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SPACE SYSTEMS SYMPOSIUM (D1)
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DRAG CALCULATIONS OF FLAPS IN RAREFIED WAKE FLOWS WITH A DSMC METHOD

Abstract

The Institute of Space Systems at the University of Stuttgart conducts conceptual studies for the utilization and human exploration of cislunar space. Part of the envisioned architecture is a spacecraft, which employs atmospheric passes/aerobraking manoeuvres to transition to a Low Earth Orbit upon return. For aerodynamic stability, the so-called geo-exploration vehicle (GEV) is equipped with rear flaps that are exposed to a rarefied gas flow. Therefore, the prediction of drag in rarefied flows is essential for the preliminary design of the thermal protection system as well as stabilizing components for such a spacecraft.

The present paper is concerned with drag calculations of stabilizing flaps in the rarefied wake flow behind a heat shield. First, a literature review of approximate methods for hypersonic and rarefied gas flows is conducted, focusing on shock shape and drag approximation. The rarefied and high-temperature gas flow is governed by chemical reactions, thermal non-equilibrium and complex flow structures. Since continuum assumptions do not at hold anymore, the gas flow is simulated with the Direct Simulation Monte Carlo (DSMC) method - a probabilistic macroscopic approach. An in-house code is used to calculate flow properties around a scaled three-dimensional model as well as surface properties with particular interest in drag and influence of flaps. Several heat shield and flap geometries are simulated and compared with selected approximation methods. Finally, recommendations for the preliminary design are given.