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PRELIMINARY STUDY OF AN ORIGAMI-INSPIRED DEPLOYABLE STRUCTURE FOR A SMALL-SCALE DEMONSTRATOR

Abstract

The progressive democratization of human space exploration has brought a potential demand for affordable large pressurized structures in space such as habitats as well as fuel tanks in orbit. Unconventional space structures are a potential engineering solution because they can optimize the structural performance for the launcher's geometric limitations.

Specifically, deployable origami-inspired structures allow for a compromise solution between available volume and cargo weight [1]. Origami-inspired structures have been studied for space applications in past [2] and recent works [3], but there are still gaps between the in-orbit requirements and technological challenges with the current state-of-the-art.

Consequently, there is a need for small scale demonstrators for this technology that will allow to characterize and validate the deployment concept. Such a small scale demonstrator would fit within 12U CubeSat (or equivalent smallsat configurations) and would unveil possible technical challenges not considered in the modelling stage.

This work builds on Grey et al. [4] exploring the design of a prototype for a deployable structure with a high packaging potential and a small number of degrees of freedom. A cylindrical origami deployable structure is studied under its processes of folding and deployment. This configuration has also the advantage of a possible pressure controlled deployment [5], one with special interest for habitable modules or, additionally, fuel tanks for transportation and storage.

In particular, the first steps towards a complete design of the demonstrator are explored: the shape optimization, the material selection and its structural behavior. To design this demonstrator, first a parametric trade-off study of the different origami patterns is performed: looking for an optimal packaging ratio. Once the geometrically optimal configurations are obtained for each origami pattern, relevant materials are selected to perform a structural response analysis.

A quasi-static analysis is performed for each viable configuration via the commercial FEM software Abaqus. The two processes are studied: the folding and the pressurized deployment. Results are compared for each of the configurations looking for critical stress and strain regions, metastable configurations, and time evolving behaviors. A final trade-off based on the structural performance of each configuration is performed and a design for the in-orbit demonstrator is selected.

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