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MISSION DESIGN AND ANALYSIS FOR IRNSS-1A

Abstract

Indian Regional Navigation Satellite System (IRNSS) is a constellation of seven spacecrafts that will provide high accuracy navigation service for Indian region. This paper describes the mission design and analysis for the first in Indian Navigation s/c series, IRNSS-1A. It is positioned in geosynchronous orbit with 29 deg inclination (Non-geostationary orbit, NGSO) at 55 deg East longitude. IRNSS-1A is equipped with four reaction wheels, two star sensors and three gyroscopes. There is a 440 N Liquid Engine for orbit raising, mounted on –Roll face. There are eight 22 N engines mounted on –Roll face and two each on +Pitch and –Pitch faces. It was launched on July 1, 2013 by PSLV into a sub-synchronous transfer orbit of 284 x 20650 km with inclination of 18 deg. Launch window was determined by the target orbit RAAN requirement of 141 deg, which was selected based on limiting number of eclipse days in a year in on-orbit phase. Since the sun-orbit geometry in transfer orbit (T.O.) varies as a function of launch date, a detailed eclipse analysis was carried out for T.O. phase based on which battery charging scheme was designed by Power subsystem engineers. Also, the sun aspect angles during ascent phase were studied. For the first time, liquid engine burns (LEB) were planned with thrust vector steering driven by quaternion profile represented onboard as a polynomial. Maneuver strategies were generated for nominal, backup and contingency scenarios satisfying operational constraints and minimizing propellant expenditure. The NGSO inclination was targeted at 27 deg considering +/- 2 deg band allowed around 29 deg by the Navigation engineers, which would give us additionally over four years operational life. A five-burn strategy was planned to achieve desired drift orbit with two near-perigee burns followed by three apogee burns. The LEB orientation phases were analyzed to check for star-sensor bright light clearances and sun incidence angles on the solar arrays for power generation. Appropriate biases about the thrust direction were worked out for the cases of violation of star-sensor constraints. Range vector profiles were studied in s/c frame considering all planned orientations in T.O. phase and accurate polarization predictions were provided to the supporting ground stations. For inclination control maneuvers in on-orbit phase, usage of –Roll face thrusters were recommended after studying the effect of cross axis components when Pitch face thrusters are used. The desired target orbit of IRNSS-1A was achieved employing the nominal maneuver strategy.