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ATMOSPHERIC REENTRY STABILITY ANALYSIS OF THE SPACE VEHICLE SARA

Abstract

The aim of this paper is to present the reentry stability analysis of the uncontrolled, non-winged, blunted cone space vehicle SARA (Atmospheric Reentry Satellite) by taking into account a ballistic trajectory. The SARA project is a cooperation between Brazilian Space Agency (AEB) and Institute of Aeronautics and Space (IAE) to develop and construct a recoverable space vehicle to perform microgravity experiments. Another Brazilian project, the suborbital rocket VS-40, provides the insertion of the SARA capsule into microgravity environment reaching altitudes above 190 km.

After accomplishing the microgravity period, the capsule will reentry into atmosphere following a ballistic trajectory and then become to experience the aerodynamics effects. Thus, considering that preliminary requirement for the project is the reentry stability evaluation, the analysis presented here will focus on two configurations for SARA: The first one, a blunted cone without flaps (aero breaking) and, the second one, a blunted cone with flaps.

The idea behind of this comparative analysis is to find the best vehicle configuration based on stability and reentry velocities criteria, constrained by rocket capabilities. These parameters may affect the capsule fabrication process in terms of complexity, when considering flap mechanisms, or in terms of dimensioning, when considering Thermal Protection System (TPS) and recovery system (parachute).

Taking into account only the stability aspects, regarding that vehicle evolves like an oscillator responding to the aerodynamically static and dynamic forces and moments, the capsule needs to present a limited level of oscillation in the attitude in order to allow a clear activation of the recovery system and consequently the parachute opening.

The stability analysis, performed during atmospheric reentry process, shall consider as initial parameters 100km altitude, Mach number greater than five and zero degree Angle-of-Attack. To deal with this multidisciplinary problem, a specific code was developed to process, in a co-simulation loop, the equations of motion, the mathematical model for blunted cone aerodynamic stability and Computational Fluid Dynamics (CFD) software. In addition, it is used the Newton's impact method modeling to achieve the preliminary aerodynamic coefficients for comparison and reference.

The work will show in details the reentry stability analysis and co-simulation methodology, which allows a stable and useful way for preliminary analyzes and support the design decisions. Several numerical results will complete the work.