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Hosted Payloads - Concepts, Techniques and Challenges, Missions and Applications (7)

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ON ORBIT SERVICING MISSION: GNC ARCHITECTURES DRIVEN BY CLIENT REQUIREMENTS

Abstract

On Orbit Servicing (OOS) is a large and ever-growing topic in the space sector. OOS mission concepts vary from refueling, orbit insertion, orbit inspection, system repair/substitution/augmenting or even planned decommissioning. All these scenarios require relative navigation, position and attitude control, as well as a dedicated robotic subsystem. A direct connection between the servicer satellite and the customer satellite is often involved, therefore docking, berthing and manipulations of some components of the customer satellite are very important elements and require an ad-hoc sensor suite as well as a tailored robotic manipulator subsystem.

For each of the considered scenarios a list of requirements on the relative navigation sensing is presented, focusing on the possible customer requests. Unlike pre-agreed mission profiles, OOS providers must take into account the customer needs when designing the operations and the interaction with the target satellite. This translates into particular design choices for subsystems and stricter requirements for the equipment. The focus is towards customer satisfaction: reliability and robustness shall be put first. In every condition, the servicing operations as well as the safety of the serviced satellite are parameters that determine the success of a servicing provider. In this framework the design of the dedicated subsystem shall take into account both safety and the requests on the customer side.

The focus of this work is the guidance, navigation and control (GNC) of OOS operations in several scenarios through the use of a single sensor suite and robotic subsystem. As a matter of fact, a robotic arm is capable of performing berthing, reaching a valve for refueling, exploiting close range inspection without a rigid link, and extracting or replacing equipment. In some cases, the servicing and the serviced satellites are already linked while in others they may be not connected with their main bodies. The GNC system of main body and robotic arm shall be able to deal with both cases, requiring a redundant sensor suite.

The use of vision systems, ranging measurements, inertial measurement units and other sensors are investigated and a proper sensor suite is designed. Moreover, the measurements logic has been derived to maximize robustness and safety of the OOS operations.

A simulation campaign is performed to verify requirements satisfaction, evaluate the nominal performances of the GNC system, and to derive important insights on the OOS GNC problem and technical guidelines for future OOS missions.