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DESIGN AND ANALYSIS OF NOVEL MECHANICAL DOCKING PORT FOR NON-COOPERATIVE DOCKING AND LIFE EXTENSION OF SMALL SATELLITES.

Abstract

The small satellite industry is prompting the growth of a new era with possibilities of infinite opportunities of the economic usage of space by providing efficient services with minimal resources and costs, thus making space more affordable for small companies. Although, small satellite missions - facing difficulties like low mission lifetime, inability to deorbit causing an increase of space junk, etc. - are not sustainable in the long run, especially for large constellations. SpaceX with Star-link and future missions from amazon can make this situation even worse. The next decade will see the biggest boom in the small satellite industry, but there will arise concern about creating more debris with much more potential to create accidents and dead satellites.

A higher range of applications can be targeted by admitting miniaturized docking mechanism and navigation strategies for small satellite docking. Complex problem statements with respect to the assembly of large structures like those of telescopes and space stations can be solved by appropriate application of the technology. It also can act as an integral part of orbital servicing platforms for small satellites that can extend mission life along with several other applications like space debris mitigation, performance of orbit correctional maneuvers, resourcing of supply for probes and orbiters, etc.

Although, small satellite docking comes with its challenges due to the mass and volume constraints, uncertainty in relative range and range-rate, lesser available margin of error, unavailability for proper actuators, etc. Current docking mechanisms have problems like low margin of error for direct hard-docking systems as MIT's universal docking port, or increased complexity in Boeing's NDS mechanism for International Space Station, or the need for an active female port in target spacecraft for electromagnetic capture; these mechanisms and the associated problems are further explained in the literature survey.

The proposed paper presents a novel docking mechanism for CubeSats, which gives way for electromagnetic docking without an active target spacecraft; it uses an eddy current braking mechanism for relative momentum dumping, which requires only an active chaser spacecraft; whereas a single servo actuated locking mechanism ensures reduced complexity and provide 6DOF docking till relative angular velocity 30 deg/sec. The Simscape model of the docking port assembly is created to analyze the working of the locking mechanism and to find a suitable actuator size for the desired performance.