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# ACTIVE LIGHTING AND CUES TO FACILITATE COOPERATIVE ON-ORBIT TWO-STAGE DOCKING BY SMALL SATELLITES

**Abstract**

Kickstarting a space economy will require technologies to facilitate trade of goods and services in space much like how the shipping container has standardized global trade via the oceans. Small satellites are undergoing exponential growth, yet their full capabilities are not realized, nor are they in a position to facilitate trading of goods and services in space as they are still not in a position to be assembled on-orbit into larger satellite, enable transfer of goods or rearranged into specialized modules meeting customer needs. These limitations can be traced down to the 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 paper, 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 novel active lighting technologies that will provide alignment cues, guidance on 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 feasibility analysis using analytical calculations and 3D physics simulations to compare conventional approaches to the new proposed approach against time and energy costs. 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 ADCS systems of the spacecraft and air tables to simulate the frictionless environment of space. Based on these results of the trade study, we aim to propose a CubeSat mission concept that will deploy and demonstrate the technology on-orbit