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Sustainable Approaches and Impact of Space Transportation Solutions on Earth + Space Environment and on General Safety (2-D2.9)

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STREAMLINING LIFE CYCLE ASSESSMENT FRAMEWORK FOR SPACE MISSIONS AT EARLY DESIGN STAGES: INSIGHTS FROM THE CHESS CUBESAT MISSION

Abstract

With the rate of satellite launches skyrocketing, so does the environmental impact of the space sector. This tendency emphasizes the need to simplify the impact assessment for early phase design, where the potential for mitigating ecological damage is greatest.

Indeed, whilst the Life Cycle Assessment (LCA) methodology provides an essential framework for the calculation of the environmental impact of a space mission (e.g. space transportation vehicles and cubesat missions), the various impact categories it outputs may cause confusion for engineers, managers and other stakeholders involved in decision-making. That may result in them cherry-picking and favoring few commonly known indicators (e.g. climate change or land use), while failing to consider a broader image due to its apparent complexity. Past work has been performed to define a methodology to reduce the LCA results into a single-score, making LCA more intuitive during preliminary design stages. However, these methodologies are still in development, requiring more LCA studies to be performed. To that end, this paper presents the LCA and the single-score methodology applied to the CHESS mission (Constellation of High-performance Exosphere Science Satellites), a 3U student-led cubesat mission conducted by the EPFL Spacecraft Team jointly with University of Bern (UNIBE) and Federal Institute of Technology Zurich (ETHZ). Variations on the design are made, including extrapolating CHESS's design to cubesats of different sizes, in order to investigate the effectiveness of the single-score method during early design stages. Moreover, this paper introduces preliminary ideas for an eco-design tool featuring an intuitive, streamlined graphical user interface, and integrated machine learning capabilities. A web-based application would facilitate recommendations for optimizing Cubesat mission design to minimize their environmental externalities without requiring users to have in-depth knowledge of LCA methodologies, thus enhancing accessibility to sustainable space solutions within the LCA domain.

Beyond cubesats, this approach holds potential applicability to Space Transportation Vehicles and other satellite types, highlighting the versatility and relevance of the single-score LCA methodology in early-stage eco-design initiatives.