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OPTIMAL DESIGN OF A NET OF ADAPTIVE STRUCTURES FOR MICRO-VIBRATION CONTROL IN LARGE SPACE MESH REFLECTORS

Abstract

Large deployable antennas are required for the advancement of space communications, Earth observation, radio astronomy and deep space exploration. The core requirements of a space antenna are high gain, high directivity and persistent accuracy, that are mainly dependent on the size of the reflector. Most contemporary space antennas have exceeded the size of launching vehicles, leading to the necessity of stowed concepts to overcome the limitation. Many structural models have been investigated by different organizations. Generally, mesh deployable reflectors are currently more mature compared to other foldable solutions and will be the topic of this paper. In-orbit disturbances affecting the deployed configuration can deteriorate the accuracy of the communications system. Perturbations originated by on board sources can be transmitted from the satellite platform to the supporting frame of the antenna. Furthermore, the structure accuracy is affected by thermal deformation and elastic vibration due to thrusters jetting. Undesired dynamic behaviour of structural components have to be predicted and counteracted. Therefore, active shape and vibration control is a key technology to correct the distortions altering the proper functioning of the system. An intelligent adaptive structure is introduced as a structure configured with distributed actuators and sensors and guided by a controller to modify the static and dynamic response of the system. In this paper, supporting structure of a very large mesh reflector is described. The antenna reflector foldable membrane is supported by a deployable adaptive truss structure. A FEM formulation is adopted to assemble the frame and it is validated by comparing it with commercial codes. According to the presented model, the active elements can be embedded in the middle of the truss elements. Of course, active control of all the devices at the same time requires a cost from the power consumption point of view which could be not affordable in space applications. However, the effectiveness is not the same for all the actuators. In this study, an optimization procedure is performed to assess the best placement and authority of the actuators that must be controlled for a variety of disturbances. The objective function is set as a weighted sum of power consumption and total weight of the devices, under the constraint that the shape of the mesh reflector respects the pointing requirements. As study cases, different strategies are implemented to coordinate the simultaneous action of the actuators devices to ensure the accuracy demanded by the mission requirements.