Paper ID: 32420
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14TH IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Space Debris Removal Issues (5)

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ION BEAM SHEPHERD RELATIVE DYNAMICS AND PROXIMITY FORMATION FLYING CONTROL

Abstract

Recent space debris studies show that the mitigation measures currently adopted by space community are not sufficient and additional remediation actions are needed to limit the debris growth in the long term. Remediation of the near-Earth space environment may involve the direct removal of space debris, also known as active debris removal. Space agencies, as well as other organizations, are investigating techniques and technologies that have the potential to support debris removal. LEOSWEEP is a EU funded FP7 project devoted to the development of the ion beam shepherd concept. This concept uses ionic beams to provide an efficient and low-risk contactless space debris de-orbiting. To provide acceptable de-orbiting performance it is necessary to maintain the distance between the shepherd and a target not more than a few target diameters. The issue of proximity formation flying control for such mission is addressed in this paper taking into account large time spans, the attitude dynamics of a debris and its uncooperativeness. Different strategies for the proximity formation flying control have been considered to minimize the propellant consumption. The robust controller to control the relative position between the shepherd and the debris has been designed taking into account the impact from the ion beam, exogenous disturbances, the errors of the relative position determination, the actuator imperfections. Robust stability of the system has been analyzed considering variations of the shepherd, target and orbital parameters. The stability and performance of proximity formation flying control have been validated by computer simulations using a nonlinear mathematical model with taking into account a wide range of orbital perturbations. Various strategies for relative motion control have been analyzed to bound the angular rate of the debris.