SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Issues (5)

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GROUND VALIDATION OF ACTIVE DEBRIS REMOVAL TECHNOLOGIES AND GNC SYSTEMS

Abstract

The access to space in the medium term future is seriously compromised by the exponentially growth of space debris. LEO polar Sun-synchronous and GEO orbits are specially populated and contested. Technologies for debris removal using active means are nowadays being seriously studied. The different ADR (Active Debris Removal) techniques can be catalogued in three main groups (rigid capture, non-rigid capture and contactless). All of them have a strong impact on the GNC system of the active vehicle during the capture/proximity phase and, particularly, during the active vehicle/debris combo control phase after capture and during the de-orbiting phase. The big challenge of ADR-related (including GNC systems) technologies is to achieve a maturity level high enough before flying in order to minimize the failure risks. Realistic and extensive ground validation is, today more than ever, mandatory in order to avoid the costly in-flight validation and to reduce the gap between ground and flight testing and validation. HW-in-The-Loop (HIL) test facilities, including realistic space-representative avionics (at processor, interfaces and real-time operating system), realistic and air-to-air stimulated breadboard perception sensors (IMU, optical cameras, laser 3D sensors) through the use of dynamic robotic devices hosting the active vehicle and debris mock-ups and reproducing accurately the spatial relative dynamic corresponding to an ADR scenario, and full GNC system prototypes, can effectively provide validation in relevant environment, effectively achieving TRL (Technology Readiness Level) 5/6 on ground and minimizing the uncertainty/risk of such technologies/systems with respect to its operational use. This paper describes the set-up of GMV's platform® dynamic test facility, successfully used for validation purposes of GNC systems for Rendezvous/capture applications in the frame of several ESA activities, and the evolution of such facility to provide effective support for ground validation of ADR technologies and systems (including GNC). Particularly, the following aspects will be presented and discussed: needed type of structural/functional active ADR vehicle and debris mock-ups, force/torque measurement and feedback capability over debris contact or momentum exchange actions, ground gravity compensation. Two specific ADR capture techniques will be analysed: debris capture through grappling robotic arm and through flexible nets. Two specific GNC related problems will be analysed: environment perception (navigation function) and control during and after the capture of the debris and the resulting combo (with the dynamic change of mass and inertia properties of the combo).