The Importance of LCA to the future of space sustainability

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1 Introduction and Background

The number of nations and commercial entities participating in space activities is at an all-time high, with satellites in orbit registered in more than 80 countries [1]. For instance, 2021 was a record-breaking year in number of launches, a record which is expected to be superseded this year. The trend is also reflected in the source of fundings for space activities, with an unprecedented increase in private investments that complement those given by public entities. Indeed, whilst for decades space has served mainly governmental and military purposes, new partnerships with the private sector have resulted in its commercialisation, making the space environment become the new economic frontier [2]. Furthermore, this trend is predicted to grow exponentially as we increase our reliance on space to offer solutions – such as SBSP, earth observation satellites – for the worsening climate crisis.

Consequently, a necessary link has to be made between the expansion of the sector – in the past overlooked in terms of environmental requirements – and the global climate commitments (e.g., Paris Agreement, EU Green Deal, SDGs, etc). Indeed, the space sector is the only industry that pollutes not only at every level of the atmosphere but also the land, seas and even Earth's orbit. The industry needs to account for and understand all of these impacts in order to help prevent climate breakdown.

As such, this paper will introduce the concept of life cycle assessment (LCA) as a possible solution to this problem, emphasising its importance to the space industry and highlighting its limitations. It will then go on to outline a case study of a space-based solar power (SBSP) system run by Metasat UK.

2 Space Life Cycle Assessment

As the name suggests, LCA (standardised through ISO 14040 and ISO 14044) is an environmental management tool that aims at quantifying the environmental impacts of a product or service throughout its life cycle (i.e., from extraction of raw materials to disposal). It relates inventory data with specific environmental impact categories and impact indicators (e.g., climate change, eutrophication potential), rendering numerical indicator results. These then go through an interpretation phase, which allows to highlight hotspots, draw conclusions, limitations and recommendations that will form the basis for environmental improvements. Conducting an LCA and integrating an eco-design at early stages allows to conceive products that have better environmental performances (i.e., lower environmental impacts) which, in return, translates in cost-savings and in potential better image of a company, thus attracting new potential investments and clients [3].

Within the space sector, this methodology has been pushed by the European Space Agency (ESA) Clean Space Office for the past decade to a point where its widescale implementation is not difficult to envisage. Despite this, some issues regarding the application to the methodology to the space sector remain. This concerns data availability, quality of data, confidentiality and external review, which are looking to be addressed by the ESA Clean Space Office, EU commission and wider space industry.

3 Case Study

Due to the growing importance of space LCA, new companies such as Metasat UK have begun to emerge. Metasat UK is an aerospace company founded in 2020 which specialises in space sustainability, focusing heavily on space LCA and space-based solar power (SBSP). With reference to the form, it aims at integrating LCA knowledge with that of the space sector in order to provide services designed to lessen the environmental impact of the space industry itself. Due to their extensive knowledge in both, Metasat UK was commissioned by the UK Space Energy Initiative (SEI) to evaluate the life cycle environmental impacts of their technology roadmap – which is based on the CASSIOPeiA solar power satellite (SPS) system. The SSSD was used to compile the life cycle inventory generated by the SEI Technical Working Group. The results of this process found that the programme produced a total of 23.6 gCO2e/kWh which is highly comparable with terrestrial-based energy systems. However, based on a planetary boundary perspective, impacts stemming from ozone depletion and freshwater aquatic ecotoxicity could potentially be considered as even more significant environmental hotspots. The full results of the study were then extrapolated to create a set of guidelines for the SEI Technical Working Group, which will be fed back into the design process so that improvements can be made to lessen the environmental impacts of the SEI technology roadmap.

4 Conclusion

LCA process provide a more robust approach for stakeholders to assess their current and future activities and ensure they comply and remain
in compliance with the changing landscape of national, continental and international norms and standards. Tools for space sustainability for measuring the environmental footprint of space products across their entire life cycle and taking a cradle to grave approach (or cradle to gate) empowers space actors to reduce their footprint for future space missions. This process was successfully demonstrated on SBSP technology using a full LCA which considered the full implementation of modern designs, with special attention to reducing hotspots for CO2 generation on the Earth environment.

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