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SMALL SATELLITE MISSIONS SYMPOSIUM (B4)
Design and Technology for Nano-Sats and Cube-Sats (6B)

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DESIGN AND ANALYSIS OF A FULL COMPOSITE STRUCTURE FOR THE 1ST GREEK CUBE-SAT BY THE UNIVERSITY OF PATRAS (UPSAT))

Abstract

The current work presents the design, development and verification by analysis of the first Greek cube-satellite developed at the University of Patras (UPSat). The key innovative approach includes the replacement of the aluminum structural frame with structural composite components, something that has never been attempted in the past by another mission in such a way. The present work deals with the design and analysis of a single-unit (1-U) CubeSat made entirely of composite materials and the comparison with a commercially available structure made of aluminum (CubeSat-kit) already certified for space use. The work was performed under the vision to prove the feasibility of manufacturing and certifying the structure for space use in the near future. For this purpose several designs of the structural components were developed, as well as assemblies of these to for the entire structure of UPSat. The various initial designs were evaluated in terms of mass and stiffness and were compared to the respective aluminum structural elements. Meanwhile, an evaluation of several lay-ups for the composite plates took place in order to identify the best combination of mass and stiffness for the UPSat structure. Once the two lay-ups with the finest properties were identified, the finite element model for two different structures was created; one made of aluminum and one of composite material. A static structural analysis was performed for which two different loading cases were considered, representing the position and orientation of the CubeSat inside the separation module. A modal analysis for two structural components was realized (a composite and an aluminum plate), for four different designs and finally for the whole structure (assembly). The results obtained indicate that a quasi-isotropic lay-up can provide adequate strength and stiffness for sustaining the launch loads and requirements. Additionally and more importantly, a reduction of mass between the metallic structure and the composite structure close to 53% was achieved, while the first eigenfrequency of both structures was the same. All the stresses and displacements were very low. The conclusion of this work is that a CubeSat's structure made of composite materials has roughly the half of the mass of an aluminum structure while maintaining the stiffness required for space structures. The results presented are very positive and encouraging for the migration of the picosatellite structural technology to composites.