

ASTRODYNAMICS SYMPOSIUM (C1)
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AUTONOMOUS ORBIT RAISING OPERATIONS FOR INDIAN MARS ORBITER MISSION

Abstract

The constant human endeavor to learn and explore has led to the study of solar system. Mars Orbiter Mission (MOM) is India's first step towards inter-planetary exploration. Precise insertion of MOM into Martian Orbit requires accurate Orbit Raising Maneuvers at a specific time while considering station visibility constraints and communication delays. This calls for the design development of an Autonomous Orbit Raising Sequencer (AORS) to facilitate an uninterrupted 440 Newton Liquid Engine (LE) firing. To achieve Orbit Raising maneuvers, spacecraft control system is configured with reaction wheels, thrusters, liquid engine, gyros, accelerometers and star sensors for attitude and orbit control. Gyros and accelerometers are the prime sensors during orbit raising maneuver using Liquid Engine. Before initializing AORS, gyro and accelerometer are calibrated for bias, scale factor and misalignment. AORS ensures orientation of MOM to desired attitude, to maintain attitude and rate, to achieve the required ΔV , arming and disarming of liquid engine appropriately. Accelerometer based engine cut-off logic is included for achieving the target ΔV . In case of LE under performance beyond limit, in order to achieve the desired ΔV , augmentation with attitude thrusters is incorporated in the logic. Sensor and actuator configuration required during LE burn is ensure by Fault Detection Isolation and Reconfiguration (FDIR). AORS autonomous configuration parameters required for orbit raising are uplinked to the spacecraft and are verified through telemetry. First, it re-orientes the spacecraft to the fire-ready position using reaction wheels with reference to Attitude Steering Profile (ASP). Subsequently, attitude control is transferred to thruster control with LE firing. During LE burn attitude control is carried out using PID control along with pulse modulator and structural interaction are suppressed using notch filter. Once required ΔV is achieved AORS terminates LE burn based on accelerometer measurement. On completion of burn, spacecraft is re-oriented back to defined orientation for further commanding. AORS has demonstrated autonomous features successfully on flight hardware during all five earth bound maneuvers, Trans-Mars

Injection and trim correction maneuvers during cruise phase. The post burn orbit determination confirms the correctness of all operations carried out on-board.