SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Concepts (7)

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NOMAD: A CONTACTLESS TECHNIQUE FOR ACTIVE LARGE DEBRIS REMOVAL

Abstract

As the collision between an old Russian Rocket's last-stage and an operational Iridium satellite demonstrated in 2009, the space debris are not becoming a threat: they already are. To mitigate risks, the biggest debris shall be removed from LEO. Although various solutions to remove such debris have been proposed, none has so far demonstrated its feasibility from a technical or cost standpoint. The envisioned techniques rely on the physical capture of debris with a dedicated mechanical system (robotic arm, tentacles, tether, throw-nets). However these methods lack versatility as they are mission-specific and limited in terms of angular momentum they can absorb. As a result they require the design of costly removal strategies. In this paper we propose an original Active Debris Removal (ADR) concept, known as NOMAD (Novel de-Orbitation method based on MAgnetic Drag), which is contact-less and offers the potential for sustainable debris removal thanks to its generic design. The NOMAD chaser vehicle is equipped with dedicated magnets and the generated field is first used to interact with the debris in torque for the initial de-tumbling phase (Lenz-Faraday's law). The magnetic field is then used in force interaction with the debris residual magnetic dipole to force its motion towards the chaser, the latter compensating continuously the induced drag by its low thrust electric propulsion system. A pseudo formation flying scheme, relying on 3D camera as relative navigation sensor and on a non-linear 6-dof controller, allows to maintain the spacecraft at a safe operating distance from the debris, to decrease progressively the orbit of the debris and to exit the strategic Sun Synchronous Orbit. The use of electric propulsion offers the possibility to perform several debris removals with a single spacecraft in a nominal mission lifetime. The angular rate of the debris prior to capture being seen as a major issue to be tackled whatever the envisaged ADR technique, an additional contactless solution for de-tumbling is also proposed, and relies on the plume impingement force of the chaser operated in force-free, to generate torques on the debris for de-tumbling purpose. We present the preliminary NOMAD system concept design, applied to the scenario of ESA's Envisat Removal from the SSO. Then, performances in the case of a de-orbitation towards IADC-compliant orbits are presented (graveyard orbit above 2000 km or orbit with less than 25 years decay time). Finally, problems areas and future work are identified.