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CLOSING THE LOOP BETWEEN SPACE CAPACITY AND LIFE CYCLE ASSESSMENT: A NETWORK-THEORETIC APPROACH

Abstract

The paper presents some foundational work which enables engineering for the sustainable use of outer space. A methodology is proposed that combines life cycle assessment with a recently developed quantification of the global health of the space environment. This will be used to establish which actions are required to minimise the environmental impact of space activities and maximise their benefit to sustainable development on Earth.

A new dynamic network model of the space environment with stochastic links is used to quantify the impact of a space object in relation to the rest of the space environment and vice versa. A previous study [1] already validated the model and preliminarily demonstrated some basic properties such as the identification of critical group of objects and the assessment of the global health of the space environment.

In this paper we extend this idea and use the criticality of nodes and the global dynamic properties of the network as environmental categories into the Life Cycle Sustainability Assessment (LCSA) framework for space systems developed at the University of Strathclyde [2] in order to generate optimal decisions on the use of space and terrestrial resources. This will be implemented in conjunction with the Strathclyde Space Systems Database (SSSD) [3], which is a tool used to implement the space LCSA framework. In this way the assessment of a new mission accounts simultaneously for its impact on both the Earth and space environments. This impact is quantified through a single loop that integrates LCSA with the network dynamics.

Through the integration of LCSA with the proposed network-theoretic metrics, one can engineer remediation and mitigation actions to make strategic design decisions that minimise the environmental impact and the use of resources.

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3. Wilson, A. R., Vasile, M. (2023). Life cycle engineering of space systems: preliminary findings. Advances in Space Research, 72(7), 2917-2935. https://doi.org/10.1016/j.asr.2023.01.023