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A ROBOTIC ARM-BASED DEORBITER CUBESAT FOR SPACE DEBRIS REMOVAL FROM LEO

Abstract

Orbital debris has been amassing since the launch of the first satellite into space. With hundreds of more satellites launched every year, in-orbit collisions and the generation of massive debris clouds are becoming increasingly likely, threatening future space missions. In addition to the government space organizations, several private space agencies are also investing heavily in space launches nowadays. Out of the three main regions of space around the Earth, LEO is the most densely populated area with space objects. With the advent of satellite mega-constellations in low Earth orbit (LEO), the LEO environment is becoming extremely crowded. As the objects in LEO orbit the Earth at high speeds (up to 8 km/s), a collision with even a small piece of orbital debris can cause serious damage to a functional satellite or a spacecraft. Therefore, it is very important to quell this growing space debris problem for the existence of future space operations. From a commercial deployment and economic point of view, it is viable to use small satellites, especially CubeSats to perform this task, when compared to the deployment of large satellites. So, in this paper, we present the mission design for a debris deorbiter CubeSat to deorbit the XSat, a microsatellite launched a decade ago, which was Singapore's first indigenously built satellite at the Satellite Research Centre, NTU. For any space object orbiting the Earth, the re-entry time primarily depends on its orbit altitude. Usually, objects below 600 km altitude, orbit several years before re-entering Earth's atmosphere and eventually burn-up. However, objects above 800 km altitude take centuries before their re-entry. As XSat is still orbiting the Earth at 817 km altitude post its intended mission life and beaoning, it is recommended to deorbit this satellite within 25 years. Therefore, we explore and analyse the feasibility of a CubeSat-based deorbit mission for the XSat. The designed deorbiter satellite is a 27U CubeSat equipped with all the debris removal payloads, which will be launched into a matching orbit with XSat. A pair of robotic arms fixed to emerge from the two opposite sides of the CubeSat's lateral structure act as a debris capture mechanism, which ensures a firm grip on the target debris object. A thruster-based active deorbit mechanism, and a hybrid deorbit mechanism using a combination of active and passive deorbiting schemes are proposed to deorbit the XSat.