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ASSEMBLY AND DISASSEMBLY COUPLED ORBIT-ATTITUDE DYNAMICS OF THE EUROPEAN REFERENCE SOLAR POWER SATELLITE

Abstract

A Solar Power Satellite (SPS), is a system designed to capture solar energy in space and transmit it wirelessly to Earth. The basic concept consists in placing a large satellite equipped with solar panels in Earth orbit to harvest sunlight. The collected solar energy is then converted into electricity and transmitted to the ground using microwave or laser beams. The advantage of this concept is that a SPS can collect solar energy continuously, without being affected by atmospheric conditions or the day-night cycle on Earth. This could potentially provide a constant and reliable source of clean energy. However, the concept faces significant engineering and economic challenges, including the cost of launching and assembling such structures in space and the disposal at their end-of-life. The interest in space-based solar power systems has been continuously growing since the early 2000s, driven by numerous advances in space technology, including the in-space assembly and space robotics experience gained during the construction of the International Space Station. The European Space Agency recently launched the SOLARIS initiative, aimed at assessing the technological, political and programmatic feasibility of space-based solar power as a means of meeting the needs for clean energy on Earth. As a result, the European reference concept will be also proposed.

This paper focuses on the problem of the coupled orbit-attitude dynamics of the European reference SPS under nominal conditions and during construction and dismantling by robotic systems. The dynamical model of the satellite is derived. The structure is subject to the range of forces present in the space environment and is perturbed by robots with impulsive actions at its edges. In order to reproduce the change of shape over time, the elements composing the modular structure are progressively removed or added. The attitude angles and the phase space associated to chaos indicators are derived and compared in different scenarios: in the nominal case, in which the satellite is continuously beaming to Earth, and during the assembly and disassembly phases. A sensitivity analysis varying the parameters of the system is conducted to establish at what point these processes destabilise the dynamics. This work represents an important step in understanding how a peculiar structure like that of a SPS can respond to a range of operational conditions.