Paper ID: 52941
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IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (1) (7)

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GNC FOR LUNAR ASCENT, ORBIT TRANSFER AND RENDEZVOUS IN NEAR-RECTILINEAR HALO ORBITS

Abstract

The NRO-GNC project is an ESA funded TRP activity that aims to develop the guidance, navigation and control (GNC) system of the Lunar Ascent Element (LAE) of the HERACLES mission. The LAE needs to carry samples from the lunar surface to the Lunar Orbital Platform – Gateway (LOP-G), which is a space station located in a near-rectilinear halo orbit (NRHO). NRHO orbits are members of the halo family of orbits, a special class of orbits specific to the three-body problem. The LAE ascends from a location close to the lunar South Pole, performs a transfer manoeuvre to the NRHO and finally conducts rendezvous operations to approach the LOP-G station where capture and berthing is performed by means of a robotic arm attached to the station. The GNC is developed for the ascent from the lunar surface, the transfer to the NRHO and for the rendezvous with LOP-G. The GNC software is validated through model-in-the-loop (MIL) simulations. The simulated real-world includes a detailed lunar gravity model, Earth and Sun third-body perturbations, SRP, propellant sloshing and detailed sensor and actuator models. The GNC design approach followed strives to maximize on-board autonomy. The ascent profile, the transfer manoeuvres and the rendezvous approach are computed on-board. Vision-based sensors (a narrow-angle camera and a wide angle camera) are used to perform the rendezvous. In addition to the main simulator mission analysis tools are developed that allow studying the ascent phase and the transfer to the NRHO. The transfer analysis tool generates NRHO orbits using high-fidelity ephemeris models of the Earth-Moon system, and solutions obtained from a circular restricted three-body model are used as an initial guess. This tool is used to investigate transfer orbits from low lunar orbit to the NRHO, supporting the design of the guidance function, and to initialize the main GNC simulator. The paper presents results from the mission analysis tool, the design of the GNC subsystem and results obtained from the simulation test campaign.