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Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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ON-ORBIT MANUFACTURING OF LARGE SPACE STRUCTURES USING SOLID FOAMS

Abstract

The development of on-orbit manufacturing processes will enable the fabrication of large space structures that are free from many of the constraints of deployable structures, for example overcoming the volume limitation of the launch vehicle payload faring. Such structures could be designed to better suit applications such as photovoltaic (PV) power generation, antennae or solar reflectors, by providing large rigid planar surfaces. These surfaces could be on a scale significantly larger than might otherwise be possible with deployables. However, to optimise such planar structures the mass of their support structures must be minimised, while providing adequate mechanical properties.

This paper will consider the use of solid foams, for example comprising a resin cured under the action of UV radiation, providing an interesting material for the support of these planar structures. It is envisaged that the foam would be applied to a membrane or thin film PV cells in a continuous manufacturing process. The dispersed nature of foams means that they can be stored in a small volume, but provide a large volume on formation for a low mass. This characteristic has seen the adoption of foams for terrestrial high strength, low weight applications. Additionally, the rapid production of foam allows for short fabrication times when compared to other on-orbit manufacturing processes, such as additive layer manufacturing. Short fabrication timescales could significantly reduce the commissioning period for commercial uses of large space structures, where early return on investment is key.

Following a discussion of the opportunities presented by foams, the paper will use a finite element model to analyse the performance of such solid foams in the in-orbit environment and to compare their performance to conventional support structures. The performance of the structure will be assessed on its mechanical stability during manoeuvring, resistance to deflection once deployed and fabrication timescale.

Following the assessment of the foam mechanical properties, considerations for operational in-orbit fabrication of large space structures using foams will be discussed. The mechanical stability of the solid foam structure allows it to maintain its shape during manoeuvring. This characteristic is critical for any application that requires high shape accuracy and rapid changes in pointing, such as is required for PV arrays when sun pointing, or antennae when switching objectives. Similar solid foams have previously been explored by Valdatta et al [1] to remove space debris.

[1] Valdatta et al. 'INFLATABLE SYSTEM BASED ON POLYURETHANIC FOAM', 721:153–60. Naples, Italy: IAF, 2013.