IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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MODELING OF SPACECRAFT USING DIFFERENT AERODYNAMIC CALCULATION METHODS

Abstract

A powerful mathematical model of an air vehicle helps to predict its flight performance. Therefore, having an accurate flight dynamics model before manufacturing the prototype is needed to design cost-effective, reusable, and reliable spacecraft with optimized flight trajectories. Such modeling involves a comprehensive evaluation of thrust, aerodynamic coefficients, and atmospheric effects across a wide range of flight regimes. The aim of this study is to compare numerical, empirical, and analytical calculation methods against experimental data to validate their aerodynamic coefficient prediction capabilities of a spacecraft at various Mach number. In this context, the aerodynamic characteristics of a spacecraft operating from subsonic to hypersonic flight regimes were investigated with different prediction techniques i.e. Computational Fluid Dynamics (CFD), DATCOM, and analytical calculation based on well-known studies. The numerical results are validated against experimental data of the spacecraft with well-documented flight characteristics. Elaborative simulation model is constructed to examine flight performance and dynamic responses. This model extensively analyses all factors acting on the spacecraft during the flight, enables to predict enhanced flight performance. The developed model is validated using real flight data. CFD results aligned well with experiments, as expected. Remarkably, analytical methods demonstrated consistency under certain conditions.