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ON THE ISSUES AND REQUIREMENTS OF BEARINGS-ONLY GUIDANCE AND NAVIGATION FOR IN-ORBIT RENDEZVOUS

Abstract

In-orbit rendezvous is a key enabling technology for many space missions including in-orbit assembly, servicing, refuelling, inspection, active de-orbiting as well as planetary exploration and return. Even though there exists significant heritage on this topic, complex hardware is generally required on both the chaser and the target spacecraft in order to measure the relative range and direction, required for rendezvous operations. The size and power consumption of the required sensors become excessive at long ranges if the target spacecraft is non-cooperative, without dedicated interfaces. In contrast, bearing (angle) measurements to a target are easier to obtain and do not require dedicated hardware on the target. For these reasons, there is a strong motivation to develop algorithms to perform in-orbit rendezvous without requiring a direct measurement of the range.

The bearings-only navigation problem has been extensively studied by the Naval and Military communities, where it was identified that dedicated maneuvers are required to render the problem observable. This creates an intrinsic coupling of the Guidance and the Navigation, as the guidance inputs determine the navigation performance. However, the complexity of the problem increases dramatically when the relative motion dynamics of the space environment are considered, making the assumptions used in the Naval and Military no longer applicable. The specifics of the In-Orbit Bearings-Only rendezvous problem have only been studied by a few of authors. Nevertheless, a complete treatment of the rendezvous-guidance coupled with a bearings-only navigation is still pending.

In the frame of developing new bearings-only rendezvous algorithms, the European Space Agency has partnered with Thales Alenia Space and the University of Stuttgart in order to develop new algorithms for bearings-only rendezvous trajectory analysis and optimization. This paper presents the results of the initial phase of this project: an extensive analysis of the Guidance Navigation and Control (GNC) requirements and system-level considerations that must be addressed in order to establish the feasibility of a bearings-only rendezvous mission.