IAF HUMAN SPACEFLIGHT SYMPOSIUM (B3)
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EXPERIMENTAL VALIDATION OF SERVICE MODULE PROPULSION SYSTEM MODELLING CAPABILITIES FOR THE HUMAN SPACE FLIGHT MISSION

Abstract

The Liquid Propulsion System Center of ISRO is responsible for the development of propulsion systems for the human-rated capsule in the Gaganyaan mission. The propulsion requirements are planned to be achieved through an integrated propulsion system called Service Module (SM) consisting of multiple bi-propellant engines and thrusters for attitude control. A system demonstration module (SDM) replicating the actual configuration of the SM is realized, multiple hot firings are conducted for the experimental verification of the system performance and validation of the inhouse mathematical modeling capabilities.

The service module propulsion system is a pressure-fed bi-propellant hypergolic system working with N2O4 and MMH propellants. A series of experiments are conducted on the demonstrator to evaluate and validate the nominal and off-nominal performance of the integrated propulsion system. The first experimental demonstration conducted for a duration of 200s validated the sequence of operations and confirmed the validity of the cold-flow performance figures. Subsequent trials validated the system performance and the mathematical modeling capabilities for the extended duration. In addition, the performance of attitude control thrusters is simulated using a pre-determined activation sequence.

The experiments successfully demonstrated the integrated propulsion system performance under both nominal and off-nominal operation. In addition, key performance figures related to pressure maintenance,

engine operating envelope, and propellant consumption are validated through an in-house mathematical model. The fuel feed-system pressure drops have shown excellent agreement with the cold flow characterizations contrary to the oxidizer feed. The pressure drop in the oxidizer feed indicated higher dispersion when compared with the water calibration. Further, the pressure regulator and the gas system have performed in line with the calibration data confirming their predictability in actual flight operation. The engines have performed consistently as expected throughout the test campaign confirming their high reliability owing to their legacy in propelling various space missions of ISRO. This paper presents the major outcomes of the mathematical modeling and performance predictions during the test campaign.