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PRECISE ORBIT DETERMINATION OF MARS ORBITER MISSION – AN EXPERIENCE DURING EARLY PHASE OF THE MISSION

Abstract

India has initiated deep space exploration program after the launch of Chandrayan-1 in Oct 2008. Beyond Moon and next to Earth, Mars is a natural target of study. India has taken a giant leap in the field of interplanetary exploration with the launch of Mars Orbiter mission (MOM) on November 5th 2013 by Polar Satellite Launch Vehicle (PSLV). MOM has a dry mass of 488 kg and 852 kg of propellant mass. It carries five payloads to study Mars's atmosphere and map surface composition and mineralogy. After a series of six Earth burns, and a trajectory correction maneuver on 11th Dec 2014 to achieve desired inclination at Mars insertion, spacecraft will be put into a highly elliptical orbit with an inclination of 151 deg around Mars after an orbit insertion maneuver around 24th September, 2014. Each maneuver demands high precision orbit as the deviation in the targeted orbit leads to fuel penalty due to limited fuel margin. Tracking of MOM spacecraft is being carried out by ISTRAC and JPL/DSN network of stations. This paper focuses on orbit determination performance analysis for MOM in Earth and Heliocentric phases.

Mars Orbiter mission is injected in to a highly eccentric orbit with perigee and apogee of 250 km and 23540 km respectively. Immediately after the launch, tracking data was collected from ISTRAC and JPL DSN station and orbit determination was carried out by weighted least square method. The Estimated orbit result is compared with launch vehicle GPS aided Inertial Navigation solution and with JPL provided orbit solution. Orbit determination in Earth phase is carried out with Doppler data from ISTRAC/ISRO and NASA/JPL ground stations. The difference between ISRO estimated orbit and JPL estimated Orbit is 14m and 13m in perigee and apogee heights and 0.0008 deg in inclination. During Earth phase, orbit is raised from 23540 km to 192920 km after performing five Earth bound maneuvers. The spacecraft escaped from the Earth's sphere of influence on 3rd December 2013 and entered in the influence of the Sun. The achieved post-fit residues in Range rate in Earth phase is about 5 mm/s. Orbit determination in heliocentric phase is being carried out with range, Doppler data and delta-DOR data from JPL/DSN and Doppler data from ISRO/ISTRAC ground stations. The estimated orbit resulted in designing the subsequent maneuvers which were executed successfully. Precise pointing and tracking of the space craft was accomplished with precise orbit determination.