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

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NUMERICAL SIMULATIONS AND EXPERIMENTAL TESTS FOR THE DEPLOYMENT OF A THIN-WALLED BISTABLE COMPOSITE BOOM

Abstract

For advanced space missions, the concurrent requirements of increasing the size of the payload while minimizing the volume of the spacecraft can be satisfied by the use of deployable structures. In a previous work, presented in IAC 2017, an ultrathin boom was characterized from the point of view of the interaction between attitude and elastic dynamics in a fully deployed configuration. In this work the critical phase of the deployment of a thin-walled bistable composite boom is analyzed both from a numerical and an experimental point of view. First, the new boom has been designed and realized using a 1k bidirectional carbon fiber fabric and an epoxy resin. The boom is made up of two layers with the fiber orientation angle +-45. The deployed form is given modelling the fabric on a rigid cylinder, covered with a Teflon layer to facilitate the demolding phase. A simulation of the deployment phase was developed performing a non-linear explicit dynamic analysis using the Abaqus 6.14 software. In particular the Explicit Dynamic tool was used due its efficiency in dynamic process with geometry change and its capability to follow the non-linear behavior of the problem. Since the deployment dynamics depends on the internal bending energy accumulated during the folding phases (namely flattening and coiling of the boom), also those phases were simulated. The numerical analysis results consist in the definition of the dynamic evolution of the boom configurations, with associated velocities and stresses. Two types of experimental tests have been conducted on the boom to confirm the numerical results. In the first one the deployment has been performed with one end of the boom connected to a fixed wall, in order to measure the deployment time and observe the deployment dynamic (in this part a comparison with an already available monostable boom was conducted). As a second test, the boom was connected to a free-floating platform in order to provide a qualitative and quantitative representation of the behavior of a real small satellite performing the boom deployment. The results show the platform linear acceleration and the attitude perturbations caused by the fast deployment of the boom, with consequent vibrations of the other flexible appendages (solar panels).