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NUCLEAR-POWERED AUTONOMOUS CAPSULE WITH ROBOTIC ARMS FOR MULTI-SATELLITE DEBRIS RETRIEVAL AND SUSTAINABLE ORBITAL MANAGEMENT.

Abstract

Since the beginning of the space race, numerous satellites and space objects have been launched into Earth's orbit, with roughly 31,000 traceable objects now orbiting the planet. These objects include both active and defunct satellites, rocket stages, and fragments, contributing to an increasingly congested orbital environment. To address the issue of space debris, this mission concept focuses specifically on capturing and deorbiting defunct, traceable satellites. The proposed solution is a nuclear-powered capsule equipped with two robotic arms and vacuum lock chambers, designed for direct orbital insertion and autonomous debris retrieval. The capsule utilizes nuclear thermal propulsion (NTP) technology, where a compact nuclear reactor superheats a hydrogen propellant to generate high-efficiency thrust, optimizing the capsule for long-duration, high-altitude maneuvers. Upon reaching a graveyard orbit, the capsule's nosecone opens as it approaches each targeted satellite. The robotic arms, equipped with a vacuum lock mechanism, engage and secure the satellites sequentially, holding them in place for stable capture. This process is repeated to collect up to three defunct satellites in a single mission, enhancing mission efficiency and reducing the number of orbital insertion and retrieval cycles. Once the targeted satellites are secured, the capsule initiates its deorbit sequence. Employing controlled thrust and landing leg deployment, it returns safely to Earth, precisely landing on a designated pad for future reuse. This mission concept integrates NTP, robotics, and sophisticated orbital mechanics for a scalable and reusable solution to space debris mitigation, showcasing a sustainable pathway for orbital management and preservation of critical satellite assets. This approach advances responsible space exploration and orbital safety, highlighting the role of nuclear propulsion and robotics in sustainable debris management for the growing demands of global space activity.