RECONNECT CHINA

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Racing to the Moon: China's Lunar exploration program in competition with the United States

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A new Cold War-style race to the moon seems to be in the making. The People's Republic of China and the United States are both investing in moon exploration with manned lunar scientific stations as the ultimate goal. The comparison with the 1960s has its limits, nonetheless, because this time the race is not only to touch down the moon's surface and return to Earth, but to promote a long-term scientific development on the moon and far beyond.

This *ReConnect China Policy Brief* breaks down the state of play of the China-US race to the moon, and considers the strategic ambitions, technical requirements, and necessary diplomatic support for such a great aim.

Genesis of China's moon exploration program

The Chinese Lunar Exploration Program (CLEP) started in 2004 with the threefold preliminary objectives to orbit around the moon, land on its surface, and return samples. These objectives were all reached through five Chang'e missions between 2007 and 2020. Three of these missions were particularly noteworthy: Chang'e 3 was China's first landing on the moon, Chang'e 4 was the first ever landing on its far side, and Chang'e 5 returned samples to Earth.

Three more Chang'e missions are scheduled by the end of the decade with the goal of preparing the next phase of China's lunar exploration: the construction of an on-site lunar research station near the south pole.

This project – which officially goes by the name of International Lunar Research Station (ILRS) – was initially a China-Russia joint program, open to international cooperation, which Beijing and Moscow inked through a memorandum of understanding in March 2021.[1] In June the same year, during the Global Space Exploration Conference (GLEX) in Saint Petersburg, both countries' space agencies (the China National Space Agency – CNSA – and the Russian Roscosmos) released a document presenting the roadmap of the project and a "guide for partnership". The document was submitted to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) in August.[2]

According to this document, the IRLS was supposed to be built between 2030 and 2035 through five missions alternatively launched by China and Russia. However, the Russian war of aggression on Ukraine in February 2022 proved to be a major setback for the ILRS development for several reasons. Firstly, in terms of diplomacy, even though China never condemned Vladimir Putin's action against Ukraine, Russia has become a very sensitive, if not toxic, partner for China in space because partnering with Moscow risks scaring away potential international partners. Secondly, the war in Ukraine has accelerated the Russian space industry's decay, as illustrated by the crash of the much-delayed Luna 25 in August 2023, the first Russian moon mission since Luna 24 under the USSR in 1976.

Russia is therefore neither a technically reliable partner, nor a helpful diplomatically for China in the race to the moon. Supporting this argument is the disappearance of any Russian contribution to ILRS at the recent International Astronautical Congress in October 2023. During his talk, CNSA's chief engineer Li Guoping showcased a slide presenting the development phases of ILRS from 2024 to 2040. Contrary to the 2021 roadmap, the whole program is now borne by Chinese missions.[3]

In parallel, the US lunar program is progressing at a steady pace. After the end of the Apollo program in 1972, the US focused on low Earth orbit with programs like the Space Shuttle and the International Space Station. In 2017, the US launched the Artemis program, aimed at landing men and women on the moon. The first mission of the program, Artemis I, successfully occurred in November 2022. It was an unmanned mission to test various systems, mainly the SLS launcher and the Orion capsule. The second mission of the program should carry a human crew around the moon in 2024. By returning to the moon and aiming at sustained presence there, the United States wishes to reassert its leadership role in space exploration, in direct competition with China.

Architecture and Technical Requirements

Performing a human moon landing mission is a complex and resource-intensive endeavour that requires careful planning, advanced technology, significant funding, and a highly trained team of engineers. It requires a powerful launch vehicle to transport the spacecraft and crew from Earth to lunar orbit and a lunar module that can land on the moon's surface and take off again.

Heavy Launchers

China's most powerful rocket to date is the Long March 5 (LM-5 or Changzheng 5) capable of lifting 8 to 9 tons to the moon. The LM- 5 is a heavy launcher in the same class as the European Ariane 5 and Ariane 6, or the American Atlas V and Vulcan. These launchers do not have the necessary lift capacity to perform human missions to the moon, as they can only carry limited cargo to this region (under 10 tons).

The China Academy of Launch Vehicle Technology (CALT, a branch of the state-owned enterprise China Aerospace Science and Technology Corporation (CASC)) is therefore developing the Long March 10, capable of carrying out the next generation manned spacecraft and lander to the moon.[4] According to available information, the LM-10 launcher could propel 27 tons to lunar orbit, the same capacity as the American SLS launcher (see below). It would have the same diameter as the LM-5 currently in operation and use the same rocket engines (YF-100 and YF-75). Relying on operational rocket engines and existing manufacturing techniques may hasten the development of this super-heavy launcher, which is expected as soon as 2027. Ultimately, two LM-10 launches would be necessary to carry a human crew and lunar lander.

In order to lift much heavier payloads, CALT is developing the super-heavy lift Long March 9 (LM-9). Prior to 2021, the LM-9 was designed as a non-reusable super-heavy launcher, comparable to the

American Space Launch System (SLS). According to information released in March and April 2023, Chinese engineers seem to have reoriented their plans for the LM-9 towards a design reminiscent of Space X's Starship rocket (see below). The LM-9 will consist of a fully-reusable, 10-meter-diameter, three-stage, 114-meter-high rocket, and will be capable of lifting 50 tons into lunar transfer orbit. It is announced to be ready by 2033.[5]

In the US, the SLS is the most potent rocket ever developed by NASA. It is poised to deliver payloads and astronauts to lunar orbit and its capabilities are described as necessary for the Artemis program. In development since 2011, the launcher is based on Space Shuttle technologies, and was successfully launched in November 2022. The US company SpaceX, for its part, is developing the Starship launcher, which is also supposed to be used in the Artemis program. SpaceX's Starship is a fully reusable system which combines a heavy launcher, spacecraft and lander. Much more powerful than the SLS, it is designed for a wide range of missions, including crewed missions to the moon, Mars, and beyond.

Manned spacecraft

According to available information, China's next-generation crewed spacecraft, developed and produced by CASC, is a reusable space vehicle. In 2016, a scaled-down prototype made its inaugural flight.[6] In 2020, the full-scale prototype completed its first uncrewed test flight.[7] This spacecraft serves the dual purpose of transporting astronauts to the Chinese space station in Earth's orbit and supporting future lunar exploration missions.

This innovative spacecraft is larger than the current Shenzhou spacecraft and possesses lunar expedition capabilities. It comprises two modules: a crew module responsible for safely returning astronauts to Earth, and an expendable service module that provides propulsion, power, and life support for the crew module while in space. Its capacity allows for either six astronauts or a combination of three astronauts and 500 kg of cargo. Notably, the crew module boasts partial reusability through its detachable heat shields, while the spacecraft is designed with modularity to adapt to various mission requirements.[8]

According to information from the China Manned Space Agency (CMS), the crew spacecraft measures approximately 8.8 meters in length and has a fully loaded weight of around 21,600 kg, including equipment and propellant. Lunar missions are on the horizon, with plans set for the 2030s.[9]

In the US, NASA has developed the Orion spacecraft, officially known as the Orion Multi-Purpose Crew Vehicle (MPCV), for deep space missions beyond low Earth orbit. In development since the early 2000s, it is designed to be launched atop the SLS. It is presented as a key component of the Artemis program. So far, it has flown uncrewed on two occasions, in 2014 and 2022. It is already considered operational and will be used for the first Artemis crewed mission around the moon, planned in 2024.

Lunar Launchers	Country of origin	Announced payload to LTO (tons)	Year in operation
Space Launch System (SLS)	USA	27	operational
Starship	USA	100-150	2023 (announced)
Long March 10	China	27	2027 (announced)
Long March 9	China	50	2033 (announced)

Lunar lander

Little information is available on China's future crewed lunar lander. According to video evidence and models presented publicly, the lander appears to be highly similar in its concept of operation to the Apollo Lunar lander.

For the Artemis program, NASA has selected the wholly integrated Starship Human Landing System (HLS). Developed by SpaceX, it uses the Starship two-stage rocket architecture, in which the second stage is also the lander itself, capable of landing on the moon with its crew. The Starship HLS requires orbital refuelling to perform is lunar mission. The Starship has successfully landed on Earth after a suborbital flight, but the first orbital test in April 2023 failed. In 2023, NASA has tasked Blue Origin to develop a second lunar lander.

Additional elements

An important and rather original dimension of China's Lunar Exploration Program is the Queqiao satellite relay program, critical for communication between Earth and human systems on the far side of the moon (orbiting or on the surface). In 2018, the Queqiao 1 satellite was launched onboard Long March-4C and put in orbit beyond the moon (at Earth-moon Lagrange point 2), in order to allow the then-forthcoming Chang'e 4 mission on the far side of the moon to communicate with Earth. Queqiao 2 is expected to be launched in early 2024 to support the Chang'e 6 sample return mission later the same year.[10]

On the US side, the Lunar Orbiting Platform – Gateway (LOP-G) is the future lunar orbit space station. It will serve as a staging point for crewed missions to the lunar surface and supports long-term lunar exploration. NASA plans to launch the first module in 2025. Additionally, NASA's Commercial Lunar Payload Services (CLPS) initiative enlists the assistance of private companies to deliver scientific instruments and technology payloads to the moon's surface. This collaboration exemplifies NASA's approach to harnessing commercial potential in achieving its objectives: for instance, the lunar spacesuits used in Artemis will be built by the private company Axiom Space.

Concepts of operation

China intends to land humans on the moon before 2030, but few details have been released so far, and the ability to achieve this mission and schedule will largely depend on the readiness of the LM-10 launcher and spacecraft. According to the latest information, China intends to use the lunar orbit rendezvous (LOR) process.[11] A concept picture suggests that three astronauts may be sent, with two landing on the moon and one piloting the command and service spaceship in lunar orbit. This is similar to the US Apollo program but with one major difference: China may send the lunar lander and crewed spacecraft on separate launchers (both LM-10) for rendezvous and docking in lunar orbit. Astronauts will transfer from the command spacecraft to the moon lander and descend to the lunar surface to conduct scientific investigations. Afterward, they will ascend to lunar orbit, rendezvous and dock with the command spacecraft for the return journey to Earth. The LOR process is chosen for its payload efficiency, allowing the heavier command and service spaceship to remain in orbit and only carry fuel for the lunar lander's descent and ascent. This concept of operation has the advantage of relying mostly on already-proven technologies such as the rocket engines and the manned spacecraft.

In contrast, the Artemis concept of operation appears more ambitious but also more complex, as it relies on brand new technologies such as orbital refuelling and fully reusable rockets. The first lunar landing mission of the program, Artemis III, is scheduled for December 2025. The mission would use an SLS launcher and an Orion spacecraft, which are operational. However, it would also use the

Starship HLS system, which is still under development and adds a high degree of complexity in that it requires several launches and orbital refuelling to fly to the moon. Despite the rapid development of the Starship vehicle by Space X, the Starship HLS is running late.

INTERNATIONAL COOPERATION

China-US competition toward the moon also exists on Earth in the diplomatic realm. The China-Russia ILRS program is seeking international partners, just like the American Artemis Accords. As stated above, Russia increasingly appears to be a burden rather than an asset in attracting partners.

Nonetheless, between July and October 2023, five countries have joined the ILRS: Venezuela,[12] South Africa,[13] Azerbaijan,[14] Pakistan[15] and Belarus.[16] One should still note that South Africa and Pakistan signed an MoU, while the remaining three only signed a "joint statement on cooperation".

In April, China also signed a joint statement on cooperation on ILRS with the Asia-Pacific Space Cooperation Organization (APSCO), which includes Bangladesh, Iran, Mongolia, Pakistan, Peru and Thailand, alongside China. The statement was signed by CNSA Secretary General Xu Hongliang (a lower ranking official compared to CNSA Director Zhang Kejian) and APSCO Secretary General Yu Qi, a Chinese national. The roadmap and concrete outcomes expected for the cooperation between CNSA and APSCO on ILRS remain blurry, as APSCO member states have little to no experience in space.

It is worth noting that these MoUs and joint statements are signed by China's CNSA and counterparts, but do not include Russia's Roscosmos, which may be telling with regard to who is actually in the driver's seat on IRLS.

In June 2021, the head of the Chinese Lunar Exploration Program, Wu Weiren, declared that Pakistan and the United Arab Emirates (UAE) had signed to join ILRS, and "more than 10 countries and organizations are negotiating agreements".[17] Since then, however, no official document or declaration has provided proof of this assertion. The UAE was once involved in Chang'e 7 mission (de facto part of ILRS), providing an instrument, but the collaboration was eventually cancelled due to ITAR compliance issues. It is even less likely for the UAE to join ILRS considering that it already joined the Artemis Accords in 2020.

During China Space Day in April 2023, Wu Weiren launched a new initiative to set up the "ILRS Cooperation Organization" (ILRSCO) in order to institutionalize the program and attract more partners.[18] The founding members were expected to sign before June, but it was then delayed until October. ILRSCO headquarters would be located in Hefei, Anhui province, within the Deep Space Science City.[19]

NASA, for its part, opened the Artemis Accords to signature in 2020. The Accords promote principles for a safe and sustainable, as well as a shared vision for lunar exploration. In September 2023, 28 countries had signed the Artemis Accords, including many of the most experienced space powers (including France, Italy, Luxemburg, the UK, India and Israel).[20] Hence, the United States so far has a fair advance on China in terms of international diplomatic and technical support.

CONCLUSION

China is strongly committed to achieving its ambitions toward moon exploration, with or without Russia's contribution. It is a matter of international scientific prestige and strategic competition with the US. Still, the Americans maintain a significant advance both in terms of technology and diplomatic support. NASA has a very long experience, drains the best brains worldwide, enjoys a comfortable budget ($25.4 billion in 2023), and benefits from a very dynamic and efficient space industry. Despite China's rapid and steady progress, it still has a significant gap to bridge with the US. Its budget is estimated two to three times lower than that of the US. China mainly relies on national engineers, and is served by a tightly controlled, rigid space industry and innovation system. On the diplomatic level, the US has tied up stronger support both quantitatively and qualitatively compared to China, whose only experienced partner is a decaying Russia.

In addition, when it comes to setting space ambitions and program orientations, there is still a strong sense that China is trying to keep up with the American model rather than going its own way. The strong governmental incentive to stimulate private investment and commercial space in China is following the US "New Space" path, although with its own characteristics. When examining the moon program alongside the Chinese LM-9 and LM-10, spacecraft and lunar lander, it appears that China is drawing inspiration from the technical choices made by the United States. Then, a question remains: with its fundamentally different political, scientific, and industrial ecosystem, will China be able to match or even outperform the results of the United States?

Although it is reasonable to anticipate significant achievements from China's Lunar Exploration Program by the end of the decade, the race to the moon is very complex, highly competitive and will extend well beyond 2030.

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