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Quentin Parker

Lunar missions exciting time for space

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The success after success of China's space program, with all its diverse elements for scientific exploration and technological development in what remains a risky business, is as impressive as it is exciting.

China launched three astronauts into low-Earth orbit on Thursday night for a six-month mission at the Tiangong space station, as part of its preparations to send astronauts to the moon by the end of the decade. During a press conference on April 24, China Manned Space Agency stated that the development and construction of systems for a Chinese manned lunar landing are progressing as planned, with the aim of achieving a moon landing by Chinese astronauts before 2030.

China's accomplishments in space exploration and technology over the past five years, in particular, are without precedent. This includes the completion of China's space station Tiangong (Heavenly Palace), whose first major component, the core module Tianhe, was launched in April 2021 and the two major science modules, Wentian and Mengtian, were launched in 2022.

China's space station continues its program of development and progress from its current T-configuration but with plans for further expansion. Indeed, the docking time for "taikonauts" from launch to entry into the space station has recently been reduced from an already impressive six-seven hours to just two and a half hours due to the development of space rendezvous and docking technologies.

Tianzhou 7, the latest automatic cargo resupply vessel, took off from the Wenchang Satellite launch center in the Hainan island in January and docked in three hours compared with the 16-19 hours taken by the Elon Musk Space-X "Dragon" capsule to dock with the International Space Station (and the about six hours taken by the old Soyuz capsules).

Also, there was the Tianwen 1 Mars mission with Zhurong Rover in May 2021 — perhaps the most complex and hazardous of China's space missions. This should be seen in the context of about 60 percent of Mars missions failing to land on the surface of the Red Planet.

Also, the Chinese Space Station Telescope, Xuntian, is scheduled for launch and operation in 2025. Xuntian is an optical and ultraviolet space observatory that will boast a 2-meter-diameter lens, making it comparable to the venerable Hubble Space Telescope. Although the resolution of China's telescope will be similar to Hubble's, its field of view will be 350 times larger.

More important, China's Chang'e (Beautiful Moon Goddess) series of lunar missions have proved amazingly successful, with the Chang'e 3 lander making the first landing on the moon way back in December 2013. The mission included a lunar lander and a small *yutu* (jade rabbit) rover that was set down in the Mare Imbrium region of the moon, a prominent lava filled basin from one of the largest impact craters known in the entire solar system and easily visible to the naked eye. It made China only the third country to achieve a lunar soft landing.

Chang'e 4, a similar mission of lander and rover, followed in 2019. It was designed as a backup in case Chang'e 3 failed. What set the mission apart was that its landing zone was on the far side of the moon, which is not visible from Earth, the first such landing in space exploration history.

This feat was made possible by the success of Chang'e 3 that gave the mission planners and scientists the opportunity and confidence to reconfigure Chang'e 4 for the more challenging but interesting far side alternative. Since this made the mission far more complicated, to maintain essential communication with the Earth a separate *queqiao* (magpie bridge) relay satellite was deployed into a halo orbit around the so-called L2 Earth-moon Lagrangian point of gravitational equipotential for stability. This mission, too, was a big success.

The Chang'e 5, which followed, was China's first lunar mission that involved bringing back rock sample from the moon. It was launched in November 2020 and landed on the moon on Dec 1, 2020. The return module came back with its precious cargo of 1.7 kilogram of moon rock two weeks later. The scooping device attached to the lander was developed by the Polytechnic University of Hong Kong while my own university, the University of Hong Kong, was fortunate enough to get a small sample of the moon rock for scientific study.

As a result, China became only the third country, after the United States and the former Soviet Union (now Russia), to bring back rock samples from the moon.

Just like Chang'e 4 was a backup for Chang'e 3 so was Chang'e 6 for Chang'e 5. Given the success of Chang'e 5, the Chang'e 6 mission has been redesigned to collect rock samples from the far side of the moon for the first time. This mission is due to be launched in the near future. If successful, this will be another science bonanza, as game-changing amounts of water ice are suspected to exist in the shadowed lunar craters which can be used as fuel for future space missions or to breathe by future space explorers.

However, international cooperation is vital in space exploration. And I believe China is keen on deepening cooperation as it has made clear in its white paper on space program published in January 2022. Indeed, many of the scientific payloads on the Chang'e landers have had international scientific packages. For example, Chang'e 4 had scientific packages by Germany, Sweden, the Netherlands and Saudi Arabia.

And while the European Space Agency supported the Chang'e 5 mission by providing essential tracking from both its Kourou station in French Guiana and Maspolomas station in the Canary Islands at various crucial parts of the mission, different scientific payloads have been provided by France, Italy and Sweden again, and a Pakistani ICUBE-Q CubeSat for Chang'e 6 for detecting ice traces on the lunar surface from orbit.

The Chang'e series of missions is not over, for Chang'e 7 is planned for around 2026 and Chang'e 8 for around 2028, with both focused on the south pole of the moon in order to build a China-led lunar base in the 2030s.

Anticipating further international cooperation, this follows the recent unveiling of the most comprehensive lunar atlas ever created, crucial for guiding future lunar endeavors. This remarkable achievement is the result of over a decade of meticulous work by Chinese lunar scientists and geologists. With this in mind, "watch this space" as humanity sets its sights on new aspirations of lunar exploration and envisions moon bases as a gateway to further frontiers.

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The views do not necessarily reflect those of China Daily.

Wu Jinyuan

First keep steps firmly on the moon

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The moon, planet Earth's only natural satellite and our closest celestial body, beckons us from 380,000 kilometers away to explore the vast expanse of the cosmos. Since ancient times, humans have dreamt of exploring space, with the moon serving as their first stop. Indeed, the moon is the first step toward uncovering the unknown — exploring the secrets of the limitless universe.

China launched three astronauts into low-Earth orbit on Thursday night for a six-month mission at the Tiangong space station, as part of its preparations to send astronauts to the moon by 2030.

The journey to realize our initial dream began in earnest in 1959 with the launch of the first scientific lunar exploration. From then till 1976, the United States and the Soviet Union engaged in a frenzied lunar race, sending 83 lunar probes into orbit, marking what historians later dubbed as the "First Lunar Rush".

While the initial surge in lunar exploration may have been driven by political, military and technological competition, the later expeditions were spurred by the true allure of space exploration. Beyond the tantalizing prospects of helium-3, a future energy source hidden in the lunar regolith, lie five types of minerals not found on Earth. That aside, the moon is also believed to have reserves of rare metals that complement those on Earth, with lunar mare basalt alone containing at least 100 trillion tons of extractable titanium metal.

In the 21st century, several countries have proposed "returning to the moon" as part of their exploration. But to date, only China has systematically pursued it through its Chang'e program. From 2007 to 2020, China completed the lunar exploration phase beginning with Chang'e 1 through five missions, culminating in the historic landing of the Chang'e 4 rover and lander on the far side of the moon in 2019.

China's lunar exploration road map till now can be divided into reconnaissance, landing and establishment. Having achieved unmanned exploration, China's next horizon is manned lunar landing. After achieving that, China's goal is to prepare for short-term habitation, conduct lunar surface research, and carry out exploration and mining.

The upcoming Chang'e 6 mission represents the first task of a new phase of the Chang'e program. Originally intended as a backup for Chang'e 5, the program is intended to fulfill a new mission: bringing back soil samples from the far side of the moon. The Chang'e 6 and subsequent missions will survey the lunar topography, land forms and material composition, and make preparations for future manned landings and establishment of lunar bases. Not surprisingly, China's manned lunar exploration program now has a detailed timetable, with the target set for 2030.

The return to the moon has become a focal point for space-faring countries this year. In April, NASA announced plans to send equipment to the moon for long-term scientific exploration. And SpaceX and Blue Origin, as providers of manned landing systems, have been making progress in developing lunar landers for large cargo.

In fact, the NASA-led Artemis program includes the space launch system rocket, ground exploration equipment, Orion spacecraft, manned landing systems, next-generation spacesuits, rovers and the "Gateway" lunar space station.

The moon, described poetically in ancient Chinese literature as a "jade plate", is once again poised to play a grand role in humankind's quest for excellence — the establishment of a manned lunar base, paving the way for future manned missions to Mars.

However, the long-term exploration of the moon and construction of lunar research stations require substantial resources, including energy, and material support. At the current level of technology, the cost of transporting 1 kilogram of materials from Earth to the moon ranges from $50,000 to $90,000. This means, if the construction and operation of lunar research stations were to rely solely on Earth's supplies, it would entail enormous costs.

This is where the lunar soil brought back by Chang'e 5 comes in. It has opened new avenues for scientists, some of whom believe it is possible to build bases using the resources available on the moon. According to Chinese scientists' research, some components of the lunar regolith can serve as catalysts for four processes: photovoltaic electrolysis of water, photocatalytic water decomposition, photocatalytic reduction of carbon dioxide and photo-thermal catalytic hydrogenation of carbon dioxide. Simulated solar radiation will help these processes to convert water and carbon dioxide into oxygen, hydrogen, methane and methanol. While oxygen is vital to human survival, hydrogen and methane are essential components of rocket propellants, and methanol is a key chemical raw material.

As German philosopher Immanuel Kant said, "Two things fill the mind with ever new and increasing wonder and awe — the starry heavens above me, and the moral law within me."

The moon serves as humanity's first stop and transit on way to the cosmos, and China is determined to keep each step firmly on the way.

The views don't necessarily reflect those of China Daily.

Wang Yanan

China, Latin America entitled to forge close space cooperation

Considering the unfathomable expanse of the universe, Earth, the only cosmic body we can call home, appears like a speck on a vast ocean. Yet in the cosmic expanse, a realm of boundless possibilities and uncertainties, lies the future of humankind. From the humble beginnings of human flight in a hot air balloon in 1783 to the monumental achievement of landing on the moon in 1969, our journey into space has been marked by remarkable achievements. Yet, given the grandeur of the cosmos, our accomplishments may seem modest.

Space technology offers a plethora of promising avenues for exploration and discovery. In space, we can unlock the mysteries of biology and life. We can explore space to make breakthroughs in medicines, cultivate more productive and resilient crops, and develop superior materials. The prospect of exploring distant planets and future migration paths of humans beckons us with tantalizing possibilities.

Unfortunately, access to these promising prospects is limited to only a few countries. There is significant imbalance among countries when it comes to space technology. While some countries possess advanced space capabilities, others lack even the basic communication satellites, and are thus deprived of the benefits of space technology.

China, as a developing country, has made significant strides in space technology, and prioritizes cooperation with other developing countries to ensure equitable access to space resources.

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In recent years, China's cooperation with Latin American countries in space technology has expanded. China's collaboration with Venezuela on a future lunar exploration station project, including the possibility of sending Venezuelan astronauts to China's space station, exemplifies this trend. China's commitment to equitable and mutually beneficial global cooperation ensures that the participating countries can synchronize their access to space technology, expand the frontiers of human knowledge and leverage China's experience in space research to develop their agriculture, industry and healthcare sectors, and boost their economy.

China's involvement in Latin American countries' space endeavors goes beyond mere provisions for satellites, because it has been participating in the construction of satellite ground control facilities, training technical personnel, and helping enhance their satellite manufacturing capabilities. This collaborative approach has not only facilitated the sustainable development of space applications in Latin America but also enabled China to use satellite tracking and communications facilities in the region to support its own space program, including deep space exploration.

But China's deepening space technology cooperation with Latin American countries has made some countries, particularly Western countries, uncomfortable, with some of them saying China's involvement could destabilize the existing space exploration order and undermine the strategic interests of other space-faring nations. By saying so, however, they reveal their refusal to accept Latin American countries' desire to develop space technology and their willingness to engage in mutually beneficial cooperation with China.

The establishment of the Latin American and Caribbean Space Agency in Mexico in 2021 is testament to the region's commitment to space exploration and development. However, China's collaboration with Latin American countries in space technology predates the establishment of the agency; it began in the late 1980s.

Over the years, China has launched satellites for several Latin American countries, including Brazil, providing vital support for their communication and resource survey efforts. It has also established space technology cooperation with countries such as Venezuela, Bolivia, Chile and Argentina. Such collaboration has not only bolstered Latin American countries' space capability but also fostered economic development and technological advancement in the region.

In the broader context, space technology cooperation represents a fundamental shift in the way we approach the exploration and exploitation of outer space. Instead of viewing space as a geopolitical battleground, we should embrace it as a platform promoting global collaboration and scientific discovery. By working together, countries can leverage their respective strengths and resources to address common challenges and realize the full potential of space exploration for the benefit of all humanity.

China's increasing role in space technology cooperation with Latin American countries holds great promise for the future of space exploration and development. By boosting collaboration and sharing resources, China and Latin American countries together can boost their space capabilities and help achieve the broader goals of scientific exploration and technological innovation.

The future of human civilization does not depend on individual countries' ability to set foot on celestial bodies, but rather on how much space technology can benefit humanity. As we journey into the cosmos, let us embrace the spirit of cooperation and partnership, and recognize that our collective future lies among the stars.

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