SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Concepts (6)

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MISSION DESIGN AND GNC FOR IN-ORBIT DEMONSTRATION OF ACTIVE DEBRIS REMOVAL TECHNOLOGIES WITH CUBESATS

Abstract

Within the frame of the ESA's General Support Technology Programme, EPFL studied two In-Orbit-Demonstration (IOD) missions using CubeSat technologies. These IODs aim at alleviating the technical risk inherent to new technologies required for active debris removal (ADR) of large space objects, by using small and low-cost CubeSat systems. Rendezvous and docking with uncooperative debris was only partially demonstrated and still raises technological issues. To test technologies such as the navigation and rendezvous (RV) sensors or capture systems, our studies show that CubeSat missions are appropriate. Already, guidance navigation and control (GNC), communications and power technologies have successfully been miniaturized and the corresponding equipments are now available to the CubeSat community. This fact extends the range of feasible CubeSat missions from the initial flight of simple sensors to more complex systems. This paper presents two CubeSat ADR experiments and demonstrates how mission design and GNC can serve the verification of navigation sensors performances as well as the validation of uncooperative debris capture using a net. Each mission is composed of a chaser and a target. The former being an 8 Units (8U) CubeSat and the latter a 4U, launched together in a 12U deployer. Both satellites are 3-axis attitude controlled. The chaser has in addition 3 degrees of freedom (DoF) translation capability using 1mN cold gas thrusters. Both CubeSats will carry GNSS receivers to assist in the determination of range and relative velocity. The global positioning and attitude data of the target will be transmitted to the chaser using an inter-satellite link having the additional capacity to measure the corresponding range. This system provides a reference validation for the RV sensors. The relative position and velocity to be controlled are fully observable. Thus a linear quadratic regulator is appropriate to ensure robust and optimal control. Based on the mission design, various close inspection configurations are demonstrated. To emphasize the feasibility of such missions, a system approach will be briefly addressed leading to a complete description of both CubeSats including mass, power, volume and data budgets. Both missions are analyzed using a 6 DoF simulator. The performances and absolute errors of the GNC as well as fuel consumption are provided. Power consumption, telecom capability and thermal aspects will be shown for sake of completeness. Current issues and limitations of the current GNC will be discussed, as well as conclusions regarding the feasibility of such missions.