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DEVELOPMENT AND TESTING OF THE GNC SOLUTION FOR THE PARAFOIL-BASED RECOVERY OF THE EARS REUSABLE SATELLITE

Abstract

The European Advanced Reusable Satellite (EARS) project, funded under the Horizon Europe programme, aims to design a low-cost reusable satellite and develop the relevant key technologies. The satellite operates in Low-Earth Orbit (LEO) to support a variety of scientific investigations and commercial activities such as microgravity experiments and in-space manufacturing; it is then designed to return to Earth autonomously, and be reusable with minimal refurbishment. The spacecraft is based on a current small-satellite platform with the addition of an innovative inflatable/deployable heat shield, a green propulsion system and a recover system based on a parafoil.

EARS focuses on the re-entry of the system, which can be broken down into several conceptual phases. At the end of the satellite's operational life, a controlled maneuver is performed that exploits the propulsion system to initiate the re-entry. Prior to reaching the Entry Interface Point (EIP), the heat shield is deployed and ballistic leg of the trajectory initiates. Finally, the decelerator sequence is triggered, leading to the descent phase under a controlled parafoil, to autonomously steer the vehicle to the capture point, where a mid-air retrieval is performed using a helicopter.

This paper focuses on the design and development of the Guidance, Navigation and Control (GNC) technologies to ensure the safe recovery and reusability of the satellite, with the final goal of reaching Technology Readiness Level (TRL) 4/5. The GNC solution for the flight of the satellite under the parafoil is presented here. The emphasis is placed on the guidance algorithm, which is used to generate an optimal trajectory on-board by relying on convex optimization, since it is considered to be one of the most critical algorithms. GNC solutions were assessed by using a tailored Functional Engineering Simulation (FES), which models the relevant environment and dynamics, in a Model-In-the-Loop (MIL) test environment. For this purpose, a 9 Degrees-of-Freedom (DoF) model was developed to physically represent the parafoil-satellite system and to correctly capture the relative rotation between the two subsystems. The algorithms

were translated in C code to perform a Software-in-the-Loop assessment of the GNC solution, in view of the future hardware implementation for Processor-In-the-Loop (PIL) testing that will pave the way to reaching TRL 4/5.