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Broad agenda seen for China's moon missions

China, in the view of some American space experts, seems determined to send humans to the moon. If so, evidence suggests Chinese engineers might want to bring their astronauts home via the same kind of "skip reentry" technique that the U.S. plans to use for its Orion capsules.

U.S. space experts have been parsing a technical overview published in April by Chinese space engineers, describing the country's 2014 circumlunar test mission, called Chang'e 5-T1, in which an unmanned capsule reentered and touched down in China's Inner Mongolia Autonomous Region.

The paper, "Technical Advancements and Significance of Circumlunar Return and Reentry Spacecraft," appeared in the journal, *Science China: Technological Sciences*, published by the Chinese National Academy of Sciences. It provided previously unreleased details, including the fact that China used a semi-ballistic, skip reentry technique, in which a capsule makes successive skips off the atmosphere, with each skip slowing the capsule and dissipating reentry heat. China guided the capsule to a

precise reentry corridor and a landing at Siziwangqi in Inner Mongolia, according to the paper.

By contrast, Apollo capsules plowed directly into the atmosphere. NASA encoded a skip reentry capability in the flight software as a backup in case of bad weather over the primary splashdown site, but the technique was never used operationally. Orion capsules will have a more advanced guidance and control strategy to implement this skip capability.

China, the paper said, also will employ the skip reentry to bring a lunar sample home from an unmanned mission it plans to launch in 2017.

China's use of skip entry is relatively complex, says Michelle Munk, an entry, descent, and landing principal investigator at NASA's Langley Research Center in Virginia.

"From my perspective, it's more complex than a simple ballistic entry. Depending on the precision of the landing they want to achieve, the guidance, navigation and control has to be fairly sophisticated," Munk says.

In the view of another American expert, the evidence suggests a desire for more than a lunar sample.



China launched an experimental unmanned spacecraft atop a Long March 3C to fly around the moon and back to Earth in preparation for the country's first unmanned return trip to the lunar surface in 2014.

The 2017 mission "shows that China is serious about developing a complete cislunar-lunar flight capability," says lunar scientist Paul Spudis. "They are shooting for cislunar space dominance and, at this rate, will likely achieve it," he adds.

Spudis was deputy leader of the science team for the Clementine probe that NASA and the Pentagon sent to image the moon in 1994. It's clear, Spudis says, the Chinese "are certifying the architecture for a human mission to the moon."

China, however, describes its plans as more limited.

China "has the ability to achieve the manned lunar landing but it has no plan to do it," the country's Xinhua News Agency quoted Zhou Jianping, chief designer of its manned space program, as saying earlier this year. Zhou's program has been limited to low-Earth-orbit missions.

"With China's current technologies of manned space flight and moon probe, we have the technology basis to realize the manned lunar mission," Zhou reportedly said.

According to the paper's authors, "The complete success of this mission indicates that the key technologies of circumlunar return and reentry have been broken through in China."

The paper also reports seven new kinds of lightweight thermal protection material were developed for the capsule, promoting the development and use of composite material in China.

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After nearly 196 hours of flight, China's Earth-to-moon-to-Earth reentry capsule parachuted into Siziwangqi in Inner Mongolia on November, and was recovered and delivered to Beijing.