15th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Space Debris Removal Issues (5)

Author: Mr. Pablo Colmenarejo
GMV Aerospace & Defence SAU, Spain

Mr. Gabriele Novelli
GMV Aerospace & Defence SAU, Spain
Mr. Darío Mora Portela
GMV Aerospace & Defence SAU, Spain
Dr. Pedro Serra
GMV Aerospace & Defence SAU, Portugal
Dr. Karol Seweryn
Space Research Center PAS, Poland
Mr. Gaetano Prisco
TSD, Italy
Dr. Jesus Gil-Fernandez
ESA, Spain

END-TO-END ON GROUND SYSTEM DEMONSTRATION OF COMBINED TECHNOLOGIES FOR DEBRIS REMOVAL APPLICATIONS

Abstract

The situation of orbital debris is becoming a worldwide concern for the safe operations of space assets. Retiring orbital debris (and extending life or repairing damaged satellites) is very attractive to satellite operators as it could decrease mission risks, increase commercial margins or missions scientific return). Debris removal services (also in-orbit servicing/assembly) require combined operation of different critical technologies, mainly autonomy, manipulation robotics, spacecraft GNC and vision-based navigation/image processing. A full combined/coupled sequence involving those critical technologies has never been performed in–orbit and has also never been tested comprehensively on ground. GMV has led a consortium (completed with Polish CBK institute and Italian TSD company) that has performed an ESA (European Space Agency) funded activity with the objective of advancing/exercising with real HW in the loop (HIL) and using a space-representative dynamic laboratory the referred key technologies required to perform complex robotic scenarios needing a rigid capture mechanism such as a robotic arm. The final goal of this activity has been to investigate/mature the complex couplings between the different control systems (GNC including image processing and robotics) for autonomous rigid capture between an active chaser vehicle and a cooperative/non-cooperative target, derive the required algorithms and perform a HW-in-the-loop end-to-end demonstration. The prototyped solution has been tested in the most realistic conditions obtainable on ground, including also the dynamics of the system as well as the relative visual based navigation system. The existing GMV *platform-art*© dynamic test facility has been used, with the addition of the hardware provided by the partners: robotic system from CBK and visual system from TSD. Ultimately, the consortium has achieved performing a comprehensive ground testing of all above-mentioned critical technologies for debris removal missions, contributing to the technologies maturation and de-risking future implementations and testing. Particularly relevant is the demonstrated availability of a HIL dynamic-based laboratory ready to host and test evolved or new debris removal solutions quickly and with a high degree of space representativeness. The paper will show the obtained results, firstly

based on pure SW-based simulations and ultimately verified/validated based on HIL dynamic laboratory tests, including system level considerations/recommendations, subsystem results/recommendations (e.g. best image processing/visual-based system set-up/combination depending on the debris removal scenario phase, target size/characteristics, etc; best/safe guidance trajectories to approach a non-cooperative target; combined operations of chaser spacecraft GNC and robotic manipulator control system; autonomy issues such as GNC modes transitions and autonomous navigation; etc).