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AUTONOMOUS CLOSE-PROXIMITY OPERATIONS IN SPACE: THE PROBA-3 RENDEZVOUS EXPERIMENT (P3RVX)

Abstract

Proba-3 is a Formation Flying (FF) technology demonstration mission from ESA. The main mission, covers the design, development, and in-flight operation of two small satellites, for the full-scale test and validation of FF mission architectures and techniques. Proba-3 has successfully passed ESA Preliminary Design Review in 2012 and is currently in phase CDE, with launch planned at end of the decade. The Proba-3 mission also offers a unique opportunity to test other technologies, including to perform Relative Dynamics Experiments (RDE). The Proba-3 RendezVous eXperiment (P3RVX) takes advantage of this opportunity to exploit the suitability of Proba-3 for the maturation of RV technology, in particular with non-cooperative targets, with two satellites, in a highly elliptical orbit (perigee and apogee height of 600 and 60,530 km, respectively), using optical Navigation. The P3RVX consortium is led by DEIMOS and includes the Technical University of Denmark (DTU) and University Politehnica of Bucharest/Institute of Space Sciences (UPB/ISS). This paper provides an overview of the P3RVX, which aims to perform in-orbit demonstrations of the Guidance, Navigation, and Control (GNC) subsystem (including the Fault Detection, Isolation, and Recovery (FDIR) functions), the operations, the autonomy approach, and the Verification and Validation (VV), for missions in highly elliptical orbits with fast and time-varying dynamics. This includes, in addition, the in-flight testing of DTU's Vision Based System (VBS) for non-cooperative scenarios. Typical close-proximity operations are considered, including non-cooperative rendezvous and forced-motion (inspection, approach/retreat, and station-keeping) maneuvers during perigee, with the latter being performed both in eclipse and in Sun-illuminated conditions. These high-level mission requirements are translated into the design of trajectories satisfying a number of constraints. In-house-developed tools are adopted to solve this problem, ensuring that the trajectories are passively safe – whenever possible – in case of a failure. Moreover, trajectory design is required to take into account the limitations of actuators, as well as sensors. The outcomes of P3RVX are aligned with ESA technology lines and, as such, are expected to have a significant impact on the community. In particular, in-orbit demonstration of autonomous GNC for elliptical orbits (in both fast and slow dynamic regions) and autonomous non-cooperative close-proximity GNC using a camera; provide technology developments generally applicable to future programs; and a significant maturation of these technologies, needed to support short and medium term Clean Space and ADR lines, as well as the development of Space Service Vehicles (SSVs).