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LINEAR COVARIANCE ANALYSIS FOR THE FINAL RENDEZVOUS PHASE OF THE MARS SAMPLE RETURN – EARTH RETURN ORBITER MISSION

Abstract

The European contribution to the NASA-led Mars Sample Return mission includes the design, development and operation of the Earth Return Orbiter (ERO) vehicle. The mission of the ERO is to autonomously detect and rendezvous with the Orbiting Sample (OS) container in low Mars orbit, capture it, seal it, and safely bring it back to Earth. Airbus Defence and Space is currently leading the Phase A/B1 study of the ERO under ESA contract, and, in particular, is investigating the vision-based GNC system design for rendezvous, leveraging on the Automated Transfer Vehicle heritage and decades of experience in vision-based navigation. This paper describes the analyses that were carried out during the Phase A of the study to identify the preliminary GNC architecture in terms of actuators, sensors, and guidance and navigation strategies. The analysis is focused on one of the most critical phases of the rendezvous, which is the terminal phase, starting with the close approach (at a distance of 3 km from the container) and terminating with the final capture of the container. Linear Covariance Analysis techniques were used to assess the preliminary closed-loop performance and to perform the required sensitivity analyses, using the dedicated in-house LINCE tool. The major advantage of using linear covariance analysis resides in its ability to characterize statistically the performance of a complete GNC system, without the need of running long Monte-Carlo campaigns. This was proven to be a very valuable asset during MSR-ERO Phase A study, where an important number of trade-offs had to be made to quickly converge toward the optimal design solution. This work presents the main outcomes of the covariance analysis for terminal rendezvous, and compares the results obtained with LINCE to the ones obtained through Monte-Carlo simulations on a phase B1 simulator that includes a detailed implementation of the vision-based GNC system for rendezvous. The comparison demonstrates once again the usefulness of linear covariance analysis in predicting GNC performance in early study phases.