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# TRACKING CONTROLLERS FOR POSITION AND ATTITUDE ON THE CHASER SPACECRAFT TO RENDEZVOUS AND DOCK/BERTH WITH A NON-COOPERATIVE SPACECRAFT.

**Abstract**

Non-cooperative target spacecrafts are those current or future assets in orbit that cannot convey any information about their states i.e., position, attitude or velocities and facilitate in Rendezvous and Docking/Berthing (RVD/B) process. The problem of designing a guidance, navigation and control (GNC) module for the chaser in a RVD/B mission with non-cooperative target should be inevitably solved if the technology for on-orbit servicing has to become a reality. By focusing on the proximity operations in a RVD/B mission and choosing appropriate guidance for achieving rendezvous, the problem associated with tracking controllers is addressed in this paper. By highlighting the necessity of out-of-plane maneuvers in a scenario encompassing a non-cooperative target, proximity operations in this work are explored with three different sub-phases which are suitably separated by hold points. They include far approach of the chaser from the entry gate in the target's orbit to the first hold point, inspection both in-plane and out-of-plane, and a closer approach to the final berthing location (to initiate docking or capture) defined by a second hold point. Accordingly, by representing the scenario with an appropriately defined non-cooperative target in a low earth orbit, guidance solutions are chosen for each sub-phase from the standard Hill based Closhessy-Willtshire (CW) solution, elliptical fly around and Glideslope algorithms. All of these solutions can be executed in pulses of constant magnitude. To realize the proposed guidance, tracking controller for position is based on a Linear Quadratic (LQ) approach and this is tested in its ability both for set point as well as trajectory tracking. At the final berthing location and prior to initiating a docking or capture, attitude tracker based on a proportional derivative (PD) form is also tested to synchronize the chaser's attitude with the target. The LQ controller is tested during all the phases of proximity operations for the proposed in-plane or out-of-plane guidance. By presenting an error analysis, the paper analyzes the performance of both the controllers in bringing the chaser from its entry gate to the berthing location. It identifies the factors influencing the tracking ability and the robustness of the LQ controller, such as chaser's mass, maneuver execution time or the pulse number. Finally, it prescribes any restrictions that may be imposed on the guidance during any sub-phase which can help to improve the tracking ability of the chosen controllers.