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COVARIANCE ANALYSIS OF ORBIT DETERMINATION FOR MARS ORBITER MISSION

Abstract

India's venture into deep space was started with Mars Orbiter Mission(MOM) popularly known as Mangalyaan. It was injected by PSLV-C25 on Nov 5th, 2013 into sub geo synchronous parking orbit of (247 x 23563) km from Satish Dhawan Space Centre, Sriharikota, India. 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 sequence of five Earth bound maneuvers, and through Trans Mars Injection, it was put into Mars Transfer Trajectory orbit around Sun. Mars Orbit Insertion (MOI) was carried on 24th September, 2014 into the Martian orbit of about (428 X 77000) km. One of the major contribution to this accomplishment is precise orbit determination. Navigation was a challenging task as it was a first attempt by ISRO and due to the complexity of the problem, it involves micro level understanding of spacecraft dynamics and perturbing environment. This paper describes the analysis on the orbit determination results through its covariance. Orbit estimation is carried out with JPL/DSN and ISRO/ISRAC network of stations in the Mars mapping phase. Doppler data is collected from both these network stations. This note emphasis on Orbit determination accuracy achieved for MOM spacecraft during Mars mapping phase of the mission. The analysis is carried out through covariance approach. JPL navigation solutions based on JPL/DSN tracking data were available during the above phases. This paper also brings out the comparison of estimated orbit with JPL solution and its covariance. Orbit Determination is carried out regularly in the Spacecraft Control Centre(SCC) for MOM using tracking data from JPL and IDSN-32 stations. The determined solutions over a duraion of 4-5 months in the cruise and mapping phase are considered for the analysis. In the orbit determination for MOM spacecraft, the differential correction process is based on osculating elements and covariance matrix is computed for these elements. Accuracy analysis was carried out based on (i) Covariance of orbital elements, (ii) Covariance of state vector accounting for consider parameters. The determied states from the converged solutions are taken and covariance matrices are computed through OD s/w considering the initial error covariance matrix. Further systematic model errors are also considered and final error covariance matrix is computed. OD accuracy at epoch is about 5 km in position and 5 cm/s in velocity.