Paper ID: 2882

ASTRODYNAMICS SYMPOSIUM (C1)
Optimization, Guidance and Control (11)

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IMPROVED PLANETARY EPHEMERIS MODEL FOR INTERPLANETARY MISSION STUDIES

Abstract

The accuracy of interplanetary design parameters such as launch date and Delta-V will depend upon how accurate is the planetary ephemeris models. Using planetary ephemeris models, one gets position and velocity vector of departure and arrival planets. Using this data, one then solves the Lambert's problem to get the design parameters. Often a grid search procedure is desired where these steps are repeated for different launch dates and transfer durations. From these searches, launch date corresponding to minimum Delta-V is selected. These studies form the basis for detailed analysis, where numerical integration of trajectories is made for proper capture at the targeted orbit of the arrival planet. The planetary ephemeris model developed by Meeus [1991] is extensively used for preliminary design of interplanetary trajectories. In this model, the orbital elements are stored in a polynomial form as a function of corrected Julian centuries. The position and velocity vector of a planet is then computed using simple transformations. For a ten year period ranging from 2010 to 2020, error in position and velocity of all the planets is quantified when using the Meeus model. The reference ephemeris used for quantifying the errors from Meeus model is JPL's DE405. Large errors in state vector are observed for the outer planets when Meeus model is used. The objective of this paper is to retain the simplicity of the expressions given in Meeus model and yet give accuracy that is close to JPL ephemeris. During interplanetary trajectory design and optimization studies, where planetary ephemeris model is called a number of times, simplified model helps in saving significant amount of computational time. The polynomial coefficients in the Meeus model are optimized so as to minimize the maximum error obtained from this model. For example, there are about 20 coefficients that need to be optimized for the Jupiter planet. These design variables are to be determined by the optimization algorithm so as to minimize the maximum error in position in the span of years ranging from 2010 to 2020. A quadratic programming methodology is used for the purpose of optimization. Without changing the number of polynomial coefficients as in the Meeus model, the optimization strategy from the present analysis resulted in upto one order improvement in the position error with simultaneous reduction in velocity error, for some of the outer planets. The improved planetary ephemeris model is proposed for Mars, Jupiter and Saturn planets with new polynomial coefficients.