Title:

Advancing Small Satellite Docking Systems using Active Lighting and Cues

Abstract:

The rapid advancement of technology and improvements in miniaturizing and modularity of spacecraft systems has led to emerging small spacecraft that are able to achieve scientific capabilities comparable to large spacecraft at a fraction of the cost. Small satellite technology is growing at an exponential rate in various avenues, but their full capabilities are yet to be realized, especially in the field of distributed systems for on-orbit servicing as well as in-space assembly, so that they can be assembled on-orbit into a larger fractionated satellite or rearranged into specialized modules. These limitations can be traced down to limited advancement of rendezvous, docking and assembly of small satellites in space.

The existing on-orbit docking mechanisms have a large heritage over a few decades and have a high TRL for larger satellites, but on-orbit docking mechanisms for small satellites are yet to be tested in a space environment. The mechanisms developed so far for docking of small satellites are primarily single phase involving magnetic force (soft capture), which does not provide a seal for transfer of material from one spacecraft to another to enable on-orbit servicing.

In this presentation, we explore various methods for two stage docking of small satellites, the first phase being an initial soft capture during which the alignment maneuvers of the two docking spacecraft are performed and a second phase being hard capture, involves the structural latching and sealing at the interface to create a tunnel, after which umbilicals can be engaged to transfer material, such as fuel, from one spacecraft to the other. To further simplify the docking process we will be experimenting with and optimizing active lighting technologies that will provide alignment cues, braking and direction maneuvering for the small satellites to dock, starting from significant misalignment and differences in velocity between a pair of satellites.

We aim to perform 3D Physics simulations and analytical calculations such feasibility calculations and detailed trade studies between different methods of two stage docking. Based on the 3D simulation results and the analytical calculations prototypes shall be developed for testing in simulated conditions in the laboratory. Ground based systems such as 6-DOF robotic arms mimicking the ADC systems of the spacecraft and air tables to simulate the frictionless environment of space will be used to validate the designs. Based on the results of the trade study, we aim to propose a CubeSat mission concept that will deploy and demonstrate the technology on-orbit.

Keywords:

Two-Stage Docking, On-Orbit Servicing, In-Space Assembly