Study on Low-Thrust Stationkeeping on Geostationary Orbit

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The electric propulsion system is now widely applied to many fields of space missions. One of the most important characteristics of the electric propulsion is the high specific impulse, which significantly reduces the mass of propellant consumed. In 2015, the ABS-3A and Eutelsat 115 West B, both of which use Boeing 702 SP bus system, were dual launched by the Space-X Falcon 9 into a super-synchronous transfer orbit whose orbital period is almost same as that of the geostationary orbit, GEO. These are the world first all-electric propulsion satellites: the on-board electric propulsion system is used for both of the transfer to, and the stationkeeping on, GEO. Japan Aerospace Exploration Agency, JAXA is also planning to develop the all-electric propulsion satellite tentatively referred as "Next Engineering Test Satellite (ETS)" to meet future needs for GEO missions.
Recent progress in the all-electric satellites and GPS signal utilization on GEO has a potential to enable autonomous, precise, and efficient stationkeeping which leads to benefits on price and performance competitiveness of new-generation GEO satellites. Given such circumstances, this paper addresses on the stationkeeping method of GEO using low-thrust. Assuming the real-time navigation is given by an on-board GPS receiver which JAXA is developing for GEO missions, the corrective delta-V is planned using a target point method which is one of implicit guidance schemes to fly along a pre-defined nominal trajectory. Figure 1 shows the diagram of the target point method, and Figure 2 shows the flow-chart of the stationkeeping algorithm.

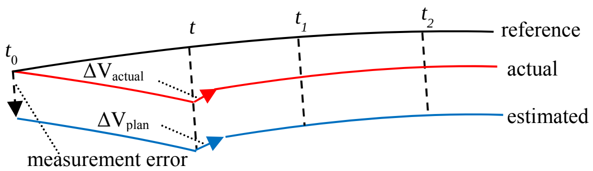

Fig. 1. Diagram of Target Point Method

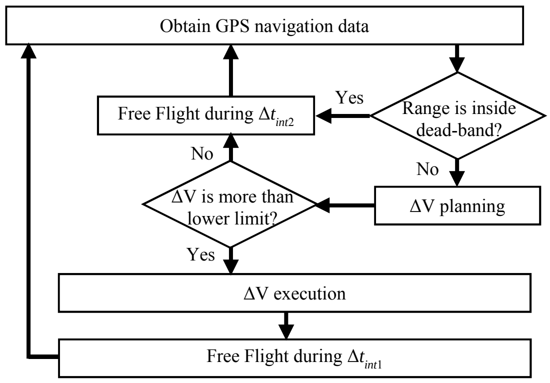

Fig. 2. Flow-Chart of stationkeeping algorithm

The stationkeeping maneuver is computed by minimizing the cost function defined as the following:

$$J = \Delta\vec{V}^T Q \Delta\vec{V} + \vec{m}_{t_1}{}^T R \vec{m}_{t_1} + \vec{m}_{t_2}{}^T S \vec{m}_{t_2} \tag{1}$$

where the $\Delta\vec{V}$ is the maneuver, $\vec{m}$ is the position deviation between the reference and estimated orbits and Q, R and S are the weighting matrices.[1] Through some cases of numerical simulations in full ephemeris, the paper will reveal the feasibility of the proposed method.

References

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