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

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RELAXATION EFFECTS DUE TO THE STOWAGE PHASE ON THE DEPLOYMENT OF ULTRA-THIN COMPOSITE BOOMS

Abstract

In the last decade, the use of deployable structures in space is growing up rapidly to provide large apertures for communication, imaging, and sensing applications, as well as solar power systems and sails. The most efficient type of deployable structure, in terms of lightness and occupied volume, is the ultrathin composite boom, which is unfolded from the rolled configuration into the much larger operational one. The boom deployment depends on the strain energy stored during the folded configuration. This energy may be reduced during the boom stowage, due to the viscoelasticity of the constitutive polymer, since it can remain in this configuration for long time. In this work, we investigated the time-dependency of boom functionality considering the viscoelasticity of the ultrathin composite material. In particular, we simulated the folding process, consisted in the two subsequent stages of flattening and coiling of the boom, and then we simulated the maintaining of the boom in this configuration for a long time, in order to account for the relaxation during the stowage. At the end, the deployment process is simulated through a non-linear explicit dynamic analysis. The boom is modeled with viscoelastic shell elements, with time-dependent properties given through a relaxation ABD matrix, computed with a two-scale homogenization approach. The first homogenization is performed at the micro-scale and gives the viscoelastic properties of the unidirectional tow. Those properties are used in the second homogenization at the meso-scale for numerical evaluation of the relaxation ABD matrix of the ultrathin composite laminate. By employing the relaxation ABD matrix in simulating the process of folding, stowing and deployment, we can predict the behavior of a boom stowed for an arbitrarily long time.