Paper ID: 18543
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SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 3 (3C)

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RESEARCH ON AREOSTATIONARY ORBIT AND STATION KEEPING STRATEGY BASED ON LOW-THRUST PROPULSION

Abstract

Stationary orbits are always important because of their valuable characteristics of stationary ground track and wide coverage, which can benefit the communications and various navigations.

In this paper, the characteristics of Martian stationary orbit, which is also referred to as areostationary orbit, are investigated using analytical formulations and numerical verifications. The station keeping strategy employing low-thrust propulsion is also considered for a long-term management based on the stability analysis of the stationary points.

The first part of this paper focuses on the impact of different perturbations on the evolution of areostationary orbit. The perturbations considered in the research consist of the non-spherical gravity effect, the third-body gravities from the sun, major planets and the Martian moons, as well as the solar radiation pressure. Compared with the geostationary orbit, the mechanism the distinct non-spherical Martian gravity field affecting the semi-major axis is more complicated; The evolution pattern of the inclination associates several tendencies due to the multiple third-body gravities; The eccentricity varies with the solar radiation pressure and the pattern is more delicate as a result of higher eccentricity of the Martian orbit compared with Earth. Next, the motion equations for the areostationary orbit were derived, and four stationary solutions were obtained under low-order zonal and tesseral harmonics. Utilizing the numerical method, the secular drift with different periodic motions were decoupled.

The second part of this paper focuses on the station keeping strategy for areostationary orbit. The longitudinal and latitudinal station keepings, corresponding to different equinoctial elements maintenance were illustrated respectively. Approximate fuel consumptions based on low-thrust propulsion were also evaluated for areostationary satellites located on different slots. In particular, the particle swarm optimization algorithm was employed to locate the precise stationary point which can be used as an initial location taking the fuel consumption as the index.

In the end, an areostationary satellite communications system was proposed, which links the Martian surface exploration with the Earth. For this scenario, the feasibility for TTC was demonstrated for the deep space control. It is expected the scenario can be significant for the future Mars exploration.