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SAFE APPROACH OF A SMALL SATELLITE WITH A LARGE SPACECRAFT. ANALYSIS OF NOMINAL AND OFF-NOMINAL SOLUTIONS.

Abstract

Safety is crucial in the contest of docking, where wrong or unsafe manoeuvres due to external causes or onboard failures can lead to collisions that must be avoided. Safety requirements deeply impact the chaser spacecraft, and this is especially true for Cubesats, as their miniaturized technologies have little in-orbit heritage and docking manoeuvres are rare.

One of these missions is the Space Rider Observer Cube (SROC), where a 12U CubeSat will be released and retrieved by Space Rider for observation purposes. The SROC mission, currently in Phase B2, is supported by ESA and the Italian Space Agency, involving Politecnico di Torino, Università di Padova, and Tyvak International SRL.

The present paper deals with an important analysis conducted by Politecnico di Torino on the definition and verification of GNC requirements and constraints, in the case of approach to Space Rider in nominal and off-nominal conditions. Since literature shows a lack of a systematic method to perform a detailed analysis of the approach phases in different scenarios, the paper proposes a step-by-step method, including 1) a qualitative root cause analysis based on ECSS rules and advice; 2) simulation sessions to investigate if corrective actions are effective; 3) refinement or change of these actions up to the definition of a complete list highlighting case-by-case the proper solution. Root-cause analysis aims at identifying possible faults and what are their causes and effects, in order to take corrective actions. A detailed Matlab/Simulink model enables the Model and Simulation approach, allowing testing of solutions against requirements and safety constraints.

The paper describes the most relevant results of the analysis applied to the SROC mission, identifying, for any possible off-nominal scenario, when the docking is still possible and when a Collision Avoidance Manoeuver (CAM) represents the unique possible solution.