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Author: Ms. Maria Anna Laino
University of Strathclyde, United Kingdom, maria.laino@strath.ac.uk

Dr. Andrew Ross Wilson
University of Strathclyde, United Kingdom, andrew.r.wilson@strath.ac.uk
Prof. Massimiliano Vasile
University of Strathclyde, United Kingdom, massimiliano.vasile@strath.ac.uk
Mr. Roberto Paoli
Romania, roberto.paoli@uaic.ro
Prof. Catalin Gales
Romania, cgales@uaic.ro

A TRANSPORT NETWORK FOR IN-ORBIT RECYCLING EXPLOITING NATURAL DYNAMICS

Abstract

Nowadays, satellite components are not systematically salvaged at the end-of-life or in cases of technical malfunctions. However, programmes like the H2020 PERASPERA are already supporting the development of capabilities for in-orbit servicing and a new generation of modular satellites with replaceable parts. Large space infrastructures, like Solar Power Satellites (SPS), are also conceived to be modular. A modular space system would enable the dismantling, reuse and remanufacturing of parts to build new space systems. It is also becoming clear that the growing number of objects in orbit makes the disposal via atmospheric re-entry an environmentally questionable solution. Thus, in-orbit recycling is a key technology for a sustainable use of space. In a scenario in which parts are recycled, there is the need to have frequent and low-cost transfers in Earth orbit to fetch and transport these parts.

This work will propose the construction of a continuous transport network connecting different orbit regimes with a Geosynchronous orbit in the Laplace plane and the Laplace plane with the Moon. This transport network will be designed to exploit a combination of natural dynamics and thrust arcs. The methodology proposed starts from the identification of regions, in orbital parameter space, around the Earth, where third-body and geopotential effects concur to modify eccentricity, radius of perigee, and inclination. A control strategy is then devised to exploit these natural effects and achieve the desired final orbit. Conversely, the cislunar region will be connected via low-energy transfers and controlled arcs.

Previous works examined the use of resonances to facilitate de-orbiting. This is, however, a slow process that needs the enhancement of a control action to allow a continuous transport of parts. Already flown missions, like SMART-1, also showed how to accelerate re-orbiting by exploiting third-body effects. Thus, the idea of this paper is to combine these natural effects and use control to patch together different dynamical structures to achieve a low-energy transport of mass to and from the target Geosynchronous orbit.

The choice of a Geosynchronous orbit in the Laplace plane as destination of all fetched parts is dictated by the interest for this orbit to operate an SPS. However, existing concepts for an SPS in Earth orbit do not include any solution for its end-of-life. A recycling transport network would offer an effective and sustainable solution. In reverse, it would allow the in-orbit manufacturing from systems already in orbit but currently not operational.