Paper ID: 65474
student

28th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Space Science Missions (2)

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CUBESAT MISSION CONCEPT FOR ENVIRONMENTAL ANALYSIS IN LOW EARTH ORBIT

Abstract

To ensure a future space development and a sustainable orbital exploitation, it is essential to improve the knowledge of the space environment and of the phenomena that could influence spacecraft's operations. Space debris could pose a threat to space operations, and a collision with such an object could degrade mission performances or could lead to a major failure of the spacecraft. The operational costs for collision avoidance manoeuvres should be included for space missions. Space debris' environment knowledge is mainly derived by ground radar observations, that allow to precisely identify objects of at least 5-10 cm in diameter in Low Earth Orbit. For smaller debris only statistical models on their concentration are available, but these models are affected by uncertainties, due to the scarce amount of data and the difficulty to model and predict space debris evolution. Other important aspects are the atmospheric models' uncertainties. These highly affect the end-of-life trajectory changing the ground footprint and the casualty risk. This work addresses the emerging need to characterise the sub-millimeter scale debris environment of the Low Earth Orbit region and to improve models' accuracy during the atmospheric reentry event of space objects. A preliminary mission study is proposed to design a 12-unit CubeSat equipped with an array of payloads, selected to characterise the sub-millimetre debris particles and the upper atmosphere temperature and pressure, as well as aerodynamic and thermal loads on the spacecraft. Initially, a parametric orbit selection for the mission is presented. The key parameters were identified as the number of sub-millimeter scale debris' impacts on a sensitive surface of the payload, the residence time of the spacecraft in the upper atmosphere, in particular the region below 200 km altitude, and the compliance with the decay time regulations. A trade-off analysis of possible payload technologies for in-situ detection of sub-millimeter scale debris is presented, starting from the state-of-the-art devices. Moreover, the possibility to retrieve reentry data below 200 km altitude is linked to the orbit design, which shall maximise the residence time below 200 km to be able to collect enough data. This has implications in orbit design. Finally, a preliminary design of the CubeSat main subsystems is presented, for an initial definition of mission budgets. The aim of this work is to propose a feasibility study for a CubeSat mission concept for a more sustainable use of space, focusing on the space debris and atmospheric modeling.