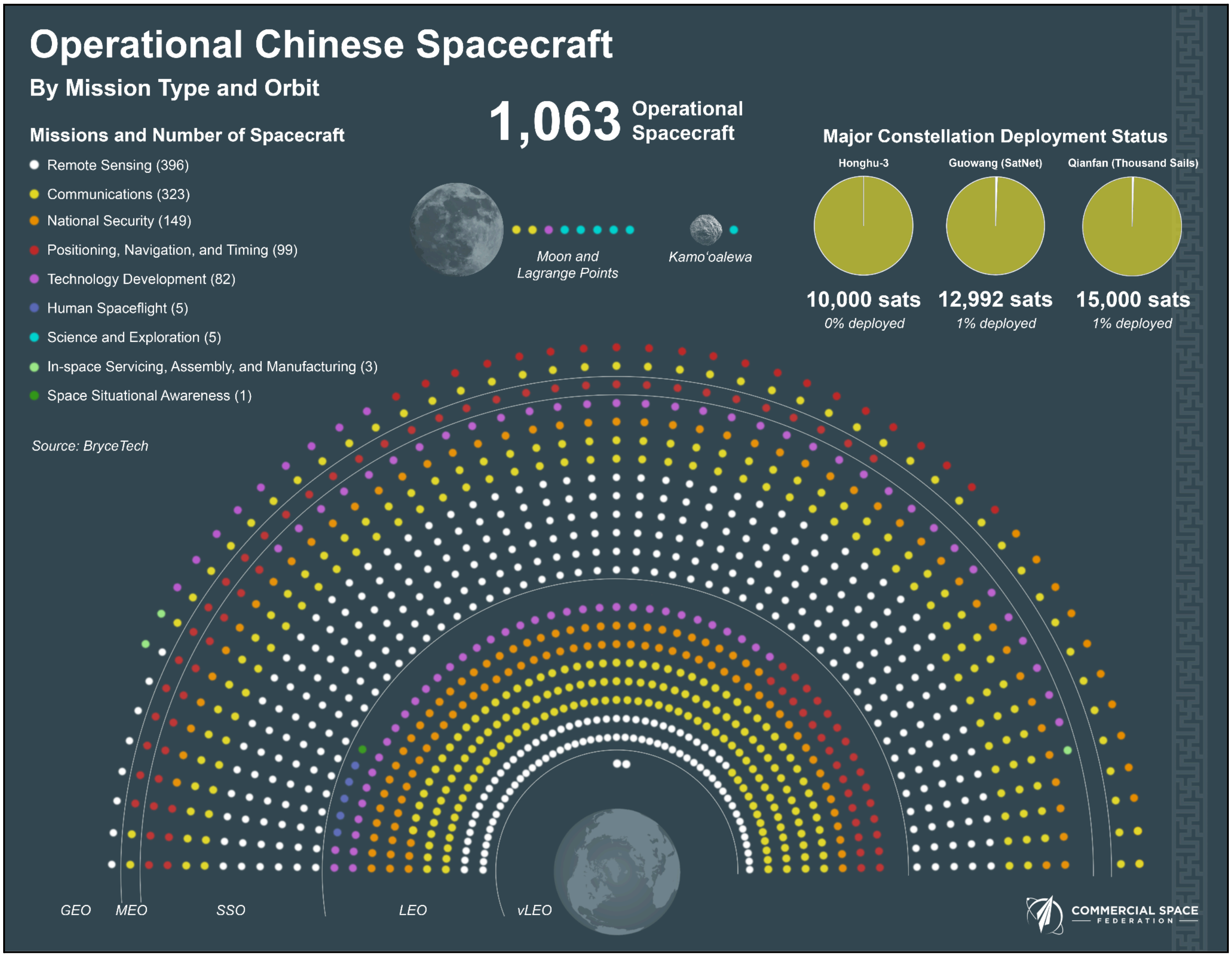
1. **Cislunar surveillance expansion**
   New lunar SSA projects—including a radio telescope and low-orbit SAR satellites—could extend China's domain awareness beyond Earth orbit, challenging U.S. space domain leadership in cislunar regions [176].
2. **Global disaster-response influence**
   China leverages RS for disaster aid in Global South nations (e.g., Mozambique, Laos), using data diplomacy to expand geopolitical sway and displace U.S. soft-power partnerships [183].

3.4. Satellite Communications (Satcom) & Positioning, Navigation, and Timing (PNT)



> *"To expand its reach… BeiDou is expanding its compatibility from smartphones and in-vehicle satellite navigation systems to wearables, drones, electric bikes and robots."*
>
> *– 2025, BeiDou white paper*

Figure 8 (reprinted): Operational Chinese Spacecraft by Mission Type & Orbit
(Satellites, Station modules, Cargo/Crew ships, Orbiters, Landers, & Probes) *Source: BryceTech*



3.4.1. What were China's goals?

Satcom & PNT

A decade ago, China's ambitions for the "Satcom & PNT" segment were already far-reaching, as articulated in the 2016 Space White Paper and reinforced by subsequent policy and regulatory actions. By 2016, China had established a comprehensive communications satellite system spanning fixed, mobile, and data relay platforms, covering the nation and extending to major global regions. Initial achievements included the launch of Tiantong-1, China's first mobile communications satellite, the completion of the first-generation Tianlian-1 data relay system, and the development of the Dongfanghong fifth generation communications satellite platform. For PNT, the Beidou-2 constellation was fully networked, providing services across the Asia-Pacific, while the global Beidou-3 system was under construction [010].

China's 10-year outlook called for building a space-ground integrated information network, expanding both LEO communications constellations, and synchronously developing ground infrastructure for TT&C, gateways, and uplinks. The aim was to deliver broadband, mobile, and multimedia services nationwide and globally, and to establish a fully integrated global satellite communications system [010]. In the second half of the decade, China began testing new commercial communications satellites, building a second-generation data relay system, and planning a large LEO constellation, confirmed by International Telecommunication Union (ITU) filings for nearly 13,000 satellites and strong support from national and local authorities [070] [196] [197].

For PNT, China's plans included enhancing Beidou's service capacity, completing a 35-satellite global network by 2020, and advancing both ground- and satellite-based augmentation. The 2021/2022 white paper outlined further upgrades to enable more integrated, precise, and intelligent national PNT services, with research into navigation-communications integration and LEO augmentation. China also began developing a next-generation BeiDou system with satellites at LEO, medium Earth orbit (MEO), and GEO, aiming for global leadership in resilient, multi-source PNT architecture [070] [198] [199].

3.4.2. How did China shift?

Satcom & PNT

Policy Shifts

China has prioritized satellite internet and commercial PNT applications as part of its national infrastructure and strategic policy since 2016, with satellite internet officially added to the "New Infrastructure" priorities in 2021 and the BeiDou navigation system completed on time in 2020 [200] [182] [201]. Then in 2023, China's satcom sector underwent a significant policy shift when a major regulator, the Ministry of Industry and Information Technology (MIIT), released its "Opinions on Innovating the Management of Information and Communications Industry to Optimize the Business Environment," effectively opening the door to commercial investment. The rapid result was SpaceSail raising over $1 billion and deploying 90 satellites within a year, and a state-backed competitor, China SatNet, transitioned from slow initial deployment to a surge in launches [202] [203].

Campaign Shifts

To drive these ambitions, China established the China Satellite Network Group to lead the Guowang broadband constellation, which aims to deploy as many as 26,000 satellites and directly compete with Western megaconstellations [204]. These national initiatives are fueling a wave of innovation among young engineers and entrepreneurs, particularly in manufacturing clusters across the country. As the government opens more of the space industry to commercial ventures, companies are racing to fill communications gaps in rural areas and to position themselves as global competitors [205] [206]. National authorities are channeling both industry and provincial resources into these projects, aiming to expand China's capabilities in satellite manufacturing and applications to meet surging domestic and international demand [206].

Investment Shifts

Government investment in China's satellite communications and PNT sector is substantial, with more than $10 billion allocated to the BeiDou navigation system and new funding streams directed at LEO broadband constellations such as the government-backed and prioritized Guowang megaconstellation, itself a merger and expansion of the Hongyun and Hongyan earlier constellation plans [207] [208]. This state-led funding is critical in building out national infrastructure, supporting both strategic autonomy in navigation and the rapid expansion of satellite internet capabilities. In parallel, China's satcom sector experienced a historic investment surge, highlighted by Shanghai Spacecom Satellite Technology (SSST), otherwise known as SpaceSail, securing a record-setting ¥6.7 billion (~$935 million) Series A round as part of a wave of funding into LEO broadband constellations that topped $1 billion in 2024. Riding a national policy push and new sector liberalizations, companies like SpaceSail and China SatNet began launching scores of new satellites, attracting a rush of public and private capital that signaled both rising global ambitions and the onset of a potential investment "bubble" in Chinese satellite communications [209] [210].

Continuing with the report's financial data sets, this section again leverages the Novaspace macro data and examines three specific verticals within Orbital Gateway Consulting's segmentation; Satellite Communications (companies whose primary line of business is operating communications satellites), the "Other" segment (primarily companies providing satellite navigation services or space-based services), and Satellite Manufacturing (companies building the satellites, satellite systems, or subsystems) [014]. Against the benchmark numbers of total government spending on China's civil and military space sectors at roughly $85–95 billion over the decade, and commercial sector funding totaling $11.4 billion over the same period, growth in the high-profile satcom and PNT segments of the industry follow that growth trend but with more sporadic surges than other segments [078].

The first year of market opening saw a striking $323 million flow into satellite communications operators, immediately eclipsing investment in every other segment. Over a half-decade later, satcom investment sputtered up and down from a similar yearly total. Then in 2024, the satcom segment experienced a record-setting year of investment totaling $1 billion, and contributing to its now sizable decade aggregate of $1.95 billion. As commercial satcom constellations and service providers expanded in dramatic leaps, the satellite navigation and space-based services segment (labeled here in the original data as "Other") has had the most tepid growth trend of the commercial sector, with $635 million cumulative investment over the decade [014].

Pure satellite manufacturing companies attracted $3.1 billion, and when combined with the commercial satcom and satellite navigation segments, this grouping of the satellite industry reached a total of $5.68 billion over a decade of growth. The broad-based growth of these verticals—each following its own trajectory during the first decade of China's commercial space sector—underscores the nation's ambition to close capability gaps and compete in high-value global market niches.

Table 7: China Space Funding (with Satellite Communications, Satellite Navigation and Space-based Services, and Satellite Manufacturing Segment Call-outs)

China Space Investment *Satcom, SatNav, & Satellite Manufacturing* *(in Millions USD)*	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total 2015-2024
Estimated Government Expenditures into Full Civil & Military Sector --- *Source: Novaspace annual Government Space Programs Report*											
China	*4,210.00*	4,909.00	*5,300.00*	5,833.00	*7,300.00*	8,852.00	10,286.00	11,935.00	14,152.00	19,886.00	**92,663.00**
Investment into Commercial Sector by Source --- *Source: Orbital Gateway Consulting*											
Private	$122.31	$37.59	$94.34	$327.22	$493.12	$876.29	$595.78	$578.00	$423.68	$599.26	**$4,147.57**
Central Government	$35.75	$66.04	$44.73	$145.57	$261.39	$238.63	$211.22	$336.23	$256.25	$754.75	**$2,350.57**
City & Provincial Government	$181.90	$60.71	$199.50	$209.71	$350.52	$569.70	$561.94	$752.22	$520.79	$1,505.65	**$4,912.65**
Year subtotal	$339.96	$164.34	$338.57	$682.50	$1,105.04	$1,684.62	$1,368.95	$1,666.45	$1,200.71	$2,859.66	**$11,410.79**
Investment into Commercial Sub-Segment --- *Source: Orbital Gateway Consulting*											
Satellite Communications segment	$322.58	$7.21	$9.45	$53.58	$206.88	$91.55	$162.31	$6.72	$85.71	$1,001.03	**$1,947.02**
Other (Satellite Navigation & Space-based Services) segment	$7.26	$0.00	$3.68	$16.92	$176.45	$36.97	$85.89	$197.39	$1.00	$109.31	**$634.86**
Satellite Manufacturing segment	$0.81	$15.15	$66.10	$184.08	$176.99	$400.70	$304.62	$576.31	$544.00	$832.07	**$3,100.82**
Grouped segment subtotal	$330.65	$22.35	$79.23	$254.58	$560.33	$529.23	$552.81	$780.41	$630.71	$1,942.41	**$5,682.70**

Satellite Communications operator — Companies operating communications satellites
Other — Primarily Companies providing satellite navigation services or space-based services
Satellite Manufacturing — Companies building satellites, satellite systems, or subsystems

3.4.3. What has China achieved?
Satcom & PNT

New Technologies, Installations, & Programs

Communication Satellites

Guowang (National Grid) — Planned as an approximately 13,000-satellite LEO broadband constellation operated by China SatNet, Guowang aims to deliver global internet coverage and compete directly with Starlink. Initial launches began in 2024, with full deployment targeted for the 2030s [211] [212].

Qianfan (Thousand Sails/G60 Starlink) — This LEO constellation, led by SpaceSail, will feature over 15,000 satellites at ~1,160 km to provide worldwide internet access. The first 18 satellites launched in 2024, with rapid expansion until late summer 2025 [213] [214].

Zhongxing (ChinaSat) Series — A GEO fleet operated by China Satcom, including Zhongxing-16 and APSTAR-6D, each offering up to 50 Gbps bandwidth for TV and broadband across China and neighboring regions. Major satellites launched since the early 2000s, with upgrades ongoing [183].

Tiantong-1 Constellation (international) — Three GEO satellites providing mobile voice, SMS, and data services to handheld devices across China, Southeast Asia, the Middle East, and Africa. The first satellite launched in 2016, with the third launched in 2021 [215].

Tianlian Relay Satellite System — A GEO relay network supporting data relay, telemetry, and command for China's space missions and communications. The first satellite launched in 2008 with the latest Tianlian-2 satellites added in subsequent launches through 2025 [216].

PNT Satellites

BeiDou-3 Constellation (international promotion) — Comprising 44 operational satellites as of 2024, including 7 GEO, 10 inclined geosynchronous (IGSO), and 27 MEO satellites, BeiDou-3 provides global PNT services with enhanced accuracy and multiple signal frequencies. Operated and built by China, it was declared fully deployed in June 2020 and supports applications from navigation to search and rescue [218] [219] [220].

BeiDou Satellite-Based Augmentation System (BDSBAS) — A GEO augmentation network designed to improve BeiDou's positioning accuracy and reliability, similar to the U.S. WAAS system. It has offered initial single- and dual-frequency services since 2020, achieving sub-meter positioning accuracy in tested regions [221] [222].

BeiDou Search and Rescue Payloads — Six MEO satellites equipped with maritime search and rescue transponders provide two-way distress signal communication with under 12-second delay and over 96 percent success rate, enhancing emergency response capabilities globally [222].

International Cooperation and Standards Integration — BeiDou has been integrated into international civil aviation and technical standards (International Civil Aviation Organization ((ICAO)), International Electrotechnical Commission ((IEC))) and actively promoted through bilateral and multilateral partnerships with entities such as the African Union, Association of Southeast Asian Nations (ASEAN), and the Arab League. China continues efforts to expand BeiDou's global adoption and interoperability with GPS, Galileo, and GLONASS [223] [224] [225].

BeiDou Applications — Widely used in transportation, agriculture, infrastructure, military, financial timing, and emergency services, BeiDou's PNT capabilities underpin critical national and international systems, contributing to an industry output valued at over RMB 530 billion (approximately $74.2 billion) in 2023 [226] [222].

Window Narrowing to Maintain Radio Frequencies for Megaconstellations — A crucial question has emerged for the megaconstellations, Guowang and Qianfan that are intended to rival Starlink and transform both national and global connectivity; can these projects deploy quickly enough to retain their international spectrum rights? The window to secure and maintain radio frequencies for these ambitious Chinese initiatives is rapidly narrowing. ITU rules require that a constellation launch half its satellites within five years and complete deployment within seven years of its frequency filing, or face reduction in spectrum rights. Chinese projects like Guowang and Qianfan are behind on these benchmarks, risking a cutoff if their launch pace does not accelerate [227]. This regulatory pressure adds urgency to China's efforts to master reusable rocket technology, which highlights national initiatives and commercial progress toward rapid, cost-effective launches needed for megaconstellation deployment [228]. Technical setbacks and programmatic delays have compounded the risk of missing these critical ITU milestones [229].

In August 2025, Guowang surged back into a deployment cadence, launching 47 satellites across six missions and raising its total operational count to around 100, now surpassing Qianfan in both pace and scale. It's suggested that this rapid comeback is directly linked to a new, telecom-experienced management team prioritizing ITU regulatory deadlines for frequency and orbit, and demonstrates the state's ability to marshal resources, launch cadence, and manufacturing capacity to keep its national megaconstellation strategy firmly on track. Furthermore, this overtaking of the headstart Qianfan established over the last year recalls past industry trends where directly-backed government initiatives still can take precedence over fully commercial ones [202].

CASIC's Next-gen Communication Platforms — CASIC has accelerated its development of next-generation satellite and satellite-adjacent technologies aimed at expanding 5G coverage and enhancing national telecommunications infrastructure. Among its most ambitious projects is the Feiyun solar-powered drone array, designed to establish a near-space network capable of supporting emergency telecommunications and internet services, effectively bridging connectivity gaps in remote or disaster-affected regions [230]. In parallel, CASIC is advancing the Kuaiyun stratospheric balloon array and the Tengyun spaceplane—a reusable, two-stage-to-orbit vehicle targeting commercial operations and reflecting China's broader push for cost-effective, flexible access to space [231]. Complementing these efforts, CASIC's satellite constellation initiatives include the Xingyun (X-cloud) internet of things (IoT)-focused L-band system, which is already deploying two of its planned 80 spacecraft to support a range of commercial and industrial connectivity applications [232]

Commercial & Public Service Uses of Satcom & PNT — China's commercial Satcom and PNT sectors are rapidly advancing, with technologies increasingly integrated into consumer and industrial markets. The Lenovo Z6 smartphone, equipped with dual-frequency GNSS and an Allystar chipset, now offers sub-meter positioning accuracy, highlighting improvements in China's PNT services [233]. Satellite communications have expanded to provide 4K television broadcasting and in-route internet for ships and planes, reflecting the growing impact of satellite technology investments [170]. BeiDou has enabled the sale of over 100 million compatible chips worldwide, supporting precise navigation in the automotive and other sectors where companies such as Geely are launching their own constellations to deliver centimeter-level positioning for intelligent driving [234] [235].

As for public services, satellite broadcasting constellations have expanded internet and mobile access to rural and remote regions, improving assistance during emergencies like wildfires and typhoons [236]. BeiDou's PNT services have supported hospital planning during the Covid-19 pandemic, guided fishing vessels, and enabled tracking for freight and supply chains, demonstrating their growing role in national emergency response and public infrastructure [237].

New Stakeholders & Hubs

Satcom & PNT Provincial Clusters — Shanghai is the flagship hub for China's satellite communications industry, anchored by the SpaceSail "Thousand Sails" (Qianfan) megaconstellation. Supported by the municipal government, CAS, and leading firms like SpaceSail and Genesat, Shanghai is one city leading China's push for LEO broadband internet through modular satellite mass production and constellation integration, positioning the project as a direct rival to U.S. capabilities such as Starlink [238] [213] [239].

Beijing serves as the strategic command and policy center for both PNT and Satcom, hosting the China Satellite Navigation Office, CAST, CASC, and CNSA, and overseeing BeiDou's national development and system architecture [240]. Nantong city is home to GalaxySpace's smart factory, producing hundreds of satellites a year [241]. While HiStarlink is headquartered in Shenzhen province and is developing satellite-based laser communication technology leading in phased-array antennas and mobile user tech for LEO broadband [242]. And Xi'an is the core hub for BeiDou signal transmission, timing algorithms, and chipsets, home to the Xi'an Satellite Control Center and key GNSS research institutes [243].

New International Engagement

BeiDou's Global Expansion Strategy — China is aggressively promoting the BeiDou Navigation Satellite System (BDS) as a central pillar of its international space strategy, positioning it as a global alternative to GPS and a flagship offering within its BRI and SIC initiatives. Chinese officials use U.N.-aligned language emphasizing a "fair and reasonable order" and encourage partner countries to adopt BeiDou to boost socio-economic development. Projects in Africa and the Middle East, such as Egypt's Space City and Pakistan's space center collaboration, exemplify this push, reflecting deepening space cooperation and integration of BeiDou into local infrastructure and applications [244] [245] [246].

China is expanding BeiDou's infrastructure domestically and across Belt and Road partner nations, aiming to provide comprehensive PNT services, especially in regions where GPS coverage is less effective. This expansion supports strategic industries including smart logistics, transportation, and smart city development, aiming to bolster technological influence and economic ties [224]. Additionally, major chip manufacturers like Qualcomm produce GNSS chips compatible with BeiDou and Western systems, anticipating their growing influence [247]. While U.S. entities remain cautious, China's push to embed BeiDou in partner countries' infrastructure is reshaping global navigation and communications networks [248].

Data from the GNSS and LBS Association of China claim that the system produced an economic output of RMB 575.8 billion (around $79.9 billion USD) in 2024 [249]. This number is likely calculated to include broad services Beidou is now compatible with, including smartphones, in-vehicle systems, wearables, drones, and electric bikes, logistics, mapping, and agriculture, and IoT. As a core part of China's global space strategy, the SIC integrates BeiDou, RS, and communications satellites to connect Belt and Road countries to China's space infrastructure and standards. While officially framed as shared development, some analysts view the SIC as a strategic tool to increase foreign dependency on Chinese systems [250].

3.4.4. What risks does America face?

Satcom & PNT

China's rapid deployment of megaconstellations and the global integration of BeiDou could fundamentally alter the competitive and strategic landscape for satellite communications and PNT. State-backed investment, aggressive standards promotion, and deepening international partnerships could threaten to displace U.S. industry leadership and erode American influence over global space infrastructure and norms.

Segment-Specific Risks to American Industry

- **Direct Competition from State-Backed Megaconstellations**
  China's Guowang and Qianfan LEO broadband projects, each targeting deployment of over 13,000 satellites, are positioned to rival large-scale U.S. commercial leaders like Starlink, and to compete in overlapping markets with European providers such as Eutelsat OneWeb These initiatives leverage state funding and regulatory support to eventually offer global internet at lower prices, threatening to undercut U.S. providers in both established and emerging markets [205] [214]. Granted, these Chinese efforts are currently behind American deployment of parallel broadband megaconstellations, but once China's reusable rockets mature, it may likely enable their rapid satellite constellation deployment, reshaping the associated markets [251].

- **BeiDou's Global Integration Displacing U.S. PNT Market Share**
  BeiDou is now operational in over 130 countries and is being embedded in smartphones, vehicles, wearables, and critical infrastructure, challenging U.S. legacy leadership in navigation and timing services and opening international markets to Chinese standards and hardware [199] [223].

National Strategic Risks

- **Erosion of U.S. Space Infrastructure Resilience and Influence**
  China's SIC and global Satcom/PNT infrastructure reduce U.S. economic and political influence in critical regions and expose participants to potential disruption or denial of service in contested environments [250]. Furthermore, by embedding BeiDou and Chinese Satcom in partner nations' infrastructure and aligning with international standards bodies, China may shift the balance of power in global space governance, threatening the U.S. ability to shape norms, standards, and security protocols in the space domain [244].

- **Centralized Strategy Arriving at Unknown Emergent Technologies First**
  China's top-down approach to unifying satellite navigation, EO, and communications under cohesive national planning may enable the development of advanced, integrated space capabilities that are difficult to anticipate or counter. In contrast, the more decentralized nature of U.S. policy may hinder our ability to match or preempt such innovation at scale.

3.5. Commercial LEO

"Sometimes another spacecraft may deliberately come close [to Tiangong] – maybe just to take a look – but it can still interfere with our operations …we first try to assess their intent. Then we choose how to respond – whether by dodging, adjusting our orbit, or releasing a small robot to grab and redirect the object."

– 2025, Sun Zhibin, of the National Space Science Centre in Beijing

3.5.1. What were China's goals?

Commercial LEO

In the mid 2010's, China's ambitions for the "Commercial LEO" segment were centered on mastering the technologies needed for sustained human presence and operations in LEO. By 2016, China had achieved major milestones: Shenzhou-9 and Shenzhou-10 docked with Tiangong-1, demonstrating both manual and automatic rendezvous and docking, and Tiangong-2 with Shenzhou-11 enabled mid-term astronaut stays and complex in-orbit operations. These successes established China's foundation in manned space transportation, assembly, and in-orbit support [010].

For the first half of the decade, China's plans focused on launching the Tianzhou-1 cargo spacecraft to dock with Tiangong-2, advancing cargo transport and replenishment technologies, and laying the groundwork for a modular space station to come that would simply be titled the Tiangong, or "Heavenly Palace." Tiangong-2 was deorbited in 2019. The aim was to complete R&D on space station modules, begin assembly, and conduct experiments to raise manned spaceflight capacity, including in-orbit servicing and new technology demonstrations. By the second half of the decade, China's aspirations expanded to launching the Tianhe core cabin module, Wentian and Mengtian modules, the Xuntian space telescope, and additional Shenzhou and Tianzhou missions to complete and operate the space station. Plans included large-scale scientific research, in-orbit servicing, and technology tests—such as mission extension vehicles and debris cleaning—while also advancing preparations for human lunar exploration and developing new-generation manned spacecraft [010] [070].

3.5.2. How did China shift?

Commercial LEO

Policy Shifts

Between 2014 and 2024, China's commercial space sector underwent dramatic transformation, driven by major policy reforms and targeted local initiatives. The 2014 State Council decision to open the sector to private capital sparked explosive growth, with the number of commercial space companies now surpassing 500 by 2025 and private firms now accounting for the majority of new entrants [071] [107]. In 2024, "Negative List" reforms further reduced barriers for foreign and private investment in LEO ventures, enhancing market accessibility and competition [252] [253].

Campaign Shifts

Local governments have accelerated this momentum by drafting action plans to embrace commercial space, establishing industrial parks to attract and cluster commercial LEO activity, in large and new metros alike, including Wuxi, Wuhan, Shanghai, Xiong'an near Beijing, and Yangjian near Guangdong. These initiatives have fostered dense innovation ecosystems, enabling rapid advances in reusable rockets, mass satellite production, and integrated space infrastructure [254].

Investment Shifts

China's funding for its manned space program, including the Tiangong space station, is substantial but remains partly opaque due to the structure of national and military budgets. Even at Euroconsult's $19.89 billion estimate for China's 2024 expenditures into its whole government sector space program, analysts believe this stated figure is likely insufficient for China to simultaneously support both the ongoing operations of Tiangong—which ushers in continuous crewed presence—and a projected $100 billion or more lunar campaign, suggesting that true investment into either campaign may be higher and distributed within less transparent budget lines [255] [256].

Meanwhile, China is credited with building Tiangong for only about $8 billion, according to interviews with chief designer Zhou Jianping from reporting around the time of its completion in late 2022. In comparison, the National Aeronautics and Space Administration's (NASA) annual International Space Station (ISS) budget is $3-4 billion, while the overall ISS budget has well exceeded $100 billion over its lifetime. Such disparity could highlight China's strategic drive to project space leadership with more focused investment per achievement [257].

Historical budget data suggests steadily increasing Chinese manned space program expenditures which largely relate to Tiangong currently. Official data shows China allocated over $5.07 billion from 1992 to 2011 on crewed space [258]. After two decades of lead up, Euroconsult states that crewed programming grew to about 33 percent of China's annual space budget in 2015 and 2016 [259]. Without further detailed data on China's crewed program, we can only envision a rough estimate for our decade of focus. If this 33 percent proportion remained the trend over Euroconsult's 2015-2024 annual expenditure figures, crewed space expenditures would stand at $1.620 billion in 2016 (33 percent of $4.91 billion) upward to $6.56 billion in 2024 (33 percent of $19.88 billion), and roughly $30.58 billion over the whole decade (33 percent of $92.66 billion) [255] . Such figures would reasonably show that China's manned space activities are underpinned by both long-term, incremental investment and ambitious recent spending, combining efficiency with an expanding strategic commitment to LEO.

3.5.3. What has China achieved?

Commercial LEO

New Technologies, Installations, & Programs

***CMS & Tiangong Space Station* —** China's crewed program is known in English as the Chinese Manned Space Program (CMS). They have completed their three-phase project, laid out as "(1) demonstrating crewed spacecraft launch and return; (2) building a laboratory capable of extravehicular activities (EVA), rendezvous, and docking; and (3) construction and maintenance of a long term space station". In April 2021, China launched the Tianhe ("harmony of heaven") core module, initiating the assembly of their Tiangong space station, and quickly began a consistent transport of cargo aboard Tianzhou ships and astronaut crews aboard Shenzhou spacecraft up to Tianhe. The Shenzhou is a state-manufactured equivalent to the SpaceX Crew Dragon and Boeing Starliner [260].

***Tiangong Modules & Components* —** China completed the core construction of its Tiangong space station in the second half of 2022 with the addition of two laboratory modules; Wentian ("Quest for the Heavens"), launched in July 2022, and Mengtian ("Dreaming of the Heavens"), launched in October 2022 [261] [262]. Both modules were launched fully assembled, similar to the Roscosmos Mir station, and docked with the Tianhe core module. They provide independent pressurized environments and house over two dozen experimental racks to support a wide range of scientific research. Tiangong is expected to operate for fifteen years or more and serve as a platform for both national and international scientific research collaborations [256].

In 2023, Chinese officials confirmed plans to expand Tiangong to as many as six modules, with the fifth and sixth modules expected to serve as additional science laboratories [264] [265]. The station's goal is to support 1,000 science missions over its projected lifespan, signaling China's ambition to rival the scientific output of the ISS [266].

***Tiangong Servicing & Activity* —** Looking ahead, the Tiangong Chinese Space Station (CSS) will be joined by the Xuntian (Chinese Space Station Telescope, CSST) in 2025. Xuntian will co-orbit with Tiangong and periodically dock for repairs, refueling, and upgrades. The telescope offers a field of view over 300 times greater than Hubble with similar spatial resolution, and carries a 2.5-billion-pixel camera designed to survey approximately 40 percent of the sky over a 10-year mission [267] [268].

Tiangong's logistics rely mainly on the Tianzhou cargo spacecraft, launched by LM 7 rockets. Since 2021, China has encouraged commercial cargo providers, signaling a shift toward broader participation in station resupply. New experimental cargo vehicle designs include Haolong, developed by AVIC's Chengdu Aircraft Design Institute, with a 7,000 kg capacity and Qingzhou, developed by Innovation Academy for Microsatellites (IAMCAS), set to launch on CAS Space's Kineticca-2 with up to 2,000 kg capacity [264].

On-orbit Tech Demos — China's Tiangong space station is at the forefront of some on-orbit technology demonstrations. Since 2024, it has hosted in-orbit validation of over 20 high-performance process chips ranging from 16–28 nm.. These Chinese domestically designed chips such as those from Loongson—a competitor to Advanced Micro Devices and Intel—offer space-hardened, cost-effective computing and reportedly outperform the processors used by other countries in space, likely supporting China's ambitions in space-based artificial intelligence (AI) and autonomous systems [269] [270].

Tiangong is also advancing lunar construction research. In late 2024, the Tianzhou-8 mission delivered bricks made from simulated lunar regolith, which are now exposed on the station's exterior for a three-year test of their durability against vacuum, radiation, and temperature extremes. These bricks, which are over three times stronger than standard red or concrete bricks, will be returned to Earth for analysis and will inform techniques for 3D-printing lunar habitats as part of China's ILRS [271] [272] [273] [274].

Tiangong Classroom — China has intensified efforts to inspire youth toward space careers through the Tiangong Classroom series, where taikonauts aboard the Tiangong space station conduct live experiments and interact in real time with students from elementary to high school. These sessions introduce students to the station's facilities, scientific experiments, and principles behind them, often demonstrating microgravity effects such as spherical flames and gyroscopic motion. On September 21, 2023, the fourth classroom session broadcasted from the Mengtian lab module, connecting with five ground classrooms—including Beihang University and several science museums—and engaged over 2,400 students and teachers [275].

New Stakeholders & Hubs

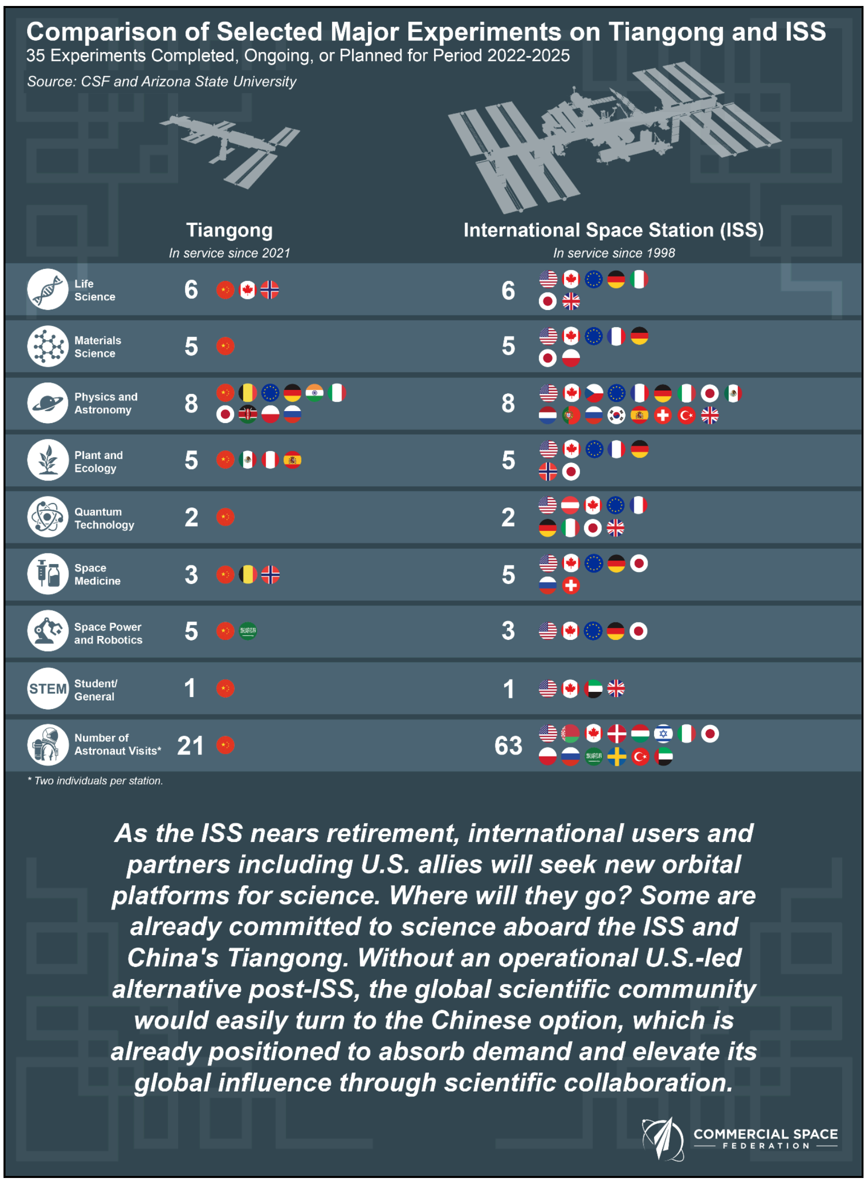
First Commercial Actors — There are reports of Chinese companies pursuing crewed and commercial LEO activities now as well. AZSpace's Dier-5 commercial spacecraft left its Wuxi factory in advance of a fall 2025 launch on ExSpace's Kuaizhou rocket, continuing its success as a Chinese manufacturer of orbital platforms, now for cargo and, eventually, crewed tourism. Alongside AZSpace's progress, other Chinese commercial companies, including CAS Space, and Deep Blue Aerospace, are also developing vehicles for suborbital tourism, while plans to open the Tiangong space station to civilian visits have circulated in the industry [276].

ISAM — China's in-space servicing, assembly, and manufacturing (ISAM) efforts have developed in recent years, blending military and commercial initiatives. Particularly, the Shijian satellite series has since demonstrated increasingly advanced capabilities. Shijian-17 (2016) showcased robotic arm operations, while Shijian-21 (2021), built by SAST, performed China's first active debris removal in GEO by towing a defunct Beidou satellite to a graveyard orbit [277]. In 2025, Shijian-25 conducted China's first publicly disclosed satellite refueling demonstration in GEO, and Shijian-26, developed by Dongfanghong Satellite Co. and academic partners, advanced on-orbit servicing and debris removal. Through 2024, there has been a noticeable increase in commercial companies entering the ISAM market, including firms like InfinAstro and Sustain Space, a subsidiary of Emposat founded in 2022 that secured early funding to develop on-orbit servicing and debris removal technologies [278] [279].

China's LEO activity ambitions extend to large-scale orbital infrastructure and resource utilization. There are reports that CAST has outlined a roadmap for space-based solar power (SBSP), targeting a 10 kW LEO demonstrator by 2028, a one mW GEO station by 2030, and a 2 gW commercial plant by 2050 [277]. In 2024, taikonauts aboard Tiangong produced ethylene, a key rocket fuel component, using artificial photosynthesis [280]. China and Russia are also planning to build a nuclear power facility on the Moon to support their ILRS ambitions [281]. Meanwhile, Tiangong is being equipped with self-defense robots and robotic assistants to enhance station security and crew support, further corroborating China's interest in autonomous and resilient space operations [282] [283].

Figure 9: Comparison of Selected Major Experiments on Tiangong and ISS

Source: ASU/CSF



New International Engagement

CES – Taikonaut Training & Cooperation — China's Tiangong space station is increasingly open to international participation. In February 2025, China and Pakistan signed an agreement to train and send a Pakistani astronaut to Tiangong, which will mark the first time a foreign astronaut will be hosted aboard the station [246] [284]. The ESA and China had engaged in joint astronaut training in the past, though discontinued currently. The training included sea survival exercises and other programming to prepare for potential future ESA missions on Tiangong [285] [288]. China has renewed its cooperation with the UNOOSA and at various points signed agreements with ESA, Russia, France, Germany, Italy, and Pakistan to support international payload experiments aboard the station [286] [287].

Science & International Experiments — China has also attempted to build international leadership via scientific collaborations. Notable examples of joint research on Tiangong or its predecessors include gamma-ray burst polarization studies with ESA on Tiangong-2, microgravity medical research with France during Shenzhou-11, numerous protein crystallization and stem cell studies, and a world-first demonstration of a space cold atomic clock. As of December 2023, 181 experiments and application projects had been selected [289]. The station plans to host international experiments through collaborations with UNOOSA's "Access to Space for All" initiative, involving scientists from countries such as Germany, Switzerland, India, Poland, Italy, Russia, Belgium, Norway, Japan, Peru, Mexico, Spain, Kenya, and Saudi Arabia [290] [291]. Tiangong's continuous presence in orbit is hoping to stimulate further industrial developments, including docking vehicles, fuel systems, experimental pods, space debris mitigation technologies, and life support systems [292].

3.5.4. What risks does America face?

Commercial LEO

China's commercial LEO ecosystem is maturing, blending state-driven investment and technological innovation to create a competitive platform centered on the Tiangong space station alongside a network of civil and commercial ventures. While this development doesn't currently challenge U.S. leadership in LEO or access to research, parallel commercial station efforts backed by NASA and industry will be necessary to sustain and renew American influence, and must be successfully and urgently deployed.

Segment-Specific Risks to American Industry

- **Accelerated Commercialization and Market Access**
  China's domestic entrepreneurship reforms, foreign investment reforms, local government industrial parks, and targeted investment have enabled 100's of commercial space companies to emerge, with private firms now even broaching LEO technologies. This could develop further and put pressure on U.S. firms vying to provide commercial LEO destinations near the turn of the decade [254] [252].

- **Advanced On-Orbit Manufacturing and Servicing Capabilities**
  Tiangong's testing of high-performance, cost-effective chips, novel robotics, and ISAM demonstrations—including debris removal and satellite refueling—strengthens China's position in next-generation orbital services and in-space industrialization [276] [278].

- **International Collaboration and Standards Setting**
  China's Tiangong station will soon officially host international astronauts, its predecessor has already supported international scientific experiments, and the collective Chinese space station program is

aligning research plans for broader participation. This growing openness presents the possibility of shifting international partnerships and technical standards [246] [290].

National Strategic Risks

- **Dual-Use Technology and Security Concerns**
  The integration of self-defense robots, AI assistants, and ISAM technologies on Tiangong blurs the boundary between civil and military applications, complicating U.S. monitoring and raising the risk of LEO becoming a contested security domain [282].

- **Erosion of U.S. Leadership in LEO Science and Industry**
  Tiangong is reaching operational milestones in research and maintaining commitments to international collaboration and research goals such as their ambition to host 1,000 science missions in the near future. With this, China could be positioned to compete as a major hub for LEO science and industry; however, the success and integration of new U.S. commercial stations could help preserve or reassert American leadership in shaping the future landscape of human spaceflight [256].

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3.6. Space Exploration

"In view of the progress being made around the world, we are expected to become the first country to deliver samples from Mars…"

– 2024, Wu Weiren, CLEP Chief Architect

3.6.1. What were China's goals?
Space Exploration

China’s ambitions for space exploration beyond Earth orbit were already substantial a decade ago, as outlined in the 2016 Space White Paper. By then, China had achieved several milestones: Chang’e-2 completed a flyby of asteroid Toutatis, Chang’e-3 achieved the nation’s first soft landing on the Moon, and a successful high-speed reentry test demonstrated mastery of critical return technologies. These efforts yielded high-resolution lunar mapping, surface composition studies, and new data on the lunar environment, establishing China’s credibility as a deep space actor [010].

Looking ahead, China’s 10-year roadmap focused on completing the “orbiting, landing, and returning” phases of its lunar program. The plan called for launching Chang’e-5 for lunar sample return, Chang’e-4 for the first soft landing on the Moon’s far side, and conducting advanced geological and astronomical research at new landing sites. China also aimed to initiate its first Mars mission by 2020, with goals to master orbiting, landing, and roving technologies, and to lay the groundwork for future Mars sample return, asteroid exploration, and even Jupiter system studies. The 2016 white paper emphasized international collaboration and tackling fundamental scientific questions about the solar system and the search for extraterrestrial life [010].

By 2021/2022, China’s aspirations had expanded further; plans included launching Chang’e-6 and Chang’e-7 for lunar polar exploration and sample return, developing Chang’e-8 as a precursor to an international lunar research station, and deploying asteroid and comet probes. The strategy also called for advancing Mars sample return, Jupiter system exploration, and boundary exploration of the solar system. China aimed to pioneer new technologies such as smart spacecraft management and innovative propulsion, while using platforms like the Chang’e series and Tianwen-1 to conduct research in life sciences and materials, consolidating its role as a leader in planetary and deep space exploration [070].

3.6.2. How did China shift?
Space Exploration

Policy Shifts

From 2015 to 2024, China enacted a series of major policy shifts that have reshaped its space exploration agenda beyond Earth orbit. The 2021 space white paper formalized national priorities for a crewed lunar landing by 2030, Mars sample return, and the creation of an ILRS in partnership with Russia and other countries [293]. The 2024 National Space Science Development Program (2024–2050) further outlined a roadmap for deep space exploration, identifying 17 priority areas and explicitly supporting missions to the Moon, Mars, asteroids, and beyond [294] [295].

These policy shifts have translated into concrete mission planning and technology development; China’s Chang’e-7 and Chang’e-8 missions will focus on lunar south pole resource surveys and in-situ resource utilization, laying the groundwork for a permanent lunar base and the ILRS [296]. The Tianwen planetary series expanded, with Tianwen-2 launching in 2025 for asteroid exploration, Tianwen-3 targeting Mars sample return around 2030, and Tianwen-4 set to explore the Jupiter system. Parallel to mission planning, China has prioritized the development of super-heavy (LM 9) and next-generation heavy lift vehicles (LM 10) and new crewed spacecraft, all aimed at enabling sustainable crewed exploration of the Moon and, by the 2040s, Mars [297].

Campaign Shifts

Between 2015 and 2024, China launched a series of high-profile campaigns and public initiatives that accelerated the growth and visibility of its space ecosystem. In 2024, China's Chang'e-6 lunar mission and the ILRS were prominently featured in national media and public campaigns, further cementing space exploration as a source of national pride and international prestige [299] [204]. Domestically, China fueled a surge in space-focused culture and workforce development. Beyond televised Tiangong Classroom lessons, the country has established immersive Mars simulation bases—such as "Mars Base 1" in Gansu province—where students and visitors experience Martian-like environments, simulated rocket launches, and hands-on science activities [300] [301]. Expansion of S&T museums, like the Shanghai Science and Technology Museum (which draws millions of visitors annually), and the integration of space themes in China's booming theme park industry, all serve to inspire youth and the public, humanize the space program, and cultivate a new generation of talent and enthusiasm for space careers [302] [303].

Investment Shifts

Precise data on China's investment into its space exploration segment is difficult to pinpoint, whether direct expenditures of the government on its civil exploration programs or government investment into private enterprise supporting lunar and deep space exploration. That being said, as early as 2015 there were reports that China's lunar exploration program might also begin involving the commercial sector to help shift away from "State-owned companies' monopoly in the space field" and accelerate technological innovation [304].

We see from 2015 to 2024, China significantly increased activity in lunar and deep space exploration programs, which would necessitate increases in budget and authorization. Some analysts forecast that expansion in China's lunar program budget is particularly expected to rise within the overall yearly increases of government funding into the civil and military space sectors [252]. Looking at the macro budget numbers, Euroconsult shows this annual overall government expenditure figure reached almost $20 billion in 2024 and had steadily increased each year since at least 2020. Similarly, the proportion of government-backed investment into private sector space ventures also increased over the same period, from 48 percent of investment in 2020 to 79 percent in 2024 [014].

Alongside this trend, there are recent reports of China commercial involvement in its lunar program is being realized, with private firms such as Star.Vision Aerospace Group Limited collaborating on satellite design, AI data analysis, and intelligent satellite platforms in the lead up to the Chang'e-8 mission [305] [306]. This introduction could signal more public-private collaboration to come in China's lunar ambitions.

3.6.3. What has China achieved?

Space Exploration

New Technologies, Installations, & Programs

CLEP - Lunar Achievements & Phases — China's Lunar Exploration Program (CLEP) has rapidly completed its first three Phases; Phase I. Orbital mapping (Chang'e-1, -2), Phase II. Lander and rover missions (Chang'e-3, -4), and Phase III. Sample returns (Chang'e-5, -6), including the historic retrieval of 1,935 grams of far-side lunar material in 2024, offering new insights into lunar geology [307].

China is currently progressing through Phase IV with Chang'e-7 and Chang'e-8 preparing for robotic prospecting at the lunar south pole and testing in-situ resource utilization technologies, such as 3D printing with lunar regolith, in preparation for a permanent research base [308]. These missions are foundational steps toward the ILRS, developed in collaboration with Russia and other partners [309]. Looking ahead, China is targeting a crewed lunar landing around 2030, supported by their Queqiao-2's Ka-band lunar relay satellite and successful early tests from June to August 2025 of their LM 10 rocket, Mengzhou crewed spacecraft, and Lanyue lander, with ground infrastructure at Wenchang being expanded to support these missions [310] [311] [312] [313].

Phase 1: Orbiters — Chang'e-1 and Chang'e-2 completed comprehensive lunar mapping and reconnaissance between 2007 and 2010 [307].

Phase 2: Landers/Rovers — Chang'e-3 and Chang'e-4 completed surface exploration missions, with Chang'e-4 achieving the historic first landing on the Moon's far-side in 2019, deploying the Yutu-2 rover [314]. The Chang'e-4 mission included international payloads including a Swedish instrument on the rover, Dutch instrument on the Queqiao-1 relay orbiter, and a German instrument on the lander.

Phase 3: Sample Return — Chang'e-5 returned 1,731 grams of near-side lunar samples in 2020, and Chang'e-6 returned 1,935 grams of far-side samples in 2024, marking a world first and including international payloads [307] [315] [316].

Phase 4: Robotic Polar Research Station Preparation — As of the publication of this report, China is actively preparing for Phase IV with Chang'e-7 (planned for 2026) and Chang'e-8 (planned for 2028), which would survey lunar south pole resources and test in-situ resource utilization technologies like 3D printing lunar bricks [307] [308] [309].

Phase 5: Crewed Mission — China is targeting a crewed lunar landing around 2030, with ongoing development of the LM 10 rocket and successful testing of the Lanyue lander, alongside expanded ground infrastructure at Wenchang [313]. They also recently completed a successful pad abort test of the Mengzhou crew spacecraft, advancing safety and readiness for a crewed landing [317].

***Chang'e-8 Payloads* —** China's Chang'e-8 lunar mission, scheduled for launch around 2028, highlights a new era of international collaboration by tentatively carrying scientific payloads from 11 countries and regions, plus one international organization listed below. These diverse projects would advance lunar science, technology, and global cooperation, as China continues to open its deep-space endeavors to partners worldwide. This international lineup seemingly would underscore China's commitment to inclusive, multinational lunar exploration and the development of the ILRS.

- **Lunar surface multi-functional operation robot and mobile charging station —** Hong Kong University of Science and Technology; Hong Kong Polytechnic University
- **Pakistan lunar rover (international) —** SUPARCO; International Society for Terrain-Vehicle Systems
- **Intelligent exploration robot for challenging environments (two micro-rovers) (international) —** Middle East Technical University of Turkey; Zhejiang University; Star.Vision
- **Radio astronomy array (international) —** South African Radio Astronomy Observatory; National Commission for Aerospace Research and Development of Peru
- **Laser corner reflector array (international) —** National Institute for Nuclear Physics–Frascati National Laboratories, Italy
- **Lunar plasma-dust environment sensor and lunar ion/high-energy neutral particle analyzer (international) —** Russian Federal Space Agency; Russian State Space Corporation
- **Lunar neutron analyzer (international) —** Ministry of Higher Education, Science, Research and Innovation of Thailand; National Astronomical Research Institute of Thailand
- **Visible and infrared imaging system for the lunar surface (international) —** Bahrain National Space Science Agency; Egyptian Space Agency

- **Lunar potential monitor (international) —** Iranian Space Agency

PEC - Achievements & Mission Sequence — The Planetary Exploration of China (PEC) program has propelled the nation well beyond cislunar space, marking significant milestones in Mars exploration and setting the stage for even more ambitious deep space missions. After an initial failed joint Mars attempt with Russia in 2011, China succeeded with its first independent interplanetary mission, Tianwen-1, launched in July 2020. This mission included an orbiter, lander, and the Zhurong rover, and marked China as only the second nation to operate a rover on Mars. Tianwen-1 entered Martian orbit in February 2021, and Zhurong landed in Utopia Planitia in May of that year [318]. Through a methodical, phased approach—first with a successful Mars orbiter and rover, now with plans for sample return and crewed missions—China is working to establish itself as a major force in planetary exploration. The PEC program's integration of advanced technology, scientific discovery, and international collaboration reemphasizes China's ambition to play a leading role in humanity's next era of interplanetary exploration.

Tianwen-1 and Zhurong Rover (2020–2023) — Tianwen-1 was China's first independent Mars mission, featuring an orbiter, lander, and rover. Zhurong, deployed in May 2021, became the first operational Mars rover outside the U.S. Equipped with six scientific instruments, it studied Martian geology and searched for water ice [319]. The rover exceeded its planned 90-sol mission, operating for 358 days and traveling 1,921 meters before hibernating in May 2022. In April 2023, officials confirmed Zhurong had not reawakened, likely due to dust accumulation on its solar panels [319]. Despite its dormancy, Zhurong's data seemed to provide evidence of an ancient ocean in Utopia Planitia [320].

Tianwen-2 Asteroid and Comet Mission (2025–2027+) — Launched in May 2025, Tianwen-2 targets the near-Earth asteroid 469219 Kamoʻoalewa. The mission aims to collect at least 100g of regolith using both anchor-and-attach and touch-and-go techniques, returning the sample to Earth in 2027. After sample return, the spacecraft will continue on to rendezvous with and study a main-belt comet [321] [322]. The spacecraft included more than 60 component parts sourced from organizations like CETC, CAS, Norinco, HIT, and numerous universities. This academic and commercial integration provides a diverse array of Chinese entities with deep space flight experience and valuable integration data for future exploration technologies [020].

Tianwen-3 Mars Sample Return (2028–2031) — Scheduled for launch in 2028, Tianwen-3 will use two launches; one for the lander/ascent vehicle, another for the orbiter/return vehicle. The mission aims to return Martian soil to Earth by 2031, searching for signs of life and studying Martian geology and atmosphere. China has invited international partners to contribute up to 20 kg of scientific payloads [323] [324].

Tianwen-4 Jupiter and Uranus Mission (Early 2030s+) — Planned for launch around 2030, Tianwen-4 will send two spacecraft; one to orbit Jupiter's moon Callisto and another to fly by Uranus. The mission will use gravity assists from Venus and Earth, investigate an asteroid en route, and study the Jovian system's magnetic fields, plasma, and moons. The Uranus probe will continue on for a flyby after the Jupiter tour [325] [326].

Mars Crewed Mission and Beyond (Post-2033) — China is starting to target robotic and crewed exploration roadmaps to Mars in the 2030s and 2040s to align around the PRC centenary in 2049 [327]. The pathway toward those goals will make use of a system of spacecraft in development now, as well as likely expanded China Deep Space Network (CDSN) capabilities [328].

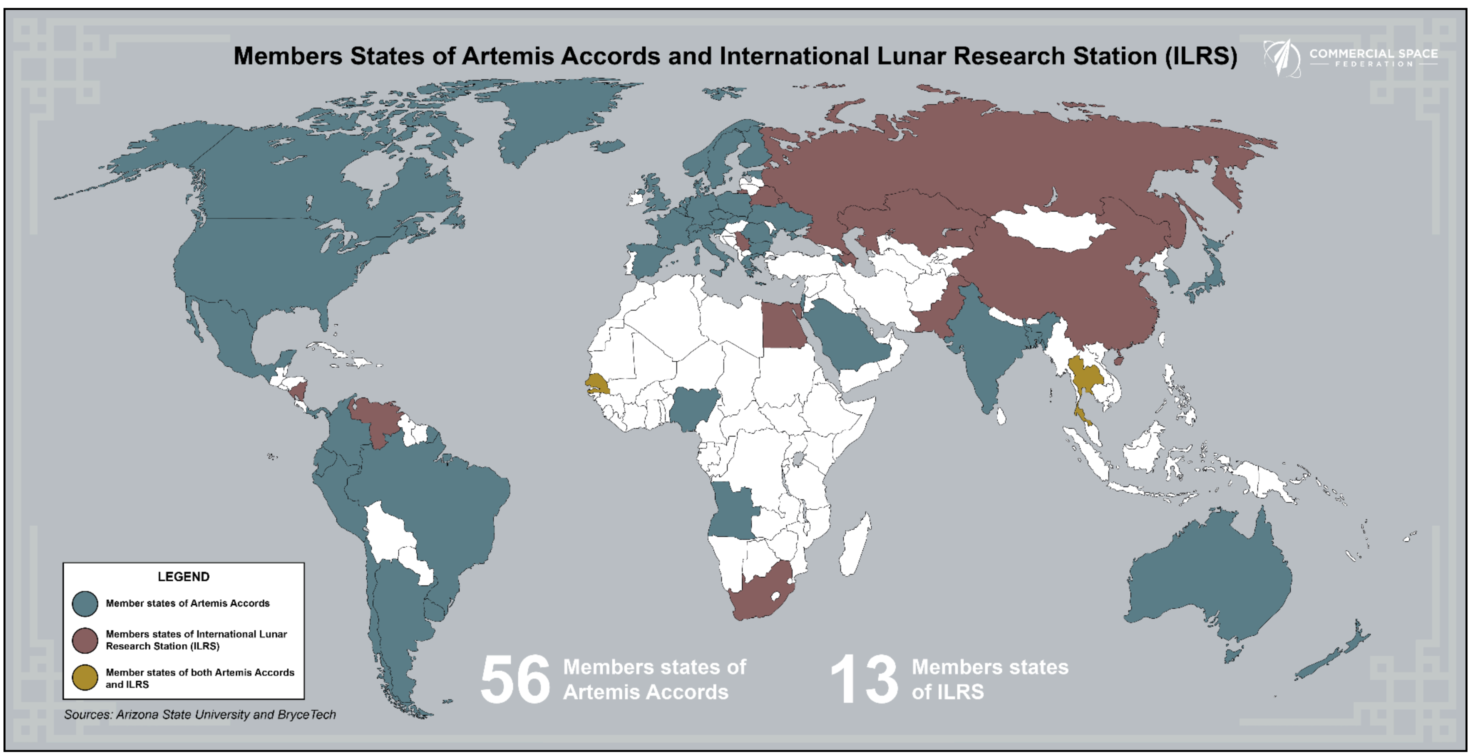
New Stakeholders & Hubs

CLEP Commercial Involvement — China's lunar ambitions include commercial participation and international collaboration, signaling a shift from purely state-involved efforts to a seemingly more open ecosystem. Origin Space, founded in Shenzhen in 2017, is China's first company dedicated to space resource exploration, focusing on asteroid mining and lunar resource utilization. The company launched satellites like NEO-1 to test asteroid observation and debris mitigation technologies, and is developing the NEO-2 lunar probe for future missions, with plans to commercialize asteroid observation data [329].

Another milestone in commercial involvement is Star.Vision, the first Chinese private aerospace firm approved by CNSA to directly participate in a national lunar mission. Star.Vision is co-developing two AI-powered micro-rovers for Chang'e-8 in partnership with Zhejiang University and Middle East Technical University (Türkiye), marking the first time a Chinese tech subcontractor plays a key role in a lunar project. The company has also engaged with partners in Kenya, Azerbaijan, Indonesia, Thailand, and Bahrain, reflecting China's growing commercial and international network in lunar exploration [306] [330].

These efforts align with China's ILRS initiative, which aims to involve 50 countries and a wide range of private and public sector partners in building a permanent lunar base by the 2030s. To date, at least 13 countries have signed on, including China, with active recruiting of new participants from emerging economies and the "Global South" [331] [332].

Figure 10: World Map of Artemis Accords vs. ILRS Participants
Source: ASU/CSF and BryceTech



New International Engagement

***ILRS Roadmap & Collaboration* —** China and Russia's ILRS follows a three-phase roadmap designed to establish a permanent, modular lunar base with broad international participation.

- **Phase 1: Reconnaissance (2021–2025/26)** has seen mixed progress between the two founding countries. China's Chang'e-4 executed lunar far-side operations, while Chang'e-6 successfully returned samples from the far side in June 2024. Chang'e-7 is scheduled for 2026, focusing on the lunar south pole. Russia's Luna-25 mission failed in 2023, but Luna-26 and Luna-27 are now planned for 2027 and 2028, respectively, to support site selection and technology verification for future infrastructure [333] [334] [335] [336].

- **Phase 2: Construction (2026–2035)** will begin with Chang'e-8 in 2028, which will test in-situ resource utilization and deliver international payloads, followed by Russia's Luna-28 (2030 or later). The phase is divided into two stages: 2026–2030 for technology verification and initial operations, and 2031–2035 for establishing core infrastructure. Five major named ILRS missions (ILRS-1 to ILRS-5) between 2031 and 2035 will create facilities for energy, communications, research, and habitation. Notably, China and Russia are now considering a lunar nuclear power plant by 2035 to support sustained operations [337] [334] [333].

- **Phase 3: Utilization (from 2036 onward)** envisions a fully operational, expandable lunar research station supporting long-term science, technology demonstrations, and human habitation. The ILRS remains open to international partners, with China actively inviting new countries and private sector entities to join the project, aiming for participation from up to 50 nations by 2035 [334] [331] [333].

China's pursuit of international leadership in lunar exploration is increasingly visible through ILRS, which by 2025 attracted a diverse group of global partners including Venezuela, South Africa, Azerbaijan, and Thailand [334]. The ILRS partnership framework, outlined at the 2022 International Astronautical Congress, opens five levels of co-leadership to commercial and international actors, starting with Chang'e-7, and makes substantial payload mass available for foreign contributions on Chang'e-8 [333] [338].

Recent missions highlight this collaborative approach. Chang'e-6 (2024) achieved the first-ever return of lunar far-side samples, carrying instruments from France, Sweden, Italy, and a Pakistani cubesat, while Chang'e-7 (2026) is set to continue this trend despite the withdrawal of the UAE's Rashid-2 rover due to export controls [339] [340]. For Chang'e-8 (2028), China has received over 30 international proposals for its 200 kg of available payload mass, underscoring growing global interest in partnership [338]. By lowering barriers to entry and offering equal participation to a wide array of countries and organizations, China is attempting to position the ILRS as an inclusive, accessible, and multilateral lunar initiative [334].

Planetary Exploration Collaboration — China is also leveraging its planetary exploration program to project international leadership and scientific openness across both Mars and asteroid missions. The Tianwen-1 Mars mission, launched in 2020, involved contributions from Austria, France, Argentina, and the ESA, highlighting China's ability to execute sophisticated missions while engaging global partners [318]. Building on this, China has opened its Tianwen-3 Mars sample-return mission, scheduled for 2028, to international payloads, allocating 20 kilograms for foreign scientific instruments—an explicit invitation for broader cooperation [341] [342].

Active on the World Stage — China's approach to global governance increasingly emphasizes international engagement and cooperation to address shared challenges like space debris, traffic management, and resource utilization conflicts. Officials consistently voice rhetoric around peaceful use of outer space and position the country as a collaborative partner in multilateral forums, aiming to counter perceptions of unilateralism and signal openness to joint leadership [343]. Their international cooperation is broad and growing; the CNSA reports that, as of 2025, they have signed 149 space cooperation agreements with 46 national space agencies and four international organizations, established 17 cooperation mechanisms, and participated in 18 international organizations, including the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) [343].

A landmark example of China's policy engagement was its 2018 agreement with Luxembourg to establish a Research Laboratory of Deep Space Exploration, supporting deep-space probe design and resource utilization technology development. While its current status is unclear, this collaboration is closely aligned with Luxembourg's SpaceResources.lu initiative, which seeks to create legal and economic frameworks for space resource use [344]. China's willingness to share research achievements and infrastructure with Belt and Road countries further demonstrates its intent to shape space governance through "collective consultation, joint participation, and shared benefits," and to position itself as a constructive and motivated actor in the evolving global space order [345].

3.6.4. What risks does America face?

Space Exploration

China's space exploration program rapidly transitioned from milestone-driven lunar and planetary missions to a comprehensive, state-backed campaign for leadership in deep space. With accelerated timelines for lunar bases, Mars sample return, and international collaboration through the ILRS, China is reshaping the competitive and diplomatic environment for American industry and U.S. strategic interests in space exploration [315] [331]. Particularly, while NASA's exploration roadmaps have experienced schedule setbacks and resets, the Chinese are moving ahead largely according to their own plans, and compelled just as much by internal drivers as external [346].

Segment-Specific Risks to American Industry

- **Displacement in Lunar and Planetary Science Markets**
  China's successful lunar sample return missions—including the first-ever retrieval from the Moon's far side—and its open invitation to international partners for ILRS and Chang'e-8 payloads position Chinese platforms as a new and viable alternative global hub for lunar science. Depending on pace of execution, this may challenge U.S. leadership in payload delivery, lunar surface operations, and scientific instrumentation [315] [338].

- **Accelerated Public-Private Innovation Ecosystem**
  China's new integration of private firms into lunar and planetary missions—such as STAR.VISION's micro-rovers and Origin Space's asteroid mining tech—is doubling down on its trend of space commercialization and technology transfer, raising the competitive bar for the U.S. in yet another segment of the space ecosystem [306] [305].

- **International Standards and Collaboration Shift**
  By making the ILRS and Chang'e missions accessible platforms for multinational participation—including payload mass allocations and co-leadership roles—China is setting own norms for lunar governance and technical standards, potentially sidelining U.S. and allied frameworks, if ILRS and CLEP plans remain on schedule while American efforts and momentum lag [331] [332].

National Strategic Risks

- **Loss of Leadership in Deep Space Governance**
  China's ILRS, with a roadmap to involve up to 50 countries and a growing list of emerging space powers, positions itself as an alternative campaign and center of gravity for lunar and planetary governance away from U.S.-led coalitions, diminishing possible future American influence over resource utilization, safety protocols, and legal frameworks [331].

- **Strategic Technology and Security Concerns**
  China's ambitions to develop super-heavy lift vehicles, autonomous in-situ resource utilization, and nuclear power on the moon raises strategic challenges to U.S. technological advantages, and could exacerbate national security concerns around lunar activities [297] [337].

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4. Path Ahead

4.1. China's Space Ascendancy and the Risk to U.S. Space Leadership

One thing is certain. China is not slowing down but accelerating beyond America's pace in many areas—(i.e., Redshift). They are not deviating from their "Space Dream"—China is living its Apollo, ISS, and commercial space eras all at once, bringing new strategic, economic, and commercial risks for America. As this report concludes, China's space program has matured rapidly—driven by strategic patience and state investment—meeting and often exceeding its goals, reshaping global space power, and posing complex risks to U.S. industry. China remains fully committed to its roadmap and milestones and will use all available resources to become a global leader in space.

Here in the U.S., innovative capabilities developed by our commercial space companies continue to push the boundaries of the possible. However, U.S. companies must deal with an uncertain and sometimes constraining policy, budget, and regulatory landscape that creates obstacles to continued success. Change is needed to unleash the U.S. space industry and further its lead in this new space race. Below, we provide recommended actions for consideration by the U.S. Congress, the White House, and Executive Branch agencies. These recommendations would focus national attention on the U.S. space industry, remove barriers to growth, and drive the investment of time, dollars, and resources needed to stay ahead of China's space ambitions

Summary of 21 Recommendations:

Spaceports and Infrastructure:

1) Provide Federal investment in spaceports through grants
2) Streamline Federal and State environmental reviews
3) Reform regulations to enable inland vertical launch and orbital reentry operations

Launch and Re-Entry:

1) Streamline commercial launch/reentry licensing
2) Reform environmental reviews for launch/reentry operations
3) Provide appropriate resources to improve launch/reentry licensing
4) Reform export controls to increase international collaboration
5) Modernize the management of airspace during launch/reentry operations

Remote Sensing and Space Situational Awareness:

1) Reform U.S. export controls
2) Reform commercial remote sensing licensing
3) The U.S. government should utilize commercial data and services to the maximum extent practicable
4) Support the TraCSS Program and distribute basic SSA data free of charge to the end user

Satellite Communications and Positioning, Navigation, and Timing:

1) Allocate sufficient spectrum for satellite operations
2) Reform Federal spectrum coordination processes
3) Ensure U.S. communication accessibility programs are technology neutral

Commercial LEO

1) Fully utilize the ISS through end of life
2) Foster a smooth transition from ISS to commercial LEO stations and research facilities
3) Continue robust NASA human operations in LEO post-ISS

Space Exploration

1) Fully utilize commercial capabilities to achieve NASA's Moon to Mars Exploration and Science Objectives.
2) Partner with commercial space to enable space science
3) Implement a mission authorization process that facilitates commercial space exploration missions.

4.2. Recommendations from the Commercial Space Federation

Spaceports & Infrastructure:

China's vision for a modern, globally integrated launch and ground infrastructure has largely been realized. The expansion of coastal and inland launch sites, operational sea-based platforms, and a robust TT&C network now support high-frequency, multi-mission cadence. These achievements have enabled China to offer cost-competitive launch options and attract international clients. For the U.S., this could mean downward pricing pressure and growing fragmentation of operational standards. Additionally, the global spread of Chinese TT&C assets could create new vulnerabilities in surveillance and data security.

There are currently 20 spaceports in the United States licensed to conduct horizontal or vertical launch suborbital, or orbital reentry operations. Some are fully federally owned ranges, while others are partnerships between government (federal or state) and commercial enterprises or fully privately-owned. As a whole, these spaceports are the backbone of the U.S. commercial space industry, providing the necessary infrastructure to conduct launch and reentry operations and deliver payloads to space. In practice, there is an over-reliance on the Eastern and Western federal ranges while usage and capacity at other U.S. spaceports is constrained by a lack of federal investment. This not only results in overcrowding at the federal ranges but also represents a national security risk due to the concentration of operations on the coasts. To achieve a resilient U.S. spaceport network that accommodates increased launch and reentry operations and continued assured access to space – stated goals of the U.S. government and U.S. Space Force (USSF) – investment and regulatory changes are needed.

Recommendation 1: Provide Federal investment in spaceports through grants

The U.S. government must invest in domestic spaceport infrastructure to meet increased launch and reentry demand and provide assured access to space. This should include regular appropriations and programmatic updates to the Department of Transportation's (DOT) STIM Grant program, as well as making spaceports eligible for other infrastructure grants.

It is worth noting that unlike all other transportation ports, there is no current U.S. federal grant program providing infrastructure development assistance to spaceports. Congress authorized the Spaceport Transportation Infrastructure Matching (STIM) Grant Program in 2010, but the program was underutilized due to restrictive programmatic requirements and has not received Congressional appropriations in over a decade. Changing those requirements and providing substantial annual appropriations to the program would provide some assistance to U.S. spaceports, but further assistance is needed to ensure sufficient U.S. space infrastructure to support industry growth.

Recommendation 2: Streamline Federal and State environmental reviews

The environmental review process represents a significant obstacle to spaceport and launch/reentry infrastructure development both at the federal and state levels. The U.S. government, as well as state governments, must recognize the critical importance of spaceport and launch/reentry infrastructure development through the utilization of categorical exclusions (CATEX) to the National Environmental Policy Act (NEPA) and a streamlining of state environmental assessments procedures. Lessening these regulatory burdens would enable spaceports to build capacity, expand facilities, and ensure that they are able to support increasing launch/reentry operations.

Recommendation 3: Reform regulations to enable inland vertical launch and orbital reentry operations

Current U.S. regulations make it nearly impossible for an inland spaceport to support vertical launch operations and overly restrict orbital reentry operations. Fully utilizing the domestic spaceport network requires regulatory reform to maintain public safety while enabling inland spaceports to support vertical launch operations. Further, removing inhibitory requirements on reentry operations is needed to allow for the return of products and materials manufactured in space. These changes should also provide the basis for future rocket cargo and point-to-point operations.

Launch & Reentry:

China's significant progress in reusable rockets and methane propulsion, along with the proliferation of private launch startups, has transformed the country into a formidable operator in small- and medium-lift markets. Potential aggressive price competition and rapid scaling threatens to erode the dominance of U.S. commercial launch in the international launch market. . The United States remains the global leader in launch cadence, but only a handful of providers represent the vast majority of operations. Many more companies are currently developing vehicles, and increased competition and segmentation is expected as the industry matures. Recent years have seen the emergence of reentry operations, and additional reentry service providers are anticipated to come to market in the near future. Developing launch and reentry vehicles is an inherently difficult and costly enterprise. However, that challenge is compounded by burdensome U.S. regulatory and licensing requirements which add costs and schedule delays, hindering U.S. national competitiveness, missions of national interest, and the economic benefits associated with the commercial space industry.

Recommendation 1: Streamline commercial launch and reentry licensing

Currently, the U.S. DOT delegates its statutory authority to license commercial space launch and reentry operations to the FAA's Office of Commercial Space Transportation (AST). In 2020, AST consolidated its four launch/reentry licensing regimes (Parts 415, 417, 431, and 435) into a single performance-based rule covering both launch and reentry operations called Part 450. However, instead of streamlining licensing, Part 450 included processes and procedures which were unclear, lacked clarity of intent, were subject to differing and often conflicting interpretations, and were eventually slower to complete than the legacy regulations.

In 2024, AST initiated an Aerospace Rulemaking Committee (SpARC) with the goal of receiving industry recommendations to refine Part 450. Once the SpARC report is issued, AST should immediately review Part 450 and related processes and implement all SpARC recommendations. Further, AST should review fundamental aspects of its licensing framework and remove any regulatory requirements that are not directly related to enhancing public safety during launch and reentry operations.

Recommendation 2: Reform environmental reviews for launch/reentry operations

AST administers the agency's environmental review process in accordance with NEPA, and the agency's implementation of its environmental review process places significant schedule and cost burdens on launch and reentry operators, spaceports, and space launch infrastructure improvements, and is the longest lead item in the licensing process. Further, it is commonplace for AST specialists to issue inconsistent environmental rulings on similar or identical topics or ask repetitive questions about issues already resolved, unnecessarily extending the licensing process.

Given the national schedule urgency for space projects, the FAA must accelerate environmental reviews, while ensuring an appropriate level of environmental oversight. The FAA has a clear model that it can immediately implement. As an agency, it has long recognized the vital national importance of airports and has identified significant airport elements, including runways, passenger terminals, and more, as qualifying for a CATEX under NEPA. The FAA should extend this existing determination to accelerate space infrastructure buildout for the same national security and economic benefits. Doing so would immediately support more efficient launch and reentry licensing determinations, allow for more rapid infrastructure development, and add certainty to the critical commercial space launch and reentry industry.

Recommendation 3: Provide appropriate resources to improve launch/reentry licensing

AST faces resource constraints which inhibit efficient administration of the Part 450 licensing process. AST diligently works to fulfill its licensing functions, yet remains a relatively small agency within the broader FAA. The substantial growth in the U.S. commercial space industry has resulted in a commensurate increase in demand for AST's services, including the licensing of new launch/reentry operators and spaceports, overwhelming current AST processes and resources. Compounding the issue is a March 2026 deadline for all launch/reentry operators to be licensed under Part 450 that creates further demand on FAA licensing procedures and personnel. To support continued industry growth and an increase in operations, AST must receive the resources necessary to effectively complete its core licensing functions.

Recommendation 4: Reform export controls to increase international collaboration

Export controls are essential for ensuring that articles or services for export do not provide a critical military or intelligence advantage to foreign actors. However, the commercial space industry remains overly burdened by International Traffic in Arms Regulations (ITAR) classification for articles which do not provide such critical military or intelligence advantages. As a result, U.S. space companies often face a disadvantage when seeking to compete or cooperate with foreign actors. As the industry continues to develop and innovate, CSF respectfully recommends that the U.S. government regularly review (U.S. Munitions List) USML Categories IV and XV and further delist items which no longer constitute a clear military or intelligence advantage upon export.

Recommendation 5: Modernize the management of airspace during launch/reentry operations

The FAA Air Traffic Organization (ATO) manages the National Airspace System (NAS) during space launch/reentry operations under coordination with the commercial operator, federal agencies, the range, and other stakeholders to ensure the safety of the NAS. Currently, much of this management is done manually; only the FAA Command Center receives live telemetry data tracking the vehicle's operation, and other coordination occurs through a telephone hotline system. As the FAA seeks to update and modernize the U.S. air traffic control system, including updates to current systems that integrate launch/reentry operations into the NAS – including the transmission of live telemetry data onto air traffic controllers' scopes and real-time hazard area generation capabilities – would improve the safety and efficiency of the NAS.

Remote Sensing & Space Situational Awareness:

China's deployment of one of the world's largest commercial RS constellations, coupled with advanced SSA networks, will enable it to offer high-resolution, low-cost imagery and global data services. This might undercut U.S. firms in key markets and expand China's influence through data diplomacy and disaster- response aid. The integration of dual-use SSA capabilities further blurs civil-military boundaries, while cislunar surveillance projects challenge U.S. domain awareness beyond Earth orbit.

The EO data provided by U.S. commercial RS operators is not only critical to the U.S. Department of Defense (DoD) and Intelligence Community (IC), but also a foundational capability underpinning nearly all aspects of life. RS companies support precision agriculture, provide key data to enhance logistics and supply chains, and are at the forefront of tracking illegal poaching activities. Commercial SSA providers are critical to tracking and monitoring space activities, enhancing the safety and sustainability of satellite systems and providing essential space domain awareness to the DoD and IC. Supporting each of these sectors would support national goals, provide for a sustainable in-space environment, and provide reliable communications capabilities within the U.S. and around the world.

Recommendation 1: Reform U.S. export controls

Many commercial space companies serve non-U.S. customers, including foreign governments (to include both military/intelligence agencies as well as civil government agencies). The U.S. commercial space industry is committed to partnering with the U.S. government in support of export regulations, including seeking export authorization where appropriate for products and services that may be uniquely adapted to defense and intelligence applications. However, current defense services rules, activity restrictions, and export licensing requirements are frequently vague, overly broad, and create significant regulatory ambiguity for industry. This undermines the ability of U.S. companies to compete internationally where commercial space companies from other jurisdictions are not subject to such broad export control requirements. Further, it complicates growing U.S. interest in commercial programs supporting national security needs and negatively impacts collaboration and cooperation among allied partners. Clarifying space export control rules and definitions would foster greater international partnerships while enhancing U.S. national security and economic growth.

Recommendation 2: Reform commercial RS licensing

The 2020 overhaul of NOAA's CRSRA regulations governing private RS satellites licensing was a drastic improvement compared to the prior regulatory framework. Now, NOAA utilizes a tiered licensing framework that imposes more stringent regulatory conditions on particular commercial RS satellite systems based on whether the same system capabilities are available domestically or internationally, with Tier 3 systems (which have no domestic or international equivalent) automatically subject to the most stringent operations restrictions and potentially additional "temporary" conditions on their license. As a result, the current three-tiered system inhibits U.S. commercial capabilities until a similar international capability exists, thus holding the U.S. industry back and in a perpetual second place in the global market.

To promote the competitiveness of U.S.-licensed private RS space systems, CRSRA should update its regulations to amend the tiered licensing structure. Tier 1 should remain the same, while Tiers 2 and 3 should be collapsed into a single Tier governed by the current standard conditions that apply to Tier 2 today. The regulations should outline a process by which additional temporary license conditions could be imposed on a limited number of commercial RS systems with unique capabilities that pose significant national security risks, only if requested by the Secretary of Defense and supported with adequate justification. In addition, such temporary conditions should automatically be removed one year after issuance of the license unless the Secretary of Defense requests and justifies an extension, and no more than two extensions of temporary conditions (for no more than one year each) should be approved. Such a framework would enable continued American leadership in the commercial RS sector while still providing a safety valve to address national security implications.

Recommendation 3: The U.S. government should utilize commercial data and services to the maximum extent practicable

The U.S. commercial RS industry is continuously innovating, iterating, and deploying groundbreaking capabilities, frequently to the benefit of U.S. government interests, national defense, scientific research, and economic growth. Federal agencies like DoD, NASA, FEMA, the IC, and others should fully leverage commercial capabilities to achieve their missions and ensure that it does not compete with private sector capabilities by building costly bespoke systems when commercially-available solutions exist.

Recommendation 4: Support the TraCSS Program and distribute basic SSA data free of charge to the end user

The Department of Commerce (DOC) Office of Space Commerce (OSC) is deploying the Traffic Coordination System for Space (TraCSS) program to provide SSA data to commercial space operators without charge to the end user. This safety system is critical to monitoring the space environment, providing conjunction warnings to operators, and reducing the likelihood of collisions on-orbit. Supporting its continued development is essential for maintaining a safe and sustainable space environment. To provide greater accuracy and ensure continued innovation, OSC should procure and utilize commercial SSA services to the maximum extent practicable, while not competing with the private SSA sector that provides advanced SSA services.

Satellite Communications & Positioning, Navigation, and Timing:

With the completion of BeiDou-3 and the ongoing deployment of LEO broadband megaconstellations, China has established itself as an emergent global standards-setter in satellite communications and navigation. This might result in the displacement of U.S. market share, forced technology transfer through standards lock-in, and attrition of American influence over critical space infrastructure. The Belt and Road SIC exemplifies how China is embedding its systems in partner nations and reducing U.S. leverage in regions of the world.

Innovation abounds in the U.S. commercial satcom and PNT sectors. Non-geostationary satellite (NGSO) operators are currently providing high-speed, low-latency broadband internet services across the globe, with direct-to-device communications soon to follow. Commercial PNT service providers support national defense while serving as complements – and, potentially, backups – to the GPS. These commercial capabilities not only connect our world but provide the foundation for global commerce, transportation, and DoD operations.

Recommendation 1: Allocate sufficient spectrum for satellite operations

Commercial space operators utilize a wide variety of spectrum bands, and that demand will only increase as the industry continues to grow and new, innovative capabilities are deployed. Spectrum availability is essential to enabling the U.S. space industry to keep pace with foreign competitors and continually improve products and services for customers. The U.S. government must provide a strong and ongoing foundation for American space leadership by ensuring robust and reliable access to satellite spectrum bands and make available additional spectrum across a wide range of frequencies to support innovation. Any request to repurpose commercial satellite spectrum for terrestrial use must be carefully and critically evaluated to not create risks and uncertainty for the millions of consumers, enterprises, first responders, and government users who rely on commercial space systems. Finally, as large foreign companies consolidate their spectrum holdings, the government must adopt policies to ensure that innovative, new American companies have opportunities to access GSO slots over the United States.

Recommendation 2: Reform Federal spectrum coordination processes

Fixing the coordination process between commercial satellite operators and federal agencies would dramatically improve the U.S. industry's ability to innovate and compete on a global scale while more swiftly delivering improved services for American consumers. By law, satellite and space spectrum cannot be auctioned and must be shared with other users, with spectrum often shared between commercial and U.S. government missions. The coordination process in these shared bands is broken; it adds at least a year to FCC licensing processes, typically results in stringent license conditions that unnecessarily constrain commercial operations, and rarely involves engineer-to-engineer negotiations based on actual system characteristics. As a result, the current federal spectrum coordination process provides a head start and an unnecessary technical advantage to foreign competitors who are not required to undertake similar processes.

This process must be streamlined under the basis of a "default to yes" coordination framework. Current processes and rules should be simplified into a simple, clear requirement: protect co-primary federal systems from harmful interference in, and adjacent to, shared bands. Federal civilian agency users would be protected through publicly providing sufficient information about their spectrum operations to enable commercial operators to design their systems to protect them, as well as recommended protection criterion that applies to each system and defines to what degree such systems must be protected. For non-civilian agency and national security-related spectrum users, including DoD systems, the IRAC process should be used to assess any post-licensing coordination requirements, while maintaining a general bias toward commercial licensing. Finally, U.S. global spectrum policy should rest on the principle that the ITU and national administrations should modernize outdated protection criteria to reflect modern system characteristics and maximize efficient spectrum sharing. This "default to yes" framework will ensure federal civilian agencies have the protections they need from commercial space operators, with outlier cases found not to be sufficient to protect federal assets handled through the public notice period at the FCC or through direct coordination following licensing.

Recommendation 3: Ensure U.S. communication accessibility programs are technology neutral

U.S. government programs such as the National Telecommunications and Information Administration's Broadband Equity, Accessibility, and Deployment (BEAD) program are intended to connect all Americans with high-speed broadband internet service. Historically, however, government guidance has favored terrestrial technologies (such as fiber) over satellite-based communications solutions. While that guidance has been reversed for the BEAD program, ensuring that all similar U.S. government efforts consider satellite-based technologies and are technology-neutral will result in more efficient usage of taxpayer funding, quicker deployment of services, and the ongoing development of the commercial satellite communications industry.

Commercial Low Earth Orbit:

In 2022, China completed initial construction and assembly of the three module Tiangong space station in LEO. Tiangong has been continuously crewed since 2022, with overlapping 6-month expeditions of three Chinese Taikonauts. China intends to maintain a permanent presence on the station and plans to add additional modules to Tiangong that include expanded research facilities. China has courted international participation in the form of research experiments and crew opportunities. ESA and some of its member states have historically shown interest in flying crew on Tiangong, and, as early as 2026, a Pakistani astronaut will become the first foreign national aboard the Chinese station.

The U.S. commercial LEO ecosystem is evolving rapidly, building upon commercial research and development activities on and around the ISS. ISS has been continuously crewed and operated by NASA and its international partners (Europe, Canada, Japan, and Russia) since November 2000. With the retirement of the space shuttle in 2011, NASA transitioned to commercially provided crew and cargo launch and transportation services. The LEO economy also includes new in-space research and development activities like materials manufacturing and pharmaceutical research. The ISS partners plan to deorbit the ISS in 2030, and the U.S. will transition LEO research activities to commercially developed space stations. NASA will also use these stations to train and prepare for eventual long-duration missions to deep space destinations like Mars. These stations are currently being developed by multiple U.S. companies under NASA's Commercial LEO Destinations (CLD) program. Together, these developments in LEO infrastructure, in-space research facilities, crew access, and cargo services will ensure the U.S. is poised to lead in the post-ISS era.

Recommendation 1: Fully utilize the ISS through end of life

The third decade of the ISS is poised to be the most productive, driven by the availability of multiple commercial and international transportation systems and growing utilization of LEO research facilities by private industry. In addition to the NASA-allocated utilization of the ISS, the ISS National Lab plays a central role in enabling this commercial progress, leveraging crew time, cargo capacity, and on-orbit infrastructure to conduct critical research and technology demonstrations that benefit both the nation and the economy. To sustain this momentum, NASA should maintain its regular U.S. crew contingent size and a cadence of not less than two crew rotation missions per year and five cargo missions per year while the ISS is operational and continue to support the ISS National Lab. These allocations are essential to support non-NASA research and commercial investigations and ensure the ISS's research potential is fully realized. Fully utilizing ISS through end-of-life will allow for continued efficient growth of the LEO economy and development of commercial customers for future LEO platforms.

Recommendation 2: Foster a smooth transition from ISS to commercial LEO stations and research facilities

NASA's CLD program supports the development of multiple commercially owned and operated space stations from which NASA plans to purchase services. Following the deorbit of ISS, commercial space stations will provide the U.S., international space agencies, and private entities with one or more platforms in LEO to conduct microgravity research and crewed operations. With China now having its own space station in LEO, NASA must continue to foster the development of CLDs to ensure that the U.S. retains human presence and leadership in LEO. Like other NASA public-private partnerships, CLDs will require federal investment, but even more critically, a stable transition timeline and clear communication of NASA's performance metrics and expected demand for crew and payload services. This will enable commercial partners to build a self-sustaining model that ensures America's leadership in LEO for decades to come.

In addition, NASA must consider how to extend liability protections to commercial partners in LEO. These protections have played a crucial role in fostering the diverse development of commercial launch and reentry cargo and crewed vehicles, and the same principle applies to the emerging LEO economy. Without an appropriate risk-sharing framework, companies and their investors and insurers may hesitate to commit the capital needed to develop viable commercial space stations without relying on federal funding. Extending liability coverage for commercial space stations provides certainty, reduces barriers to entry, and signals that the U.S. government is committed to creating a viable marketplace for commercial space station operators.

Recommendation 3: Continue robust NASA human operations in LEO post-ISS

When ISS deorbits in 2030, NASA and our international partners should continue a regular cadence of long-duration missions in LEO. With Artemis missions currently planned for one a year, a LEO platform will be an important proving ground for U.S. crew and ground operators to retain and expand the skills and knowledge to conduct long-term in-space operations. Furthermore, a robust commitment from NASA is critical to the success of commercial LEO operators.

Space Exploration:

China's comprehensive campaign for deep space leadership—highlighted by lunar sample returns, Mars and other deep space science missions, and the ILRS—has shifted the competitive and diplomatic environment. By opening its platforms to international partners and broaching alternative approaches for lunar governance, China is challenging U.S. leadership in lunar exploration, planetary science, resource utilization, and the shaping of legal frameworks for space.

NASA's Artemis program and the Commercial Lunar Payload Services (CLPS) program are driving demand for commercial lunar landers, space suits, rovers, surface power and infrastructure, communications, and propulsion. Multiple U.S. companies are pursuing celestial resource mining for use in-space and back on Earth. Artemis capabilities are being designed to support future human missions to Mars, with an emphasis on public-private partnerships.

Recommendation 1: Fully utilize commercial capabilities to achieve NASA's Moon to Mars Exploration and Science Objectives.

NASA's stated goal for Artemis is a sustained U.S. presence in cislunar space and on the lunar surface. For years, NASA's Artemis manifest has shown aspirational plans to launch one crewed mission to the Moon a year starting in the 2030's, hardly a cadence that will allow for a build up of lunar infrastructure ahead of China [347]. Furthermore, this schedule depends on the successful development of a new upper stage for the Space Launch System for missions after Artemis III [348]. Given NASA's expected budget profile, a sustained or even regular presence on the Moon cannot be achieved unless NASA transitions high-cost pieces of its architecture to commercial capabilities. NASA should transition to commercial transportation capabilities for Artemis and leverage commercial capabilities to land science, and eventually crew, on Mars. Having multiple commercial providers will increase the frequency of missions to keep the U.S. firmly ahead of China long-term.

As NASA considers new pieces of its Moon to Mars architecture, NASA should conduct industry studies early in program formulation before finalizing an acquisition strategy. Program managers should always consider firm-fixed price contracts when determining the mission acquisition strategy.

Recommendation 2: Partner with commercial space to enable space science

In recent years, NASA's Science Mission Directorate (SMD) initiated new programs like CLPS and the Commercial Satellite Data Acquisition (CSDA) program that take advantage of capabilities developed by the U.S. commercial space industry. These programs benefit NASA and the research community by enabling more frequent S&T demonstration opportunities at relatively low cost. Additionally, by strategically investing in the growth of the U.S. commercial space industry, NASA is broadening the supply of commercial space services – for itself, other agencies, and non-government customers. SMD, like other parts of the agency, faces budget constraints. Maintaining the status quo by slowing down science missions and hoping for better days to come is not a viable solution. Instead, like NASA's human exploration programs, SMD should embrace commercial solutions and innovative contracting solutions that enable the potential to do more science with less.

Recommendation 3: Implement a mission authorization process that facilitates commercial space exploration missions.

As commercial activity in space continues to grow, it is critical that the U.S. government's oversight of these activities is designed to get missions to the launch pad. Recent actions at the FCC and FAA to review existing regulations will certainly help. Further, the August 2025 Executive Order, "Enabling Competition in the Commercial Space Industry" directs the DOC to propose a process for authorizing non-governmental space activities not governed by existing regulatory frameworks. Clearly identifying DOC as the agency that can grant mission approval is an important step in unleashing the commercial space exploration industry,giving these missions a clear path to approval. As DOC develops a mission authorization regime, it should ensure the process adheres to the following fundamental principles:

- Presumption of authorization: An application should be deemed authorized unless explicit violations of U.S law or international treaty obligations are identified and communicated to the applicant, utilizing appropriate security measures as needed. The process should provide for an opportunity to cure any issues raised with the proposed activity within a set timeframe.
- Minimally burdensome: Authorizations should require limited data from an applicant; any limitations on operations should only relate to explicit violations of U.S. law and international treaty obligations.
- Predictable: DOC should establish clear, stable requirements, consistency in review processes, and strict timelines for authorizing an activity.
- Transparent and Responsive: There must be timely and detailed communications between an applicant and DOC and the ability to track the status of an application.
- Clear authority: DOC must have final say in authorizing an application and drive all interagency discussions.

As the global space environment becomes more multipolar and contested, the future will be shaped by those who remain attentive, adaptive, and proactive. U.S. leadership in space will depend on recognizing these shifts, investing in resilient capabilities, and forging international partnerships that reinforce transparency, security, and shared norms. The findings of this report highlight urgent risks that demand immediate and sustained action—ensuring that America's role in the next chapter of space history is defined by vigilance, strategic foresight, and reinvigorated engagement.

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Acknowledgements

The authors gratefully acknowledge the many contributors who made this report possible. We thank the subject matter experts, policy professionals, and industry reviewers whose perspectives sharpened our analysis. We are indebted to colleagues who provided extended content guidance and access to specific data sets, and to those who offered in-depth data analysis and graphic design support that strengthened both substance and presentation. Finally, we appreciate the support extended to the authorship team from colleagues and loved ones, an anchoring network without which this work could not have been completed.

The insights and analysis presented in this report reflect the independent work and perspectives of the authors at the time of data collection, analysis, and report preparation. They do not represent the official views, positions, or endorsements of Arizona State University, its affiliated units, or any external partners, reviewers, or stakeholders who contributed input during the development of this work.

The recommendations advocated for in this report reflect the analysis of the Commercial Space Federation (CSF) and should be understood as its institutional perspective.

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