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INTRODUCING SPACE FOOTPRINT: CASE STUDY ON THE SUSTAINABILITY OF GEO RESOURCE

Abstract

The Space Footprint is introduced as an indicator of space sustainability, akin to terrestrial concepts like ecological, water, and carbon footprints. This construct evaluates the carrying capacity and utilization of the available orbital space — a finite, natural, common resource surrounding the Earth. The method underpinning the Space Footprint, denoted as C=f(N,A,T,S,E,O), weaves together the population size (N) of space objects, the environmental attributes (A) of the orbital realm, technological innovations (T), societal ramifications (S) of space utilization, ecological impacts (E), and operational efficiencies (O) to assess orbital sustainability. This approach goes beyond the quantification of the number of space objects, to consider their operational dynamics, their tendency for debris proliferation, equitable access to the space resource, and the aggregate consequences on the space environment. It aims to support strategies that harmonize technological development with the conservation of the orbital environment, ensuring the enduring feasibility of space endeavours for current and future generations. This paper elucidates the Space Footprint's formulation as a rating and scoring tool and operationalizes the indicator through a case study focused on Geostationary Orbit (GEO). In this case study, the Space Footprint is calculated for a time series analysis of GEO space resource utilization. The indicator considers the varied actors in the orbital space and aims to examine the equitable distribution of benefits derived from such utilization, offering insights into how different entities access and exploit GEO space resource. The study presents the indicator's capacity to assimilate diverse data streams, facilitating the simulation and scrutiny of the Space Footprint across varied orbital space resource utilization scenarios. This case study illustrates how the indicator might guide the optimization and preservation of orbital resources against the backdrop of escalating space debris, large constellation deployments, and their long-term environmental repercussions. The insights gleaned from this research are intended to champion sustainable practices and inform policy and strategic decisions in orbital resource management. Future research will extend the application of the Space Footprint to other critical orbital regions like LEO and MEO, potentially necessitating methodological adaptations to accommodate the distinct characteristics of each orbital domain.