



What is China Doing at the Lunar Distant Retrograde Orbit?

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China's Chang'e 5 (CE-5) orbiter, which as of January 2022 has likely moved to the lunar Distant Retrograde Orbit (DRO), is probably conducting enabling telemetry, tracking and control and Very Long Baseline Interferometry (VLBI) tests to support Chinese preparations for the next stage of China's Lunar Exploration Program (CLEP), according to Chinese government information and Chinese academics.^{1,2,3,4,5} According to western space watchers, if CE-5 is indeed in DRO, it would be the first man made object there.⁶ In 2020, China invited domestic and international payload proposals for its next CLEP mission, the Chang'e 7 (CE-7), and specifically requested a VLBI payload for the relay satellite and a test laser communications payload for the orbiter.⁷ However, in advance of, and even after this solicitation, Chinese researchers have continued to publish competing proposals for the ultimate navigation and communications architecture which CE-7's relay satellite will eventually support.^{8,9,10} Among these competing proposals are architectures which include communications relay satellites in DRO, indicating CE-5's tests in this orbit are a key component to Chinese planners' decisionmaking.

China intends to launch the CE-7 probe between 2024 and 2025 to the lunar south pole. CE-7 is composed of five separate spacecraft, namely an orbiter, lander, rover, hopping probe, and a polar relay satellite. CE-7 cannot use China's current lunar relay satellite, Queqiao, orbiting the Earth-Moon Lagrange Point 2 (E-M L2) because Queqiao's specific E-M L2 position isn't able to support a landing closer to the lunar south pole, according to a detailed Chinese media report.¹¹ To achieve precise landing determination, CE-7 will release its relay satellite before the other 4 components move into lunar orbit. Chinese academic articles describe that CE-7's relay satellite will eventually be networkable with Queqiao and probably become the first components of China's future lunar communications and navigation architecture for deep space exploration, and robotic and crewed missions.^{12,13}

China has consistently built backup spacecraft for its national missions and upon achieving its primary goals, Chinese engineers use the backups for science and technology tests to support future missions. The Chang'e 2 was the first such mission extension.¹⁴ In the case of CE-5, it is not a backup but composed of many components in order to achieve China's multi-stage lunar sample return mission. After delivering the return capsule to Earth orbit in December 2020, CE-5 has used the remaining 200 kg of propellant to first travel to Earth-Sun Lagrange Point 1, where it conducted space environment tests and snapped a picture of the Earth and the

Moon.^{15,16} It then seems to have proceeded back to lunar orbit in September 2021.¹⁷ Space trackers, as of January 2022, believe they have identified CE-5 in DRO.¹⁸

It was no mystery that CE-5 would continue China's trend for mission extensions. The 2014 Chang'e 5-T1 tested very similar spacecraft components and fuel reserves for the lunar sample return mission, so Chinese planners knew how much reserve fuel they would have if it wasn't used for any emergency measures.¹⁹ China also shared insights with the global community on CE-5's mission extension. During the Global Space Exploration Conference (GLEXP) in June 2021, normally widely attended under non-COVID conditions, the CE-5 Deputy Chief Designer shared with reporters that the spacecraft would return to the Earth-Moon system.²⁰

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ENDNOTES

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² Liu Lei, et al, “OmniUV: A Multi-Purpose Simulation Toolkit for VLBI Observation,” (Draft submitted 01/2022), <https://arxiv.org/abs/2201.03797>

³ Gao Zhaoyang, et al, “Coverage Analysis of Lunar Communication/Navigation Constellations Based on Halo Orbits and Distant Retrograde Orbits,” 03/2020, <https://www.cambridge.org/core/journals/journal-of-navigation/article/abs/coverage-analysis-of-lunar-communication-navigation-constellations-based-on-halo-orbits-and-distant-retrograde-orbits/6E81EBFC372BBEC99379D752EE108048>

⁴ 曾豪, et al, “地月 Halo 与 DRO 支持的往返月球任务轨道,” 宇航学报, 12/2021

⁵ Shanghai Astronomical Observatory, Chinese Academy of Science, “探月与航天工程中心主任刘继忠一行考察调研上海天文台 VLBI 指控中心与天马望远镜,” 07/2021, http://www.shao.cas.cn/2020Ver/xwdt/zhxw/202107/t20210723_6147203.html

⁶ Scott Tilley, “What in tarnation is a Distant Retrograde Orbit (DRO)?,” 01/2020, <https://twitter.com/coastal8049/status/1481117857303785472?lang=en>

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- ¹⁰ Gao Zhaoyang, et al, “Coverage Analysis of Lunar Communication/Navigation Constellations Based on Halo Orbits and Distant Retrograde Orbits,” 03/2020, <https://www.cambridge.org/core/journals/journal-of-navigation/article/abs/coverage-analysis-of-lunar-communicationnavigation-constellations-based-on-halo-orbits-and-distant-retrograde-orbits/6E81EBFC372BBEC99379D752EE108048>
- ¹¹ Sohu, “嫦娥七号有多难? 五台航天器合体内含新月球车, 还要制造人工月震,” 12/2021, https://www.sohu.com/a/510794557_100167360
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