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PRELIMINARY DESIGN OF A CUBESAT DEMONSTRATOR FOR AN ORIGAMI-INSPIRED DEPLOYABLE STRUCTURE

Abstract

Rising commercialization of the space industry has led to increasing demand for large structures in space, such as habitats and fuel tanks. However, due to the limited payload volume available, the shape of such structures is highly constrained. This calls for a structure that is flexible enough to be stowed during launch but stiff enough to withstand structural loads.

Origami-inspired structures are an appealing design compromise as they can dynamically change their shape and volume while maintaining structural integrity. They also present the advantage of a high packaging ratio, scalability, can largely maintain their structural properties after repeated deployment, and possess flight heritage with space technology like sunshields and solar arrays. The present work aims to further the knowledge in this field by testing the viability of this concept with a deployment demonstrator fit for a 12U CubeSat mission.

Two potential deployment concepts have been identified—telescopic deployment and inflation. The telescopic solution is reliable and has extensive flight heritage but adds weight and complexity to the structure. Inflation, however, is lightweight, has fewer parts, and provides a directly pressurized structure, but runs the risk of depressurization. Nevertheless, it has been used successfully to deploy origami booms and sails in space and other inflatable structures like the BEAM.

Different origami patterns are selected for each of the deployment concepts. The telescopic deployment calls for the Yoshimura pattern due to its straight, non-rotational folding behaviour, and for inflation, the Kresling and Miura-Ori patterns are considered. The concepts are traded off after preliminary modelling, weight estimations, and materials and manufacturing considerations.

The driving requirement of this comparison is the maximum usable inner volume, but the packaging ratio is also taken into account. The materials proposed are dual matrix composites. These composites utilize a soft/rigidizable matrix at the folding lines and a stiff epoxy matrix elsewhere, making them capable of large deformations while also maintaining stiffness to carry structural loads.

Next, an ideal pattern configuration is identified via a parametric study. This configuration is then integrated into the 12U CubeSat structure, and Low Earth Orbit (LEO) environment conditions are imposed on it for further in-orbit simulation.

The origami demonstrator will serve as an economical in-orbit proof-of-concept for a viable deployment technology using an innovative stowing method and novel materials and will pave the way for the transportation and deployment of much larger structures in space than currently possible.