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Title

Mechanical design of a deployable morphing aeroshell for 12U CubeSat atmospheric reentry

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Abstract

There is a wide application spectrum of deployable aeroshells for de-orbit and re-entry of space vehicles by using flexible heat shields. By expanding to a larger diameter prior to entry in order to increase drag, such a technology has shown to provide higher entry performance suitable for earth or a variety of planetary high-speed entries that require high temperature thermal protection systems materials. Also, innovative shape-changing mechanisms exists in the literature for controlled re-entry and safe recovery of CubeSat class systems to recover payloads and data from LEO at low cost for post flight inspections and experimentations. Shape morphing during atmospheric entry could enable trajectory control by providing enhanced flight maneuverability and high-precision landing. This paper presents a CubeSat design concept that directly incorporates a mechanically deployable re-entry aeroshell within the standard 12U form factor by investigating aerodynamics and heating of a flexible thermal protection system having shape-changing capabilities. Focus is given to the design of the deployment system through multibody and structural simulations. Furthermore, a high-performance polybenzimidazole (PBI)-based thermoplastic material is investigated to efficiently dissipate the incident heat flux acting on the thermal protection system. The deployable surface can be modulated by a single actuator in order to modulate the lift-to-drag ratio for guided entry. Additionally, once deployed, the system can activate eight small movable aerodynamic flaps that can be individually morphed via an SMA-based actuation to control the trajectory and target the entry vehicle into the desired area for landing. This paper is framed within a joint research project for scientific and technological cooperation between Italy and Brazil in the field of space science, co-funded by the Italian Ministry of Foreign Affairs and International Cooperation (MAECI) and by CONFAP through the involved Brazilian State Funding Agencies (FAPs).