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BLENDING ENVIRONMENTAL LIFE CYCLE ASSESSMENT (LCA) AND RISK ASSESSMENT (RA) APPROACHES IN THE DESIGN OF SPACE SYSTEMS: A FOCUS ON THE SPACE DEBRIS CRITICALITY ASSESSMENT

Abstract

Several actors of or related to the space industry, such as ArianeGroup and the European Space Agency (ESA), have identified LCA (according to ISO 14040/44) as the most appropriate methodology to measure and minimise their environmental impact. To demonstrate the value of life cycle thinking during the design phase of space systems, a life cycle assessment (LCA) study of Ariane 6 in the exploitation phase is currently performed.

On the one hand, LCA offers a holistic evaluation: it compiles and evaluates the inputs (i.e. resource consumption), outputs (i.e. emissions) and the potential environmental impacts of a product system with respect to a functional unit. On the other hand, Risk Assessment is a very broad analytical tool which can be applied to measure or estimates exposure and severity at the individual level (i.e. for a given life cycle phase of a particular mission).

First, LCA and RA can be carried out separately and then their results can be used in a complementary way using multi-criteria decision analysis to convert and weigh both sets of results. Second, both methodologies can be blended at different levels of integration. Combining both methodologies allows a harmonisation of the results which depend on the functional unit of the system under study.

Given this context, the combination of RA and LCA seems particularly relevant in the space sector for a wide range of applications: (i) obsolescence or supply risk assessment due to environmental regulations, directives or geopolitical circumstances (e.g. European REACh regulation, Critical Raw Materials), (ii) toxicity-related impacts of manufacturing or disposal processes (e.g. using engineered nanomaterials), (iii) criticality of the orbital environment in term of space debris, (iv) casualty risk during the atmospheric reentry.

The priority has been given by the ArianeGroup to the integration of space debris related impact within the LCA framework. LCA studies of space missions should indicate trade-offs not only between typical impact categories, e.g. toxicity and climate change but also with regard to the potential impact of space debris. Indeed space debris is a particular threat dealing with space safety (i.e. RA) but also for the long-term sustainability of outer space activities (i.e. LCA).

Consequently, a specific LCA indicator considering space debris related impact has been developed by us and will be presented. Going further, a consistent methodological framework aiming to generalise and

extend this approach during the early design of space mission will be presented.