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FEASIBILITY OF AN IN-ORBIT MULTIPURPOSE SERVICER FOR SATELLITE LIFE EXTENSION: SYSTEMS, MISSIONS AND ECONOMIC CONSIDERATIONS

Abstract

With the recent advancements driven by Moore's Law in launch and satellite technologies such as reusable launchers and nanosatellites, humanity has shifted to a new paradigm of space activities, truly harnessing the potential of the Low Earth econosphere, with its own risks and concerns. With 5200 active space objects and 2610 defunct satellites currently, with projections of 20,425 satellites by 2030, along with the long-debated trade-off considerations between short-life small satellite missions and long-life monolithic satellites and the development of affordable heavy-lift launchers, the need for an all-purpose In-Orbit Servicer is paramount now more than ever. Having a servicer will also unequivocally reduce probability distributions of collisions by Kessler Syndrome reverse-exponentially, accelerating the clean up of Earth orbits, as the source of defunct satellites is in itself eliminated. Combining the architectures of kick-stage and heavy-lift launchers, this work has developed a servicer, using proven technologies with heritage and techno-commercially validates it through systems design with simulation validations of low TRL subsystems, mission design and validations with budgeting, with Gantt chart, business and pricing model and financial projections highlighting moderate development capital and low operational expenses, leading to faster financial breakeven and commercial viability. Innovations include retrofitting with flexible solar panels under hinged nose cone flaps and upgraded avionics, reversible payload interface linkage and armatures utilizing different end-effectors for different requirements of the client satellite including refueling, orbit maintenance, component replacement, deorbiting and utilizing the existing reaction control system for propulsion of the servicer. The mission operations also address redundancy through flower constellations, with reusability and replenishment through relaunches, also utilizing port capabilities for resupply in International Space Station as another redundancy, addressed in the elliptical orbit design allowing contact opportunities due to superpositions with ISS orbit causing low maintenance expenses but high client frequency and low orbit expenses due to optimization to maximum satellite density regions in space, projecting very high returns on investment, having better long-term returns than short-life smallsats, as explored in use cases. These profitabilities have been estimated using pricing differentials in actuarials due to debris decrement through servicer functioning and increase in revenue of client satellites due to extended operations. Such a service will truly bridge the gaps addressed by neither Conventional nor New Space methodologies, thus catalyzing economic growth of the Earth orbit econosphere successively in a highly sustainable manner, further leading to downstream benefits to humanity worldwide.