SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

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ROBOTIC REFUELING SYSTEM FOR SPACE PLATFORM SERVICING

Abstract

Robotic On-Orbiting Servicing (OOS) is a relevant technology development and research topic within the space community being the solution to increase the already in orbit active platforms flexibility and exploitability during and over their nominal lifetime. Within the broad OOS domain, the robotic refueling capability is definitely attractive as it would allow keeping active in orbit platforms which could still keep working fruitfully but actually switched off because of fuel depletion; refueling capabilities are also envisaged to enhance usability of small LEO launchers: tugs dedicated to LEO-GEO payload transfer, permanently located in LEO and regularly refueled to accomplish the orbit transfers, would be available, relaxing the in orbit transportation current bottleneck. The design of On-Orbit Refueling (OOF) systems is intrinsically multi-disciplinary as structuralinterfaces, fluidic, thermo-dynamics control, material selection, relative dynamics and procedural aspects must be simoultaneously taken into account and harmonized. As far as the mechanical interfaces are dealt with, two strategies can be traded-off: the docking and the berthing philosophies, the former of which has a strong heritage from the already flying solutions on ISS, the latter having the strongest reference on the ISS robotic arms. Moreover, while the former heavily affect the design of the two space vehicle to be connected, the latter, at least on the target satellite, imposes lighter configuration requirements, opening the door to a larger set of applicability and reusability. The paper critically discusses the mechanical interface strategies, highlighting the re-usability of existing technologies for OOF design and implementation and their area of applicability and presents the rationale behind the technical requirements for the berthing strategy, more flexible and exploitable in OOS than the docking strategy. The berthing functionality is accomplished by a robotic arm which supports the fluidic line too, the end effector of which ensure the fuel line connection between the chaser and the target. A feasibility study run to assess the drivers and the sensible parameters to design a service module (chaser) to accomplish OOF. The fuel typeto be transferred, the recipient inertial properties and attitude control authority, the operational orbits are assumed as parameters. In particular, the thermodynamic analyses drove the thermal control, as well as the fuel transfer actuation strategy, and feeding lines, valves and tanks design; furthermore, by coupling the fuel transfer analysis together with the stuck (target) dynamics, drivers on the flexible robotic connection and operational constraints were obtained and will be presented.