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Space Structures 2 - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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DESIGN OF DEBRIS REMOVAL MISSIONS PERFORMED BY ROBOTIC GRASPERS

Abstract

The well known increase of the orbiting debris, leading to a critical condition in which additional launches could be precluded, calls for mitigation and removal practices. First, and maybe easier to accomplish with respect to other concepts under study, some missions should be probably carried out in a close future to grasp large unused orbiting objects, like upper stages or idle spacecraft that already ended their operational lifetime. The focus on large objects, even if they are a limited subset of orbiting spent bodies, helps in two ways: the reduction of the cross section for possible impacts, and, more remarkably, the reduction of the number and size of additional debris to be generated in a possible collision. As a result, these targets can justify the cost and the complexity of removal missions which, even if almost traditional in the approach and not-too-far from current operational capabilities, still pose significant technical problems. The paper aims to present the complete operational sequence of a removal mission to be performed by a robotic spacecraft. The analysis begins from the parking orbit where the spacecraft waits for the call-on-duty, encompasses the critical target approaching, recognition and chasing phases, details the grasping and finally ends with the analysis of possible options for the dismissal of the captured debris. The issues relevant for the different phases are discussed, with a special focus to the grasping operations, when the robotic arms of the servicing spacecraft, after the determination of the relative kinematic state of the target, should carefully embraces and precisely catch, in a safe area, the orbiting body. Such an approach should bypass obstacles like solar panels and avoid the break-up of the target, possibly degraded due to its long exposure to space environment. The results of extensive simulations under reasonable, engineering hypothesis for the mission's scenario are presented, with the estimate of torques and forces to be exerted by the robotic arms. The attitude issues for the servicing spacecraft, as well as the vibration behavior for an accurate end-effector positioning during robotic arms maneuvers are considered. The confidence in the findings of these numerical studies is strengthened by the know-how gained with the related experimental activities performed during recent years in the labs at Sapienza – Universita' di Roma by means of dedicated, small test-beds.