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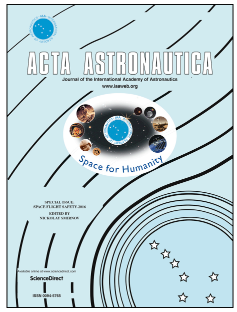

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Shape accuracy optimization for cable-rib tension deployable antenna structure with tensioned cables

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Abstract

Shape accuracy is of substantial importance in deployable structures as the demand for large-scale deployable structures in various fields, especially in aerospace engineering, increases. The main purpose of this paper is to present a shape accuracy optimization method to find the optimal pretensions for the desired shape of cable-rib tension deployable antenna structure with tensioned cables. First, an analysis model of the deployable structure is established by using finite element method. In this model, geometrical nonlinearity is considered for the cable element and beam element. Flexible deformations of the deployable structure under the action of cable network and tensioned cables are subsequently analyzed separately. Moreover, the influence of pretension of tensioned cables on natural frequencies is studied. Based on the results, a genetic algorithm is used to find a set of reasonable pretension and thus minimize structural deformation under the first natural frequency constraint. Finally, numerical simulations are presented to analyze the deployable structure under two kinds of constraints. Results show that the shape accuracy and natural frequencies of deployable structure can be effectively improved by pretension optimization.

Keywords: Shape accuracy optimization; Deployable structure; Tensioned cables; Pretension; Finite element method; Genetic algorithm[1]

1. Introduction

Numerous large-scale space structures have been designed and widely applied to accomplish specific missions in a complex space environment [1-3]. Such characteristics as lightweight, large aperture, and simple structure have made cable-beam deployable structures very attractive in the field of satellite antennas in recent years. Addition of cables increases the stiffness of this type of deployment structure, and the initial stiffness of cables is rendered by tension forces. Given their low weight, cables solve to a certain extent the problem on balance between stiffness and weight of deployable structures. Representative examples include several deployable antennas, such as ETS-VIII [4], TFDR [5], the TerreStar and SkyTerra antennas [6], and tensegrity antennas [7,8]. As shown in Fig. 1, Harris' TerreStar-1 [6] has a novel deployable structure with radial ribs and tensioned cables. It was launched in 2009 and has demonstrated its performance in orbit. This antenna represents the current state-of-the-art large deployable space mesh antenna.

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