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STRUCTURAL DESIGN OF BOOMS FOR THE SOLAR SAIL OF HELIANTHUS SAILCRAFT

Abstract

Solar sail is a promising propulsion concept that exploits solar pressure to navigate in space without the use of chemical or electrical propellants, therefore enabling missions otherwise not attainable by traditional propulsion. For instance, synchronous solar sail with the Earth-Moon barycenter may be used to obtain a long warning time of solar storms caused by Coronal Mass Ejection. This is the main objective of the Helianthus mission, used as a test study case in the research activities on solar photonic propulsion carried out jointly in the frame of an Agreement between the Italian Space Agency and DIAEE – University of Rome "La Sapienza". In this paper, we describe the design of the structural subsystem for the solar sail of the Helianthus sailcraft. This subsystem is composed of four deployable ultralight booms, which deploy and keep the membrane in tension. The booms have to withstand the axial load, generated by the tensioned membrane, which must be smaller than the critical load at buckling. At the same time, the booms need to have sufficient stiffness to prevent a large out-of-plane displacement of the membrane leading to reduction of the thrust. First, we determined the geometry and the dimensions of the boom cross-section to optimize the stiffness. Next, we performed a structural numerical analysis on a full-scale model of a square solar sail (40 m x 40 m) with four supporting booms. For such configuration, we simulated the sail tension in order to determine the axial load acting on the tip of each boom and we assessed the displacements due to the solar radiation pressure. Simulations were carried out by finite element method using the software ABAQUS. Results are presented at both system and individual component levels. Acknowledgements This work is performed jointly under the Implementing Agreement between the Italian Space Agency and DIAEE – University of Rome "La Sapienza" n. 2019-28-HH.0 - CUP n. F84I19001070005 related to RD activities on solar photonic propulsion. The Implementing