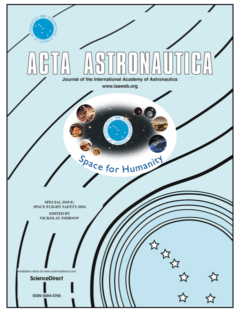
Accepted Manuscript



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PII: S0094-5765(18)30566-6

DOI: 10.1016/j.actaastro.2018.06.040

Reference: AA 6958

To appear in: *Acta Astronautica*

Received Date: 18 March 2018

Revised Date: 17 May 2018

Accepted Date: 17 June 2018

Please cite this article as: S. Mungiguerra, G. Zuppardi, L.Spanò. Cuomo, R. Savino, Effects of solar panels on Aerodynamics of a small satellite with deployable aero-brake, *Acta Astronautica* (2018), doi: 10.1016/j.actaastro.2018.06.040.

Effects of solar panels on Aerodynamics of a small satellite with deployable aero-brake

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Abstract

This work is focused on the aerodynamic analysis of a small satellite provided with a deployable aero-brake. The satellite is intended to perform a completely aerodynamic de-orbiting maneuver from Low-Earth-Orbit. A brief discussion about the aerodynamic effects of the position of the aero-brake along the longitudinal axis of a simplified axisymmetric system is presented. Moreover, a more complex architecture, envisaging deployable solar panels for the enhancement of power generation along the orbital path, is proposed and analyzed. The present paper is aimed at the evaluation of the influence of such a configuration on the satellite aerodynamic parameters. Computations have been carried out by means of a Direct Simulation Monte Carlo (DSMC) code at altitude of 150 km, velocity of 7800 m/s and in the interval of angle of attack 0-180 deg with a spacing of 10 deg. The results verified that the deployable solar panels strongly influence Aerodynamics of the satellite. One of the most relevant aspects is the variation of the longitudinal stability equilibrium that becomes more stable. Furthermore, the deployable solar panels increase the aerodynamic drag when the aero-brake is closed, affecting the drag modulation capability.

Keywords*:* Deployable aero-brake; Solar panels; Small satellite Aerodynamics; Direct Simulation Monte Carlo Method; Longitudinal stability

Declarations of interest: none.

1. Introduction[†]

In recent times, the concept of variable geometry capsules gained an increasing importance in the aerospace field, thanks to key features of such systems making them light, low-cost alternative to more conventional planetary re-entry vehicles. The main characteristic of these technologies is the low ballistic coefficient, which makes possible performing an atmospheric re-entry with reduced thermal and aerodynamic loads. Furthermore, both deployable and inflatable capsules can be easily accommodated into the launch vehicles in the folded configuration and then deployed or inflated, according to the mission profile, with the high-temperature resistant aero-brake working also as a heat shield for the capsule payload.

Examples of inflatable systems, proposed and already tested, are the European Inflatable Re-entry and Descent Technology (IRDT) [1] and the American Inflatable Re-entry Vehicle Experiment (IRVE) [2]. An inflatable Nanosat De-orbit and Recovery System has been specifically designed for CubeSat payloads by Andrews Space [3]. Beside those, different concepts for re-entry systems, based on mechanically deployable heat shields, exist. In 1990, a deployable capsule was developed using an umbrella-like heat shield, made of silicon fabrics, called Parashield [4]. A similar satellite, called Bremsat, was studied in 1996 at the University of Bremen [5]. More recent concepts are the ESA PARES [6], designed for a robotic mission making possible the recovery of a payload from the International Space Station, and the NASA ADEPT (Adaptive Deployable Entry and Placement Technology) [7], conceived for a manned Mars mission.

The present paper is focused on a Low-Earth-Orbit (LEO) small satellite, with an adjustable deployable aero-brake. This allows the satellite to perform an aerodynamic de-orbiting maneuver without the need for a dedicated propulsive system and provides it of "in-orbit control" capabilities, by means of the aero-shield surface area modulation. The effectiveness of drag modulation for trajectory control of small spacecrafts was

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