IAF SPACE SYSTEMS SYMPOSIUM (D1)
Technologies to Enable Space Systems (3)

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ADVANCED GNC FOR IN-ORBIT AUTONOMOUS ASSEMBLY OF FLEXIBLE VEHICLES – IOA-GNC

Abstract

The next steps of space exploration involve expanding human presence in the solar system. Future foreseen steps consider building larger, more complex structures like an Evolvable Deep Space Habitat, as well as exploring our neighbourhood and enhancing human-robot interaction by developing robotics and autonomy technologies. In Orbit Assembly (IOA) project is an ESA funded TRP activity that studies and simulates possible solutions for future steps, with the main purpose of increasing capabilities, performances, safety and reliability of complex missions. The principles to develop are mainly two: use of advanced control techniques to perform rendezvous/mating operations (berthing or docking) in systems growing in complexity and changing their physical properties throughout the assembly process; and the increase of mission safety in case of contingencies, by the use of Fault Detection and Accommodation paradigms to overcome subsystem level failures, and the use of autonomous planning techniques to correct mission level failures by making on-board decisions and generating new mission plans. These ideas are applied to three different scenarios: first, an orbiting Lunar Space Station with an approach similar to the ISS, where several modular structures approach from low Earth Orbit to the Station orbit and perform rendezvous and docking, becoming part of the main structure; second: a Lunar Space Telescope, where a multi-purpose tug transports a set of reflectors that will be assembled into a unique reflective surface and used by the telescope as a large primary mirror bigger than a classic monolithic telescope, starting from their parking orbit to a Hub/Central Module orbit, performing docking with the Hub/Central Module and assembling the reflectors into the structure by means of a robotic arm; and third, a Halo Space Telescope, similar to the Lunar Space Telescope scenario, where self-propelled reflector modules approach the Hub/Central Module and dock to it using their own GNC systems and propulsive capabilities instead of a tug, in a halo orbit near a Lagrangian point. For this third scenario, the reflectors are deployed

from the launcher/transport spacecraft and perform autonomous rendezvous operations, approach the Hub/Central Module and perform berthing by means of a robotic arm located in the Central Module itself. These three scenarios present a wide range of possibilities and challenges, with principles applicable to future missions foreseen in the development roadmap. The paper will present the different missions architectures, the design principles of the robust GNC/control systems and the results obtained from a Matlab/Simulink simulator-based test campaign.