ACTIVE REMOVAL OF LARGE MASSIVE OBJECTS BY HYBRID ENGINE MODULE

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During the last 40 years, the mass of orbiting artificial objects increased quite steadily at the rate of about 145 metric tons annually, leading to a total of approximately 7000 metric tons. Now, most of the cross-sectional area and mass (97% in low Earth orbit, LEO) is concentrated in about 4500 intact objects, i.e. abandoned spacecraft and rocket bodies, plus a further 1000 operational spacecraft [1]. Simulations and parametric analyses have shown that the most efficient and effective way to prevent the outbreak of a long-term exponential growth of the cataloged debris population would be to remove enough cross-sectional area and mass from densely populated orbits. According to the most recent NASA results, the active yearly removal of approximately 0.1% of the abandoned intact objects would be sufficient to stabilize the cataloged debris in LEO, together with the worldwide adoption of mitigation measures. The typical targets for removal would have typical masses between 500 and 1000 kg, in the case of spacecraft, and of more than 1000 kg, in the case of rocket upper stages [1]. Nevertheless, few abandoned objects have a mass over 4000 kg, representing a huge source of space debris in case of accidental collision. This paper specifically deals with the feasibility study of active removal of large massive objects, such as the second stages of the Zenit launcher (about 8300 kg), by using a hybrid engine module for propulsion needs. In detail, the engine is transferred from a servicing platform to the debris target by a robotic arm so to perform a controlled disposal. Typically, in hybrid rockets a gaseous or liquid oxidizer is injected into the combustion chamber along the axial direction to burn a solid fuel. Hybrid rocket technology for de-orbiting applications is considered a valuable option due to high specific impulse, intrinsic safety, thrust throttleability, low environmental impact and reduced operating costs [2]. In particular, throttleability results very important for maneuvers with big and fragile objects, such as Earth observation satellites. During the de-orbiting transfer, high impulses of thrust could destroy the thin structure or the solar panels of these kinds of spacecraft, thus giving birth to a new source of space debris. The possibility to regulate the engine thrust, in order not to stress the spacecraft with severe accelerations, represents a strong advantage in terms of mission safety. The paper describes some critical aspects of the mission with particular concern to the target selection, the hybrid engine implementation, the operational systems needed for rendezvous and docking with the target, and the disposal strategy.

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References

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