Systematic Computation and Stationkeeping Analysis of Quasi Halo Orbits in High-Fidelity Model for 6U CubeSat EQUULEUS

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Libration point orbits, in particular those around the Earth-Moon L_1/L_2 points, have attracted great attention as potential locations for future human space exploration. EQUULEUS, which is a 6U CubeSat being developed by the University of Tokyo and JAXA, will target the EML2 (Earth-Moon L_2), with a purpose of scientific observation where the CubeSat will assess the flux of meteors impacting on the dark side of the lunar surface.

Although ARTEMIS, the first EML orbiter by NASA[1], is the one and only mission that has reached these orbits so far, many micro- or nano- satellites including CubeSat with small DV (Delta-V) capabilities are expected to get there in the near future. Previously, however, analysis of libration point orbits in the Earth-Moon system has been conducted mostly in simplified dynamics such as CR3BP (Circular Restricted Three-Body Problem), and that in full-ephemeris model is very limited to a few cases[1]. We need to generate and analyze many various quasi halos as potential target orbits in high-fidelity model, since the limited DV capability does not allow us to choose arbitrary orbit insertion conditions, which would be a common challenge in many small satellites. Analyzing stationkeeping cost is also of vital importance because of the strictly limited DV amount.

The purpose of this paper is, therefore, to introduce a systematic way to compute families of quasi halo orbits, and to analyze their properties such as stationkeeping cost with possible errors (OD (orbit determination), OI (orbit insertion), and execution errors). The proposed methodology enables us to design the quasi halos of various size, shape, and arrival time as we want and assess the properties for all of them in the full-ephemeris model. This study will contribute not only to EQUULEUS mission, but also to many future missions that target and stay around the EML region.

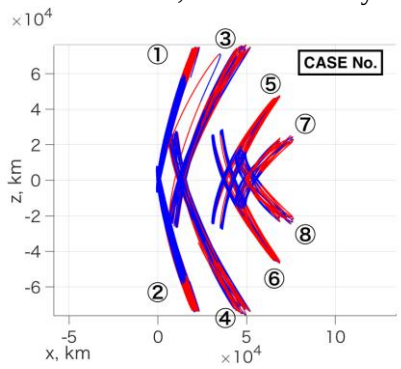

Fig. 1 Portion of generated quasi halo in full-ephemeris model

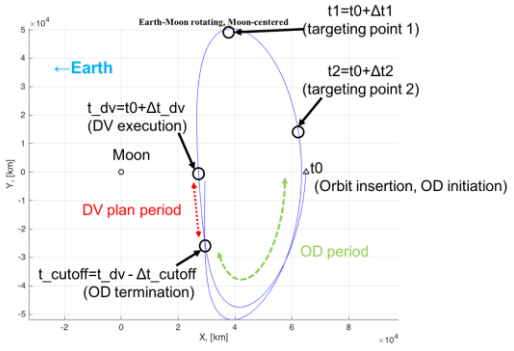

Fig. 2 Stationkeeping strategy

Table 1. Preliminary results of stationkeeping analysis (N=10000 for each quasi halo; OD and OI errors (1σ): 1 km (pos), 1 cm/s (vel), execution error (1σ): 1 % for each component)

Properties \ CASE	1	2	3	4	5	6	7	8
Annual DV cost [m/s]: mean, (stddev)	1.96 (0.24)	2.13 (0.24)	10.00 (1.67)	9.92 (1.66)	17.36 (2.30)	17.34 (2.34)	36.16 (4.78)	36.19 (4.73)
No. of revolution	26.4	26.3	14.2	14.2	12.1	12.1	12.4	12.4
Period per revolution [day]	7.3	7.3	12.0	12.0	13.6	13.6	14.2	14.2

References

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