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INSPECTION OF SPACE RIDER WITH A 12U CUBESAT: ENSURING SAFETY AND EFFICIENCY

Abstract

Observing orbiting objects with CubeSats can effectively support various applications, including inspection of operational spacecrafts like the International Space Station or other satellites. The SROC (Space Rider Observer Cube) 12U CubeSat is being developed to carry out several in-orbit proximity operations, including rendezvous and close inspection of Space Rider, the new European reusable spacecraft. The trajectory defined for the observation of the vehicle from its vicinity is the subject of this paper.
Space Rider inspection is based on realizing a Walking Safety Ellipse: an out-of-plane elliptical periodic relative trajectory around the target spacecraft such that the chaser never crosses the primary spacecraft velocity vector, thus not compromising its safety. The inspection phase starts from a hold point with a range between 500 and 700 meters from Space Rider, allowing the chaser to stand next to the inspected target as long as necessary before starting the inspection. The desired trajectory is achieved with two impulses: the first one, through an out-of-plane approach, takes the observer from the positive in-track hold point to another point next to the spacecraft, then the second impulse inserts the chaser into the Safety Ellipse. The inspection trajectory strongly relies on the difference between the ballistic coefficient of the two bodies which causes them to decay at different rates. This discrepancy leads to an unequal velocity which causes one body to surpass the other.
Given the number and variability of parameters in the Walking Safety Ellipses design, an iterative methodology emerges as the optimal approach. The iterations are based on several nested cycles, simulating the manoeuvre with different in-track coordinates for the ellipse centre, out-of-plane approach durations and mean true anomaly for the injection point. The first two variables characterize the Safety Ellipse, while the latter places the starting point on the defined ellipse. The resulting potential inspections are then analyzed based on several constraints such as the maximum camera range and the adequate illumination conditions, allowing the determination of the best manoeuvre through a comprehensive trade-off based on the constraints satisfaction rate and the required Delta-V, resulting approximately in 0.6 m/s.
This paper highlights the main challenges faced during the design of this trajectory and the solutions implemented to design the optimal Walking Safety Ellipse able to meet the inspection requirements. Moreover, the strategy adopted to effectively iterate the inspection parameters is illustrated. Finally, preliminary results from the optimization are provided and discussed.