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THE RECYCLER: AN INNOVATIVE APPROACH TO ON-ORBIT SERVICING AND REPURPOSING

Abstract

Due to its unique properties, the Geosynchronous Equatorial Orbit (GEO) hosts one of the most relevant sectors of the satellite industry, with hundreds of satellites providing telecommunications, meteorology, military, and many other similarly crucial services. GEO satellites can be very expensive to build, launch and operate: they are hence expected to work seamlessly throughout their lifetime, and a malfunction can represent a major economic loss. Instead of replacing the satellite or accepting reduced performances, a malfunctioning satellite could be repaired on site by replacing the faulty component with a functional one, harvested from non-operational satellites and later repurposed.

This paper presents the concept of the “Recycler”, a spacecraft used to procure replacements for operational GEO satellites by harvesting intact components from non-operational spacecraft in the GEO graveyard (the region with altitude approximately $\text{GEO} \pm 250$ km) and surrounding areas. By recovering and repurposing existing hardware, the Recycler would be accessing a previously non-existent second-hand satellite market.

The preliminary mission design and analysis for the Recycler are described, together with a system-level assessment of required components. Given a database of potential targets and a set of client satellites, the Recycler performs multiple missions between several target satellites and a Space Factory, where parts are stored to be later repurposed or recycled for raw materials. Methods to find the optimal sequence of multi-target transfers are investigated, including several phasing strategies and methods to simulate low-thrust trajectories, evaluating the mission times and ΔV 's. Moreover, the target approach procedure, and the technologies and processes to assess the satellite's non-collaborative target's attitude and state are reported. The full rendezvous sequence, including a closed-loop approach to the target and station keeping maneuvers, is simulated to evaluate times and ΔV 's required. Finally, the possibility of using a swarm of scanner satellites to perform inspections of unknown targets is discussed, with the final aim of characterising the GEO debris environment.