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ASSEMBLY AND DISASSEMBLY DYNAMICS OF A MODULAR SOLAR POWER SATELLITE

Abstract

This work originates from the problem of the disposal of large-scale infrastructures in space, like Solar Power Satellites (SPS). To date, satellite components are not systematically saved at their end of life or in the event of technical malfunctions. The growing number of objects in orbit makes disposal via atmospheric re-entry an impractical and environmentally unsustainable solution. For this reason, it is increasingly necessary to develop technologies that support a more sustainable use of space, such as in-orbit servicing and recycling. In this context, large space systems, such as SPS, are conceived to be designed as modular with replaceable parts. A modular system would allow it to be disassembled, its pieces re-manufactured and used to build new space systems. In recent years, several programmes (like the H2020 Peraspera) have been supporting the development of in-orbit servicing capabilities via robotics solutions and have been pushing towards the construction of a new generation of modular satellites.

This paper focuses on the problem of the coupled structural, attitude and orbital dynamics of a large flexible and modular structure while it is being assembled or disassembled by robots. Previous works in the literature have already investigated in detail the dynamics and control of flexible structures in space, such as solar sails and SPS. Nevertheless, none of these have analysed the dynamics of a structure that changes shape and geometry over time, during the process of assembly and disassembly, and is perturbed by impulsive actions at its edges.

In this paper, the dynamical model of a large modular and flexible structure is derived. The structure is modelled with a simple lumped-masses model, in which each element is connected with elastic/dissipative links. The structure is subject to the range of forces present in the space environment and the interaction with robots is modelled as localised external forces acting on it. To reproduce the change of shape in time, the concentrated masses are progressively removed or added. The response of the structure to this process is simulated. The motion of each single mass is analysed, together with the motion of the centre of mass of the whole structure and the overall angular momentum.