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ORBIT-ATTITUDE INTEGRATED CONTROL ON SMALL-AMPLITUDE PERIODIC ORBIT AROUND SUN-EARTH L2 IN TRANSFORMER MISSION

Abstract

The Sun-Earth libration point orbits provide nearly fixed relative geometry with respect to the Sun and Earth, and they are useful for infrared astronomy, for example, taking advantage of nearly constant thermal environment. In particular, the amplitude of small-amplitude periodic orbits around the Sun-Earth L2 is about twenty thousand kilometers, which is much smaller than that of classical halo orbits, which is in the order of million kilometers. Because continuous thrust control is required to stay on the small-amplitude periodic orbits, utilizing Solar Radiation Pressure (SRP) is an efficient option to save propellant consumption. On the other hand, it requires attitude control with respect to the Sun to control thrust due to SRP, which may conflict with requirements from the astronomy observation, and a new strategy is necessary to satisfy the both requirements from orbital control and observation. The joint research team consisting of universities in Japan and Japan Aerospace Exploration Agency has been working on the Transformer mission, where the spacecraft transfers to and stays on a small-amplitude periodic orbit around the Sun-Earth L2 and performs the infrared astronomy there, and developing the mission and the spacecraft system. The significant characteristic of the spacecraft is that it comprises a number of panel structures, connected to each other by actuatable joints, and the configuration of the entire body is transformable. This enables two kinds of attitude controls; one is the control of SRP and the other is the nonholonomic control, both of which utilize the transformability of the spacecraft configuration but are fundamentally different. Torque due to SRP is an external torque and it changes the angular momentum of the entire spacecraft system, and its control is realized by changing the configuration of the reflective surface of the spacecraft and by reflectivity control using the Reflectivity Control Devices mounted on some of the panels. Note that force due to SRP must agree with the requirement from the orbital control. On the other hand, the nonholonomic attitude control is based on the internal torque excited by actuators between the panels, and the total angular momentum is unchanged. By combining these controls with the configuration variation, it becomes possible to realize propellant-free attitude control satisfying both requirements from orbital control and astronomy observation. This paper reports the latest study results on the orbit-attitude integrated control.