# Orbit Determination for CE5T based upon GPS data

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***Abstract:*** *Launched on October 24, 2014, China's Chang'E-5 Test Vehicle (CE-5T) is its fourth lunar probe to conduct atmospheric re-entry test on the capsule design planned for Chang'E-5 mission. In addition, with a multiple-mode receiver onboard, CE-5T was tested on its ability to receive the side-lobe weak signal of GNSS satellites.*

*On the Earth-moon transfer orbit and the lunar free return trajectory, the onboard receiver received GPS signal successfully. Restrained by the flight planning, the receiver was switched on at a geocentric distance of 30,000 km and was switched off at a maximum geocentric distance of approximately 60,000 km. The collected tracking data from the GNSS receiver includes pseudo range and phase measurement. Also, a filter is assembled in the receiver, which processes the available pseudo range measurements and provides estimates of the state of CE-5T.*

*In this manuscript, we describe the CE-5T mission in brief, analyze the GPS tracking data and reconstruct the orbits of CE-5T using GNSS tracking data. First, we compute the geometric visibility of GPS satellites according to the state of CE-5T. The possibility of receiving the side lobe signal of navigation satellites is analyzed theoretically; the received signal power and the number of satellites available in relation to the geocentric distance are studied, with the position dilution of precision also provided. The results show that the on-board receiver can receive the side-lobe signal, and its navigation and positioning for the large elliptical orbit phase (the Earth-Moon transfer orbit and lunar return trajectory) using the GNSS satellite side-lobe signal is achieved. Then, orbit determination is performed using pseudo range and phase measurements. Finally, the reconstructed orbital accuracy of CE-5T is assessed using the precise orbit calculated from the ground based tracking data. The results indicate that the positioning ability can be achieved for orbits with geocentric distance less than 60,000 km, provided the sensitivity of the receiver is better than -160 dBm. Additionally, both the navigation solution and pseudo-ranging are processed and analyzed, and the former is also employed to calculate the orbit. The noise level of the navigation solution is better than 10 m. Using differential pseudo-ranging, the noise level is approximately 8.5 m. 1 hour long data of the differential pseudo-ranging can achieve a 1 hour forecast orbit accuracy of better than 100 m, which will have to be obtained with long-arc data for the ground-based tracking stations.*