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ASSEMBLY AND OPERATIONS FOR A CISLUNAR ORBIT SPACE STATION

Abstract

Challenging space exploration missions are envisaged in the next future, involving a cooperation of humans and robots to accomplish ambitious goals beyond Low-Earth orbit. During the ideation of these forthcoming space programmes, international scientific community is focusing its attention on the sustainability of the entire long term program, carefully sizing the intermediate steps and meticulously identifying new technologies needed to carry out the proposed activities. In particular, a gradual construction of a space station in cislunar environment is seen as a key element of the entire project and it opens an interesting field of multidisciplinary studies from a space system engineering perspective.

The paper is founded on recent works focused on analysing the dynamics and controllability of large and flexible space structures in non-Keplerian orbits. The developed coupled orbit-attitude semi-analytical models, based on a Three-Body Problem modelling approach including the most relevant perturbing phenomena, such as the Solar Radiation Pressure (SRP) and the fourth-body (Sun) gravity, are here first exploited to assess alternative strategies to assemble the space station in the vicinity of the Moon. In fact, this future large space infrastructure will be credibly set up in-orbit by means of many rendezvous and docking automated activities, which should be carefully and progressively designed to reduce complexity, costs, and ensure reliability and repeatability. Therefore, the paper discusses the sensitivity analyses conducted with respect to selected criteria (e.g. inertia properties and configurations to minimize control action, rendezvous trajectories to simplify infrastructure construction) to rank the emerged potential assembly strategies and get to final alternative large spacecraft configurations. Then, the nominal operations plan is presented for the proposed assembly baselines. The minimization of active control actions is foreseen: the full space of solutions is studied to highlight possible stable conditions that may be exploited to host and operate the cislunar station with minimum control effort. Analyses are presented according to the non-Keplerian orbits classes evaluated as the most suitable for a large infrastructure location: L2 Halo, NRO and DRO.

Rendezvous and docking in non-Keplerian environment have never been tested in real applications and the literature is somehow missing an extensive research on this topic, especially when orbit and attitude dynamics are considered together.

Finally, particular configurations for the space station in spin stabilized dynamics are examined as artificial gravity generator, which may be very favourable for prolonged astronaut permanence in space.