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CHINA'S EXPANDING SPACE CAPABILITIES

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Space-based capabilities today impact every aspect of day-to-day life. Space systems also allow projecting combat power across the globe by permitting intelligence gathering, supporting navigation and targeting. For long the United States and the former Soviet Union, later Russia, dominated the space capability, and tacit militarisation. The last three decades saw China's massive economic growth and emergence as a rising space power with massive satellite launch capabilities. China has today fully integrated countries' space and counter-space capabilities into its warfighting machinery and strategies. They have tested and put in place sophisticated anti-satellite (ASAT) weapons. Anti-satellite technologies include land-based missiles, experimental lasers, and signal jammers. Simultaneously they are working on cyber and electronic warfare (EW) capabilities to deny or degrade space-based communications and navigation. All of these have been integrated into the People's Liberation Army Strategic Support Force (PLASSF). Expanding constellations of satellites also can now keep a watch on all military and sensitive technology operations. Space Situational Awareness (SSA) has become an important activity with mushrooming

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numbers of space satellites. Technologies have matured, and private funding and players are coming big into all aspects of space in a big way. China today has its own global satellite navigation system, a permanent space station, and many extra-terrestrial missions. China has successfully launched an orbital space mission from a sea-based large semi-submerged barge in the Yellow Sea.[1] China's was the heaviest first satellite placed into orbit by a nation, exceeding the combined masses of the first satellites of the other four previous countries.[2] China is already building a space station and is getting all set for its Mars Lander mission.[3] China has successfully performed a soft landing of a rover on the moon, including the only ones to land on the dark side. China has plans to exploit Earth-Moon space for industrial development. China's habitable space station, Tiangong, will be operational by the end of 2022[4] and put Chinese astronauts on the moon in the mid-2020s.[5] China's space programme is linked to developing advanced military technologies. China had launched Dark Matter Particle Explorer (DAMPE) in 2015,[6] and the world's first Quantum Experiments at Space Scale (QUESS) satellite in 2016. China is averaging 20 space missions a year. China is getting all set to position itself as the leading space power and to start setting and dictating global space norms.

1. Hanneke Weitering, "China Aces Its 1st Rocket Launch at Sea, Puts 7 Satellites in Orbit", Space.com, June 5, 2019, at https://www.space.com/china-first-sea-rocket-launch-success.html. Accessed on May 2, 2022.
2. Mathew S. Williams, "All You Need to Know About the Chinese Space Program", *Interesting Engineering*, March 16, 2019, at https://interestingengineering.com/all-you-need-to-know-about-the-chinese-space-program. Accessed on May 2, 2022.
3. Martin Pollard, "China completes crucial landing test for first Mars mission in 2020", Reuters, November 14, 2019, at https://www.reuters.com/article/us-space-exploration-china-mars/china-completes-crucial-landing-test-for-first-mars-mission-in-2020-idUSKBN1XO0IQ. Accessed on May 2, 2022.
4. Andrew Jones, "China's Tiangong space station", Space.com, August 24, 2021, at https://www.space.com/tiangong-space-station. Accessed on May 2, 2022.
5. Mike Wall, "China lays out ambitious space plans for next 5 years", January 29, 2022, at https://www.space.com/china-five-year-plan-space-exploration-2022. Accessed on May 2, 2022.
6. Charles Q. Choi, "China's Cosmic 'Monkey King' Satellite Looks for Dark Matter", Space.com, November 30, 2017, at https://www.space.com/38937-china-monkey-king-satellite-dark-matter.html. Accessed on May 2, 2022.

SPACE ORGANISATIONAL STRUCTURE

Formed in 1993, China National Space Administration (CNSA) is responsible for civil space administration and international space cooperation. The other agencies are China Aerospace Science and Technology Corporation and China Manned Space Agency. They all work closely with the People's Liberation Army (PLA). China has a large number of universities doing research in Aerospace and Astronautics. China has four satellite launch centres,[7] Xichang in Sichuan, Jiuquan in Gobi Desert Inner Mongolia, Taiyuan in Shanxi Taiyuan, and Wenchang on the Hainan Island. Their main monitoring and control centres are in Beijing and Xi'an. They have a network of other stations in China and abroad, including in Pakistan, Kenya, Namibia, and Argentina. They also share space tracking facilities with France, Brazil, Sweden and Australia. The PLASSF Space Systems Department (SSD) is the consolidation of all PLA's space-based C4ISR systems.

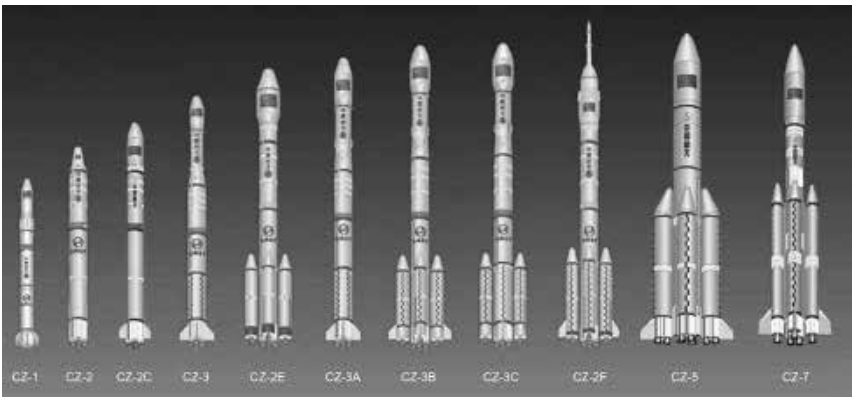
CHINESE LAUNCH ROCKETS PROGRAMME

China has light, medium, and heavy-lift launch vehicles. Light-lift vehicles place small payloads into LEO. Medium-lift for larger satellites into LEO and MEO and smaller satellites in GEO. China has a Chang Zheng CZ (also Called Long March) series of space launch vehicles (Figure 1). CZ-2E (A) is for the launch of Chinese space station modules with payload capacity up to 14 tons in LEO. CZ-3 rockets are a series of three-stage geosynchronous satellite launchers. The CZ-5 is a Chinese heavy-lift space launch system. The core stage uses liquid hydrogen (LH) and liquid oxygen (LOX) as propellants. The CZ-5 is meant for the Chinese space station programme and lunar programme. The CZ-7 medium-lift rocket will support human space flight. CZ-9 will be a super-heavy launch vehicle that is still evolving and is planned for a maximum payload capacity of 140,000 kg to LEO, 50,000 kg to Lunar Transfer Orbit, or 44,000 kg to Mars

7. "How is China Advancing its Space Launch Capabilities?" *China Power*, August 25, 2020, at https://chinapower.csis.org/china-space-launch/. Accessed on May 2, 2022.

around 2028.[8] CZ-11[9] is meant for a quick-reaction orbital launcher. With the 58-ton launch mass and a 120-ton lift-off thrust, CZ-11 may be able to lift 700 kg to a sun-synchronous orbit. China is improving its space launch capabilities. Modular SLVs allow tailoring of specific configurations.

Figure 1: Chinese Space Launch Vehicles



Source: Space.com

CHINESE CREWED SPACE PROGRAMME

The first crewed space programme known as Project 714, was officially adopted in April 1971 but was later cancelled. In 1992, the first phase of Project 921, to launch a crewed spacecraft was cleared. In June 1993, China Aerospace Industry Corporation (National Space Bureau) was founded in Beijing. The Shenzhou programme had four uncrewed test flights and two crewed missions. Shenzhou 1 spacecraft was launched on November 20, 1999, and recovered after a flight of 21 hours. Shenzhou 3 and 4 were launched in 2002, carrying test dummies. Shenzhou 5 was China's first crewed mission in space on October 15, 2003, which carried Yang Liwei in orbit for 21 hours and

8. Liu Zhen, "Countdown to 2028 for launch of China's super heavy-lift CZ-9 rocket", *South China Morning Post,* September 31, 2021, at https://www.scmp.com/news/china/science/article/3150624/countdown-2028-launch-chinas-super-heavy-lift-cz-9-rocket. Accessed on May 2, 2022.
9. Leo Bruce, "Atmospheric research satellites launched by Chang Zheng 11", NasaSpace.flight.com, https://www.nasaspaceflight.com/2022/03/tianping-2-cz-11/. Accessed on May 2, 2022.

made China the third nation to launch a human into orbit.[10] Shenzhou 6 followed two years later, ending the first phase of Project 921. Missions used Long March 2F rockets from Jiuquin Satellite Launch Centre. The Tiangong served as a manned laboratory for testing orbital rendezvous and docking. The second space lab was Tiangong 2. It had the POLAR gamma-ray burst detector, a Space-Earth quantum key distribution, and laser communications experiment to be used in conjunction with the Mozi 'Quantum Science Satellite', a liquid bridge thermo-capillary convection experiment, and a space material experiment.[11] Also included are a stereoscopic microwave altimeter, a space plant growth experiment, a multi-angle wide-spectral imager and a multi-spectral limb imaging spectrometer. Onboard TG-2 there is also the world's first-ever in-space cold atomic fountain clock. As of April 2022, China's next step is the construction of Tiangong space station which is ongoing. To date, China has successfully completed 20 missions, without any astronaut fatality.

CHINESE LUNAR EXPLORATION PROGRAMME[12]

The Chinese Lunar Exploration Programme began with Chang'e 1, launched on October 24, 2007. It did a 3D mapping of the moon for future soft landings, and for ascertaining potentially useful resources. Subsequent Chang'e series spacecraft involved soft-landing on the Moon and deploying lunar rover 'Yutu'. Chang'e 4 landed on the South Pole (Aitken Basin), on the far side of the Moon on January 3, 2019. It was considered a landmark achievement. Chang'e 5 was launched on November 23, 2020 and brought 1.7 kg lunar samples back to earth. The next phase will involve a robotic research station near the Moon's South Pole. Chang'e 6, 7 and 8[13] will explore useable

10. Erik Gregersen, "Shenzhou Chinese Spacecraft", *Encyclopaedia Britannica*, January 30, 2020, at https://www.britannica.com/technology/Shenzhou. Accessed on May 2, 2022.
11. Rui C. Barbosa, "China launches Tiangong-2 orbital module", NasaSpaceflight.com, September 14, 2016, at https://www.nasaspaceflight.com/2016/09/china-launch-tiangong-2-orbital-module/. Accessed on May 3, 2022.
12. "Chinese Lunar Exploration Program", Wikipedia, at https://en.wikipedia.org/wiki/Chinese_Lunar_Exploration_Program. Accessed on May 3, 2022.
13. Andrew Jones, "China has moon's south pole in its sights with 3 missions launching this decade", Space.com, December 30, 2021, at https://www.space.com/china-upcoming-moon-missions-details. Accessed on May 3, 2022.

natural resources and experiment with 3D-printing a structure. A small sealed ecosystem will be created for a future lunar science base.

CHINA'S DEEP SPACE EXPLORATION PLAN

Chinese researchers proposed deep space exploration roadmap to explore Mars, an asteroid, Jupiter, and further targets, within the 2020-2030 time frame. Mars Global Remote Sensing Orbiter and Small Rover (HX-1), the Tianwen-1 mission was a Martian exploration mission launched in July 2020 which landed the Perseverance Rover with the attached Ingenuity helicopter drone. The Mission includes an orbiter, a Lander, and a rover. Asteroid Exploration Mission (ZhengHe) is proposed for launch around 2022-2024. Mission goals include asteroid fly-by observations, and Mars Sample Return Mission (HX-2), proposed for launch around 2028-2030. Mission goals include in situ topography and soil composition analysis, deep interior investigations to probe the planet's origins and geologic evolution, and sample return. Jupiter System Exploration Mission is proposed for launch around 2029-2030, to arrive at Jupiter around 2036.[14] Mission goals include orbital exploration of Jupiter and its four largest moons, the study of the magneto-hydrodynamics, and investigation of the internal composition of Jupiter's atmosphere and moons. A mission to Uranus has been proposed for implementation after 2030, with a probe arriving in the 2040s. It is presumed to be part of a future planetary fly-by phase of exploration and would study the solar wind and interplanetary field as well. Mars crewed phase in 2040-2060.[15] China plans a space solar station, with a capacity of 100 MW that could span at least one square kilometre, and become the biggest man-made object in space. China plans to accomplish a 200-tonne megawatt-level space-based solar power station by 2035, according to the China Academy of Space Technology.[16]

14. Khor Eng Lee and Aaron Khor, *China's long march of modernisation: blueprint & road map for the nation's Full Development 2016-2049* (Australia: Xlibris, 2019).
15. Ajay Lele, *Asian Space Race: Rhetoric or Reality?* (Springer, IDSA, 2013), p. 89.
16. Ryan Morrison, "China reveals plans to launch a fleet of mile-long solar panels into space to beam energy back to Earth by 2035—and says the system could have the same output as a nuclear power station by 2050", MailOnLine, August 18, 2021, at https://www.dailymail.co.uk/sciencetech/article-9904651/China-reveals-plans-launch-fleet-mile-long-solar-panels-space.html. Accessed on May 3, 2022.

GLOBAL BEIDOU NAVIGATION SATELLITE SYSTEM

China's navigation system with 35 satellites boasts the largest fleet of satellites. The BeiDou-3 constellation alone equals the US GPS's 31 operational satellites. In comparison, GLOSNASS has 26, and Galileo Systems has 26 satellites. Outnumbering the three other satellite providers, China is well on its way to becoming the world leader in technology and in space. The BDS will be used for positioning, timing, and wide-area differential and short-message communications. It can also be used for public security, forestry, fishing, search and rescue, etc. After the Ukraine conflict, it has become clear that the US could deny access, and there is a need for its own satellite navigation system. It will also support China's new "Space Silk Road". The BDS will also play an important military role including reconnaissance, and a short-messaging platform, both of which are not in GPS. The military mode will have greater accuracy. It will also support precision-guided missiles, smart bombs, navigation and operation of ships, other vehicles, and troops. Russia and China have signed "the Agreement on Peaceful Use of BeiDou and GLONASS", and large-scale cooperation in the satellite navigation field.

REUSABLE SPACE TECHNOLOGY

Expendable, single-use space launch vehicles are costly. Reusable technologies are initially expensive to develop but in the long run work out cheaper. China's Academy of Launch Vehicle Technology modified a Long March (LM-8) into a Reusable SLV (R-SLV), and launched it for the first time on December 22, 2020. The Chinese private company, i-Space, plans to launch the country's first commercially developed R-SLV, called Hyperbola. Spaceplanes have been another option. China, having developed hypersonic glide vehicles, should be able to develop a spaceplane. China is developing the Shenlong and Tengyun spaceplanes. The first prototype was launched in 2020.

SPACE PROGRAMME PLA LINKAGES

China's space programme supports its military modernisation efforts. China continues to improve its counter-space weapons capabilities and has enacted military reforms to better integrate cyberspace, space, and EW into joint military operations. The PLA

routinely incorporates jamming and anti-jamming techniques against multiple communication, radar systems, and GPS satellite systems during exercises. China continues to develop jammers dedicated to targeting SAR aboard military reconnaissance platforms, including LEO satellites.[17] Additionally, China is developing jammers to target SATCOM over a range of frequency bands, including military-protected extremely high-frequency communications. The PLA views space superiority, the ability to control the information sphere, and denying adversaries the same, as key components of conducting modern information-centric wars. Space and counter-space operations are now an integral part of PLA campaigns. The PLASSF integrates cyberspace, space, and EW capabilities into joint military operations. The SSF is the core of China's information warfare force. Chinese military strategy documents also emphasise the growing importance of offensive air, long-distance mobility, and space and cyberspace operations.

CHINESE SPACE-BASED C4ISR CAPABILITY

China's evolving command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) military paradigm, when interfaced with the cyber, space, and electronic warfare, are a great asset for the network-centric battlefield. The technologically advanced offensive weapons fused with C4ISR systems, make them much more formidable. The Chinese believe that information dominance is the key to winning conflicts. This could be done by denying or disrupting the use of communications equipment of its competitors. In addition to strike, air and missile defence, anti-surface, and anti-submarine capabilities improvements, China is focusing on information, cyber, and space and counter-space operations. ***China has made even greater strides in space-based C4ISR*** **a**s part of the PLA's integrated civil-military space programme, counter-space technologies and systems.

17. Andrew S. Erickson, "China Analysis from Original Reports, New DIA Report—Challenges to Security in Space", February 11, 2019, at http://www.andrewerickson.com/2019/02/new-dia-report-challenges-to-security-in-space-offers-copious-china-related-information/. Accessed on May 3, 2022.

Concurrent improvements in counter-space capabilities will also put the adversary assets in space, air, and sea-based at risk.

MILITARISATION OF SPACE PROGRAMME

China is pursuing laser weapons to disrupt, degrade, or damage satellites and their sensors and possibly already has the capability to employ laser systems against satellite sensors. China is developing many reversible and non-reversible counter-space Directed Energy Weapons (DEW) that can dazzle electro-optical sensors or even destroy satellite components. China has many ground-based high-powered laser weapons to engage satellites even causing structural damage. Chinese military researchers say they have built and tested an anti-satellite robotic device that can place a small pack of explosives into a probe's exhaust nozzle.[18] China is likely to field ground-based laser weapons that can counter low-orbit space-based sensors.[19]

The PLA's doctrinal emphasis on EW includes jamming and anti-jamming techniques to deny multiple types of space-based communications, radars, and GPS navigation. Targeting SAR satellites protects their own terrestrial assets by denying imagery and targeting. China is also developing jammers to target SATCOM over a range of frequency bands.

The PLA emphasises offensive cyberspace capabilities as a major component of integrated warfare. China would use its cyber-warfare capabilities to target space-based assets to achieve information dominance early in the conflict and to slow the adversary's mobilisation and targeting ability. They will conduct cyber espionage against adversary space platforms to acquire high-end technology.

China is developing sophisticated on-orbit capabilities, such as satellite inspection and repair, at least some of which could also function as a weapon. The PLA has an operational ground-

18. Stephen Chen, "Chinese scientists build anti-satellite weapon that can cause explosion inside exhaust", *South China Morning Post*, October 21, 2021, at https://www.scmp.com/news/china/military/article/3153174/chinese-scientists-build-anti-satellite-weapon-can-cause. Accessed on May 3, 2022.
19. Wire agency feed, "China develops laser weapon that could destroy satellites in space", *Mint*, March 19, 2021, at https://www.livemint.com/news/world/china-develops-laser-weapon-that-could-destroy-satellites-in-space-11647654842355.html. Accessed on May 3, 2022.

based ASAT missile intended to target LEO satellites. PLA units continuously train with ASAT missiles. China reportedly intends to pursue additional ASAT weapons capable of destroying satellites up to GEO. Militarisation of China's space programme has global implications, including for India. The high investment is difficult to match.

CHINA'S ORBITAL THREAT CAPABILITIES

China is developing space-based satellite inspection and repair which could one day be used as a weapon. China has launched multiple satellites for space maintenance tasks and space debris clean-up. In January 2022, Shijian-21 moved a derelict BeiDou navigation satellite to a high graveyard orbit above GEO. The Shijian-17 is a Chinese satellite with a robotic arm, and such systems could be used to grapple with other satellites. China is also working on space-based kinetic weapons for targeting purposes. China conducted the first fractional orbital launch of an ICBM with a hypersonic glide vehicle on July 27, 2021.

CHINA'S SATELLITE SURVEILLANCE ABILITY

China reported it had set a new record of orbital launches in 2021, with 40 missions put into space.[20] China is investing heavily in spy satellites, dozens of which are snooping around the world at any given time. China uses a multitude of sensors—such as satellites soaring above, over-the-horizon radars, surface warships and submarines, maritime patrol aircraft, and underwater sensors—to keep track of adversaries. The second cluster of Yaogan-32 satellites flew to space in November 2021. Yaogan 34-02 were launched on March 17, 2022. The first Yaogan-30 triplet was lofted into space on September 29, 2017. These satellites operate in groups of three by gathering information derived from ship/aircraft radar and electromagnetic signatures. These allow the PLA to pass over an area 19 times per day in vertical-imaging mode, or 54 times a day in off-vertical SIGINT

20. Elizabeth Howell, "China launches military satellites into orbit after delay", Space.com, November 4, 2021, at https://www.space.com/china-launches-military-satellites-yaogan-32-nov-2021. Accessed on May 3, 2022.

mode. There will be almost continuous coverage of key areas of the globe. Yaogan-30 is just one ELINT part of the extensive Yaogan network that includes SAR and optical-imaging satellites. Other than the Yaogan series of triplets, there is the JianBing-8 constellation for maritime surveillance.

OTHER FUTURISTIC SPACE INITIATIVES

Some of the other Chinese space-related initiatives are a Space-based ASAT system comprising small and nano-satellites developed by the Small Satellites Research Institute. More advances in China's BeiDou navigation system are planned with 60-70 satellites. China has a deep-space tracking network using the world's largest single-dish radio antenna of 500 metres in Guizhou,[21] and a 3,000-km VLB radio antenna. There is a plan for a Deep-Impact style mission to test the process of redirecting the direction of an asteroid or comet.

IMPLICATIONS AND OPTIONS FOR INDIA

China's economy has been booming for many decades. This, combined with global power ambitions, enables China to assign huge sums to its space programme. The total number of Chinese annual space launches is currently unmatchable. Forty launches a year cannot be matched even by the USA. It is not just quantity, they are moving ahead in technology and achieving new milestones. China's success with its space start-ups is another area for India to emulate. Chinese companies have formed joint ventures with many European companies. China's success with Reusable Launch technologies is also important.

China's space capability has major military applications and has been converted into a force-multiplier. They will use it for surveillance and targeting. Also, Space will be used for Cyber-attacks and electronic warfare. India will have to substantially increase the number of military support satellites and create ground links and applications for operational usage. Many more satellites are required

21. "China launches world's largest single-dish radio telescope", domain-b.com, January 13, 2020, at https://www.domain-b.com/industry/Aerospace/20200113_dish_radio.html. Accessed on May 3, 2022.

for a more frequent revisit of the area of interest. India needs to promote the participation of the private sector. It also needs to monetise space capabilities. Lastly, coordination with space assets of like-minded friendly countries would be cost-effective.