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ADVANCING SPACE SYSTEM ARCHITECTURES WITH IN-ORBIT REFUELING TECHNOLOGIES ON GEOSTATIONARY SATELLITES

Abstract

In the evolving domain of In-Orbit Servicing (IOS) and space exploration, the paradigm of In-Orbit Refuelling (IOR) has emerged as an extremely pivotal domain. Currently, there are around 590 active geostationary orbit (GEO) satellites orbiting Earth and the prediction is that this number will increase even more within the next years. The easy accessibility of space, pushed by the advancements in reusable rocket technology, brings a new set of challenges including transportation, operations and space debris management and mitigation.

The following paper intends to delve into space sustainability and transportation and logistics with a focus on IOR as the pivotal solution to extend the operational lifespan of satellites, thus, reducing the need for decommissioning them. Through a comprehensive analysis on current satellites design and market trends, this study presents a novel design for a fluidic architecture refueling system tailored to GEO satellites, with the ability of supplying both chemical (Hydrazine) and electrical (Xenon) propellants to both unprepared satellites, i.e. past satellites that lack a standardized refueling interace) and prepared satellites (future satellites with a standardized refueling interface). Propellant transfer technologies, fluid dynamics in microgravity, functional analysis on operation for successful in-orbit refueling missions are explored to design the refueling architecture. The proposed system also intends to address the concerns of space debris and sustainability by offering a cost-effective and commercially viable service for space companies that require mission liefspan extensions. Besides, it enables a new set of opportunities as satellite providers would not be constrained by fuel requirements, leaving more margin for useful payload. Successfully addressing these challenges requires a multidisciplinary effort and innovative solutions to push the boundaries of space exploration, enabling more ambitious missions. A mission concept of operations is studied for optimally supplying the propellant for a set of satellites.

This research integrates the work of IOS and IOR and contributes to the development of in-space logictics by bridging the gap between current technological capabilities and future architectural visions and aims to set a baseline for efficient space operations for future missions.