

The Lunar Orbit Phasing and Rendezvous Tests of Chang'e 5 Reentry Flight Experiment Vehicle

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Abstract: *Chang'e 5 is the first lunar sample probe of the China's Chang-e third stage project sample return mission. After Chang'e 5 probe landing on the moon, it will collect the soil samples on the lunar surface and then package them into the ascent module of the lander. The ascent module will blast off from lunar surface into lunar orbit and actively rendezvous with the union-module of the orbit module and the return module along with delivering the samples to the return module. The orbit module will fire up to return the earth carried with the return module and separate out from the return module into the space before entering the atmosphere. The return module will reentry into the atmosphere through the way of the leaping and land on the earth after being decelerated repeatedly. There are four main technical difficulties of Chang'e 5 with the lunar orbit rendezvous and docking, the lunar surface sampling, the lunar surface lifting up and the high speed return to the earth.*

The Chang'e 5 reentry flight experiment vehicle is the test vehicle of Chang'e 5. The vehicle was launched in October 24, 2014, consisted of the service module and the return module. On November 1, following the vehicle returning from the moon, the return module separated from the service module and landed on the earth smoothly, which indicated the reentry flight experiment mission being successful.

Afterwards, the service module raised up the orbit to continue the next expanding test. During the first period of the expanding test, the service module has completed two experiments, one is the large elliptical orbit experiment with the apogee of 540,000 km and the perigee of 600 km, the other is surrounding of the earth-moon L2 point detection and returning to the moon experiment.

After that, the service module continued to conduct the lunar orbit rendezvous verification for Chang'e 5 mission. In the expanding test second and third periods, the service module has played two roles of the orbit module and the ascent module for Chang'e 5. During the second period the service module has conducted the lunar phasing orbit maneuver test for being replaced with the Chang'e 5 orbit module and in the third period the service module has completed the lunar orbit rendezvous maneuver test for being replaced with the Chang'e 5 ascent module.

This paper presents the service module expanding test in the second and third period, involved of the orbit maneuver strategy design and implement results of the lunar orbit phasing and rendezvous. The second period expanding test was carried out in February 6 to 7 2015. The service module has completed the lunar orbit phasing test through three orbit maneuvers, which simulated the Chang'e 5 orbit module to produce the lunar orbit rendezvous flight condition during the lander sampling on the moon surface. The third period expanding test has been in progress in March 3 to 7 2015, comprised of two sections: firstly the service module's orbit was reduced from 200 km

lunar circular trajectory to the ellipse trajectory with the perilune of 18km and the apolune of 180km through three orbit maneuvers. Secondly the service module carried out four orbit maneuvers of long-range rendezvous to simulate the Chang'e 5 ascent module flight from the 18km high from the lunar surface to the appropriate rendezvous position of 200km circular orbit. This test imitated the process of the Chang'e 5 ascent module conducting the lunar orbit rendezvous.

In the second and third periods of the expanding test, the service module's flight has verified the related technologies for Chang'e 5 mission, including the trajectory maneuver strategies of the lunar orbit phasing and the lunar long-range rendezvous, the ground and onboard cooperative regulate sequences, trajectory measurement and flight control precision, especially the lunar orbit rendezvous nominal trajectory design and scheme being assessed. The data and experiences of the test will provide a variety of value references for Chang'e 5 mission.

Keywords: *Chang'e 5 Reentry Flight Experiment Vehicle, Lunar Orbit Phasing, Lunar Orbit Rendezvous.*