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A COMPARATIVE STUDY OF DRAG-WIRES AND DRAG-SAILS FOR DRAG ENHANCEMENT OF SPACECRAFT – STOWING, DEPLOYMENT, CHARGING AND OVERALL OPERATION

Abstract

This article compares the Ultra-thin Wire Drag Enhancement System (UWDES), a novel concept for de-orbiting using drag enhancement, with the relatively more common Drag Sail Drag Enhancement Systems (DSDESs). The UWDES is designed to use ultra-thin wires, stowed in a container before deployment, as drag enhancing structure upon deployment through electrostatic charging and a simple lid release mechanism. In comparison, a DSDES may need a complex system involving mechanisms and actuators for stowing and deployment. The article presents the various configurations and models of a UWDES and makes a case for further research. In comparison, the DSDES has a limited scope with regards to research and development. For the DSDES to be effective, the sail is required to have a certain orientation. In comparison, the UWDES is effective in practically every orientation of a host spacecraft. The DSDESs may have limited operational range in that they are functional in altitudes with adequate atmospheric density ($<$ 600 km altitude Earth orbits). Whereas, the UWDES when deployed in an "orb configuration" projects about 70-80 percent of its maximum EAED irrespective of the host spacecraft's orientation. Additionally, a UWDES may interact with space plasma to generate an added drag force (Plasma-braking due to Coulomb Drag). This feature of UWDES may make it suitable for application in upper low altitude Earth orbits. Last but not the least, the article makes a case for the robustness yet simplicity of the UWDES over DSDES. For a given mass of a material (e.g., aluminum block), the drag wires drawn out of it produce more effective area experiencing drag (EAED) than a fabricated drag sail of the same thickness. While a drag sail of $<$ 5-10 microns thick may not be a viable drag enhancing structure, drag-wires of the same thickness would present an effective solution. With advancements in

nanotechnology (nano-wires, nano-tubes, etc.) there is much scope for generating extremely high drag-experiencing area with a compact UWDES facilitating the de-orbiting of spacecraft in significantly smaller duration compared to drag-sails.