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ORIGAMI-INSPIRED DEPLOYABLE SPACE HABITATS

Abstract

Origami is increasingly used a source of inspiration in a wide variety of disciplines. The physical properties of foldable origami structures can be tuned as desired, and their mechanical behaviour does not change with size; their applications thus range from the smallest to the largest scales. Origami principles can be used to create minuscule surgical devices for biomedical applications, design building skin elements, and build large deployable solar arrays. In this project, we explore cylindrical origami structures, referred to as “origami bellows”, as novel geometries for orbital space habitats. The dimensions of habitats, such as modules attached to the International Space Station, are limited by the tight mass and volume constraints imposed by launcher payload fairings. Future deployable space habitats based on origami bellows have the potential to achieve large internal volumes when deployed, while being capable of compacting to a smaller stowed configuration for launch.

To assess the feasibility of such habitat designs, the deployment performance of a selection of origami bellows was investigated. Bellows formed from Kresling and Miura-ori patterns were considered; both can expand axially but differ in that Kresling patterns maintain a constant cross-section during deployment, whilst Miura-ori patterns experience an additional radial expansion. Our scope was also limited to bellows patterns which are stable in both the stowed and deployed configurations. Habitats were judged on their internal and effective volume expansions; the latter being adjusted to account for the practicalities of operating within a complex habitat geometry. Exploring the design space of the origami bellows, we find that significant internal and effective volume expansions are achievable, particularly for Miura-ori geometries. Nonetheless, we make the argument for Kresling patterns as a more practical option due to their simpler geometries, despite smaller volume expansions. We find our Kresling geometries to have effective volumes between 2.5 - 3.6 times greater than a conventional habitat launched in a fairing of equal volume.

Our work shows that origami-based designs do indeed have potential to greatly outperform current space habitat designs and concepts. In future work, this will be supported by more refined structural analysis to verify deployment behaviour. Furthermore, wall material and thickness need to be considered, and other potentially viable patterns should be investigated.