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DRAG ENHANCEMENT FOR SPACECRAFT USING NUMEROUS ULTRA-THIN WIRES
ARRANGED INTO DRAG-WIRE WEBS OF VARIOUS CONFIGURATIONS

Abstract

The concept and design of a novel drag enhancement system called the Ultra-thin Wires Drag Enhancement System (UWDES), is presented. The UWDES uses numerous ultra-thin wires to form a three dimensional (3D) web through electrostatic charging. The 3D web structure is designed with the objective mitigating space debris, particularly in low altitude Earth orbits for pico/nano/micro-satellites by causing their rapid orbit decay. The ultra-thin drag-wires are stowed inside the container module of the UWDES and at the end of a spacecraft's mission life, deployed by releasing the container lid, followed by electrostatic charging. In comparison to drag sails, the UWDES drag-wires provide more effective area experiencing drag (EAED) for a given mass and size of the material used to fabricate the drag enhancing structure. For a unit cube of side 1 cm, (i) beaten into a square sheet of 1 micron thickness and (ii) drawn into a wire of same thickness, the EAED for (i) is 1 square meter and (ii) is 1.2732 square meter. The

ultra-thin drag-wires of the UWDES are held straight in a tuft with all strands fused together at both ends. When they are electrostatically charged, due to mutual repulsion on acquiring like charges, they unwind from spool and deploy out of container module to gradually arrange into a 3D web structure. With this, all the individual ultra-thin drag-wire strands are exposed to incoming molecules and atoms of space atmosphere and thus augment the EAED of the host spacecraft. Based on the amount of charges supplied to the wires, they arrange into various configurations like boat-shape, spindle/pear, globe and flower. Taking into consideration the host spacecraft's attitude with respect to the velocity direction, each of these configurations results in varying EAED. It may be argued that the deployment mechanism of UWDES, which involves a lid release relay and then electrostatic charging, is simpler in operation and has a lesser chance of deployment failure compared to drag-sails that employ moving parts like motors. UWDES variants namely fixed-spool and deployable-spool variants are available for integration to spacecraft which vary in the way the ultra-thin wires are deployed from container. Also, based on charging, the UWDES modules are of both passive- and active-charging variants. UWDES modules can be of various form factor like 1U (according to CubeSat standards), 1.5U, flat rectangular box form, etc and can be integrated either externally or internally with the host spacecraft.