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The 5 Spacecraft Behind China's Moon-Rock Mission

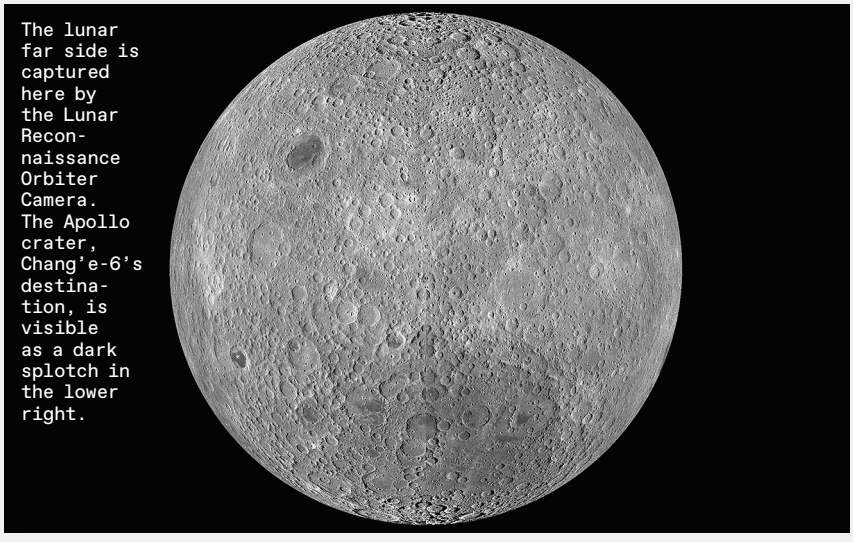
› Chang'e-6's trip to the lunar far side is no easy task

BY ANDREW JONES

China launched a spacecraft in March that is planned as the first act in a complex, multistep campaign to collect samples from the far side of the moon as soon as this summer and deliver the precious cargo to Earth—an unprecedented feat.

Queqiao-2 ("Magpie Bridge-2"), a communications relay satellite, launched 20 March on a Long March 8 rocket from the Wenchang Space Launch Site in Hainan province. If all goes well, Queqiao-2's stable and highly elliptical lunar orbit will take it out beyond the moon, able to view both its far side and Earth, for vast portions of the satellite's 24-hour orbit. From here it will assist a series of landing, sampling, and lunar-ascent maneuvers needed to sample the lunar far side—which never faces Earth, thanks to our planet's gravity tidally locking with the moon's rotation as it orbits Earth once every 27.3 days.

With Queqiao-2 in place, the Chang'e-6 mission—a stack of four spacecraft—is scheduled to launch this month. It will target a landing in an Apollo crater on the far side of the moon to both scoop up and drill for up to 2 kilograms of rock samples.



The lunar far side is captured here by the Lunar Reconnaissance Orbiter Camera. The Apollo crater, Chang'e-6's destination, is visible as a dark splotch in the lower right.

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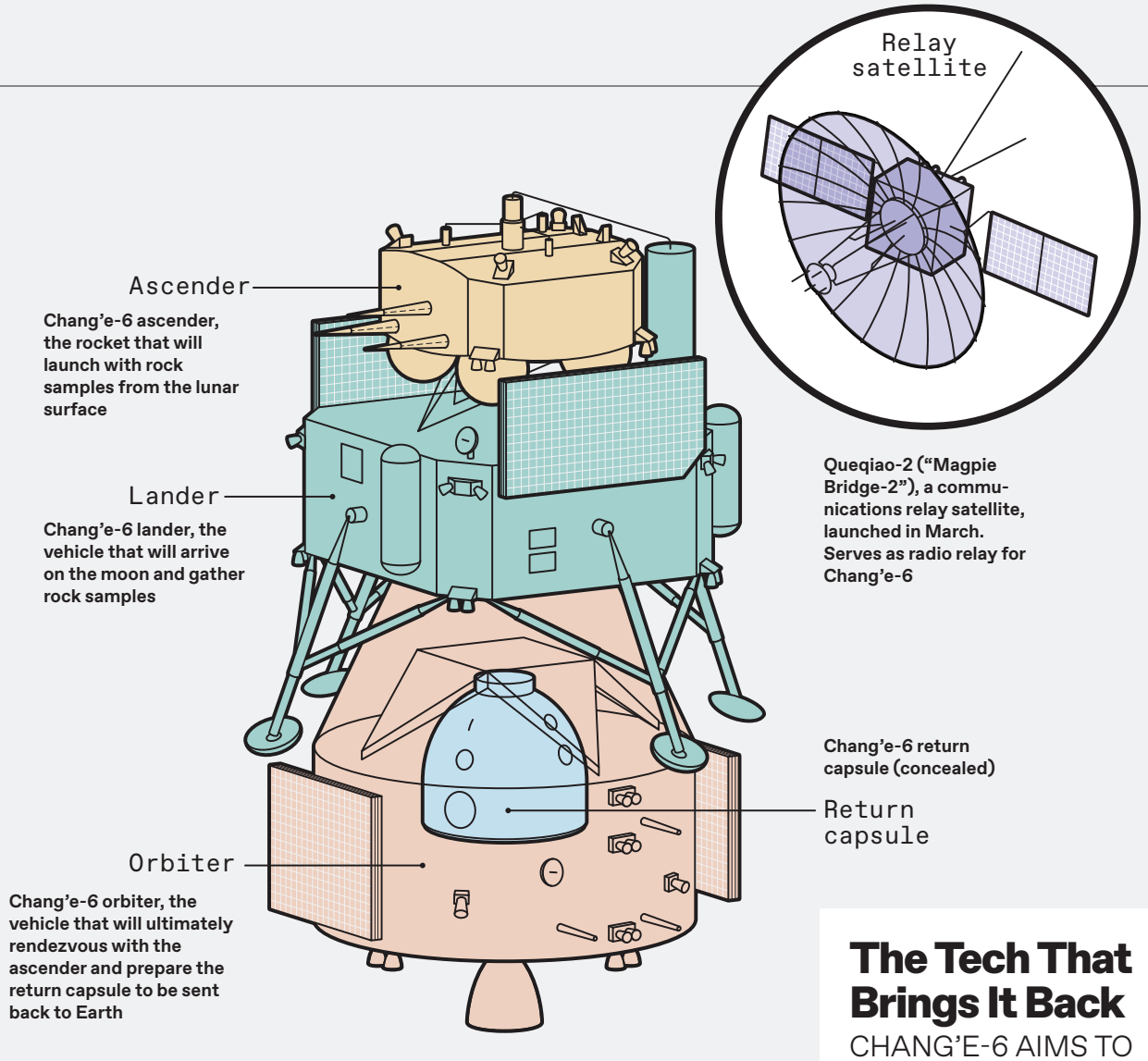
Chang'e-6 will launch on a larger Long March 5 rocket. After launch and separation from the rocket—according to a 2021 paper by engineers from the Beijing Institute of Control Engineering—the mission's service module will steer the course of its five-day journey to the moon, then fire its engines to enter a polar lunar orbit. The lander will then separate and prepare for its touchdown attempt. (The 2021 paper concerns China's previous moon-sample mission, Chang'e-5, in 2020. However, the Chang'e-6 spacecraft are identical to those used for Chang'e-5, and the often inscrutable China National Space Administration has indicated substantial similarities between the two missions in both public presentations and public remarks by prominent engineers. So, lacking a more definitive authority for the Chang'e-6 mission plan, it can only be stipulated that Chang'e-5's plan provides sufficient indications of the course of the upcoming mission.)

"Landing is always the hardest, because everything is so time critical, you can't just pause halfway through and try again later," says Jonathan McDowell, a Harvard-Smithsonian astronomer and a space-activity tracker and analyst.

As analysts have lately witnessed—Japan's Smart Lander for Investigating Moon landed on its nose in January, while Intuitive Machines' IM-1 toppled on its side in February— even apparently successful lunar landings can be rough.

China has, however, landed on the far side with Chang'e-4 and performed a near-side moon-rock sampling with Chang'e-5 in 2020. The Chang'e-6 lander and ascent module—initially intended as backups in case Chang'e-5 failed—will likewise descend onto the surface in phases, according to the mission paper noted above. After an initial deceleration at 15 kilometers above the moon's surface, the lander will reorient itself to a vertical position when it is 2 km away. The lander will then use lidar—light detection and ranging—and optical cameras to guide it through a coarse-hazard-avoidance phase and, starting at an altitude of around 100 meters, a hovering, fine-hazard-avoidance phase to a safe landing spot.

Once on the surface, the lander will, like Chang'e-5, begin collecting samples, with its activities likely to be wrapped



up within a couple of days, according to designers of the previous mission. The samples will be loaded into the ascent vehicle sitting atop the lander. The ascent vehicle will lift off around a couple of days after landing.

"The next hardest bit is the rendezvous," says McDowell, noting that the process should be similar to that used by Chang'e-5, although this time it will be supported by the Queqiao-2 satellite.

Launching into orbit from another planetary body is a rare and challenging event, with only the Soviet Union's Luna program, the Apollo missions, and Chang'e-5 having accomplished it.

The samples will be transferred to a reentry module aboard the service module, which will then prepare for the trip back to Earth. The reentry module will be released just prior to reaching Earth. The capsule, protected by a heat shield, is expected to make a semiballistic skip reentry, as performed by Chang'e-5, first bouncing off the atmosphere to kill some of the extra speed involved in lunar missions before making a final, fiery plunge.

The mission is expected to take 53 days from launch to landing in Inner Mongolia. As to why China is orchestrating this complex celestial performance, Yuqi Qian, a postdoctoral fellow at the University of Hong Kong, explains that the samples could contain material ejected from the lunar mantle, providing unprecedented insights into the numerous differences between lunar far and near sides as well as the history of the Earth-moon system itself.

"They may largely reshape humanity's current understanding of the lunar early evolution from a never-sampled site," Qian says. ■

The Tech That Brings It Back

CHANG'E-6 AIMS TO LAND 2 KILOGRAMS OF LUNAR REGOLITH BY JULY

IN 2018 AND 2020, the China National Space Administration launched uncrewed missions to the lunar far side and near side, respectively. The near-side mission, Chang'e-5, collected rock samples and rocketed them back to Earth. Now CNSA is planning to launch a sample-collection mission to the lunar far side, as soon as this month. Chang'e-6 will be similar to Chang'e-5—although this time it will face the additional difficulty of performing all its activities on the moon's hidden side. It will be in touch with Earth only via the recently launched communications relay satellite Queqiao-2.

Illustration by Chris Philpot