Paper ID: 40523
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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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DESIGN, TEST AND COMPARISON OF MECHANICAL SUPPORT PRINCIPLES TO INCREASE THE ROBUSTNESS OF DEPLOYABLE THIN-SHELL CFRP-BOOMS OF THE DEORBITING DEVICE ADEO

Abstract

Gossamer space structures like solar sails, drag sails or solar arrays expand to very large dimensions while at the same time aiming for low masses, leading to a low areal density. In many cases these applications are designed using ultra-lightweight booms, spanning out sails or other membranes. For launch and transfer however these booms need to be stowable and compact, while demanded to withstand the sail loads during deployment and in operation phase. Developing Gossamer space structures and participating in different projects, the German Aerospace Center – DLR – in most cases uses such booms as major structural components. These delicate thin shell CFRP booms feature a double omega cross section that can be flattened and rolled up for stowage. However, for a successful operation they have to provide certain stiffness, buckling load capacity and robustness. In the industry led project ADEO, a truncated pyramid shaped configuration for a drag augmentation device, is accomplished using such booms combined with four sail segments as a so called drag sail. Realizing a boom root deployment enables the boom tip to be pushed out of the housing and to deploy the sails. Due to this principle a transitional zone forms from the flattened to the fully deployed boom cross section. Thus reducing the second moment of area and therefore local stiffness of the boom, the transitional zone needs to be mechanically supported. Realizing this with a boom-support-guide device, this supportive structure fulfills a secondary function of guiding the deploying boom from the boom hub into the destined direction away from the spacecraft. In this paper the influence of the mechanical support and guiding on the buckling behavior, stiffness and friction during deployment of a boom is studied. To do so the mechanical characteristics of the initial and for two alternative designs of the boom-support-guide are investigated and compared. Experimental data is acquired by combined mechanical boom bending and compression tests in a vertical test stand with booms mounted onto a realistic deployment unit. By simulating occurring sail and deployment loads with a certain spectrum of angles of attack and according boom lengths, values for boom buckling, collapse and boom tip deflections are acquired and analyzed in typical load-deflection curves. Furthermore deployment simulations of booms guided thru the supports are performed in order to determine the friction forces. Finally the acquired experimental data and characteristics of the different designs are compared and discussed.