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ONBOARD STATE VECTOR ACCURACY IMPROVEMENT BY SEGMENTATION OF ORBIT FOR MARS ORBITER MISSION

Abstract

Indian Space Research Organization is planning a mission to Mars in the near future with its launch vehicle in October 2013. The objective of the mission is to demonstrate the technology of reaching Mars, exploration of Mars surface and its atmosphere. Being the first Indian mission to Mars, the likely orbit for a less thermally complex spacecraft forgoing aerobraking for orbit insertion could be a highly eccentric orbit with apoareion height of 80000km and periareion height of 500km. Payloads are mounted along yaw axis of the spacecraft and high gain antenna, mounted on roll axis of the spacecraft is used for communication with the ground. This necessitates pointing roll axis towards Earth and yaw axis towards Mars for imaging. The computation of reference attitude of the spacecraft required for controlling the orientation of spacecraft needs orbit information onboard with a better accuracy near periareion region than near apoareion region. Two different approaches for onboard state vector generation is thought off, one based on Chebyshev polynomial and the other with numerical integration (NI) of equation of motion with limited dynamical model. In Chebyshev's approach, the state vector obtained from full force model is fitted with Chebyshev polynomial series and coefficients are uplinked. Using these uplinked coefficients, orbit is generated onboard by evaluating the Chebyshev polynomial series. High eccentricity of the orbit leads to unacceptable curve fitting error in state vector due to large variation of the orbit around periareion. An attempt is made to improve the accuracy by splitting orbit into two segments with a smaller segment around periareion and larger one around apoareion. Curve fitting accuracy realized with this is of 200mt around periareion and 12km around apoareion region over an orbit. In NI approach, state vector generation onboard is by integrating the equations of motion using numerical integration method with zonal and tesseral harmonics of order 4 by 4 using a Predictor-corrector and Runge-Kutta-Gill Integrator using uplinked initial state vector. Even in this approach, prediction error over an orbit is very high due to which reinitializing the input to NI onboard with one for periareion segment and the other for apoareion segment is done which improved the position accuracy from 80 km to 4 km around periareion and 35km around apoareion. The study indicates segmentation of highly eccentric orbit is a must for better position accuracy onboard for either of polynomial or by numerical integration approach.