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THE POLLUTING POTENTIAL OF SPACE DEBRIS DEMISE IN THE ATMOSPHERE: TRENDS AND PATHS TOWARDS SPACE SUSTAINABILITY

Abstract

The number of anthropogenic satellites orbiting the Earth has been increasing in an unconstrained manner, threatening the sustainable access to space. This trend is expected to continue with ongoing plans for large constellations of small satellites in spite of numerous claims of skepticism concerning its impact on ground- and space-based scientific assets [1]. While it is widely understood that most pieces of debris will completely burn up during reentry, the impact on Earth's atmosphere has only been lightly studied and the long-term consequences remain unknown, with possible consequences to the ozone layer [2].

This paper presents a forecast of pollutant deposition in the atmosphere resulting from the demise of anthropogenic objects reentering from low-Earth orbit [3]. We resort to orbital environment evolutionary models to establish reentry forecasts driving the accumulation of reentry byproducts. Molecular dynamics simulations are used to resolve byproducts of thermal ablation upon reentry and, generating inputs for atmospheric models [4]. An estimation of residence time for such pollutants is provided, and a further assessment of putative solutions towards a more sustainable approach to space debris disposal is performed from both technical and legal standpoints while exploring the concept of atmospheric carrying capacity.

References: [1] NASA, "Space Station Applications Accepted for Filing, Space Exploration Holdings, LLC (SAT-AMD-20210818-00105)," Report No. SAT-01598 , 2022. [2] Federal Communications Commission, "Request for Orbital Deployment and Operating Authority for the SpaceX Gen2 NGSO Satellite System," Order Authorization IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105, 2022. [3] J. P. Ferreira et al, "Quantifying Spacecraft Demise Byproducts in the Era of Mega-Constellations," in 73rd International Astronautical Congress, France, 2022. [4] J. P. Ferreira et al, "Preliminary Assessment of Environmental Impacts from the Demise of Reentering Satellites in the Upper Atmosphere," in AIAA ASCEND, United States of America, 2023. DOI: 10.2514/6.2023-4773