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PARAMETRIC LIFE CYCLE ASSESSMENT OF A SPACE LAUNCH SERVICE BASED ON A LOX/BIOMETHANE SEMI-REUSABLE LAUNCHER

Abstract

ArianeWorks, an innovation platform initiated by CNES and ArianeGroup, has accelerated the development of Themis, a low-cost and reusable rocket stage demonstrator, paving the way for the 2030 European launch family. In accordance with their shareholder's ecodesign vision, ArianeWorks initiated the implementation of an ecodesign strategy within the Themis Program ecosystem for the preparation of the future of European access to space. As a first step, the Life Cycle Assessment (LCA) of a launch service based on a semi-reusable launcher derived from Themis, propelled by LOx\Biomethane and operated in the Guyana Space Center was performed. This study implies the development of a specific framework to account for the reusability of the lower stage, requiring the use of an adapted functional unit, the introduction of new phases in the lifecycle, and a specific parametrization to depict its complexity. The study goes on to frame the questioning on the comparison of the environmental performances of semi-reusable and expendable launchers over one year of operations. The data collection and the early design stages modeling enabled an insightful impact assessment. A focus on the main system parameters through a sensitivity analysis can subsequently lead to the definition of requirements to limit environmental impacts or can be used to support trade-offs. Impact assessment results confirm that the production of structures and propellants is responsible for the greatest share of lifecycle impacts regarding the Ariane heritage. Recovery and refurbishment of lower stages also play an important role due to additional impacts generated by extended life phases, but also enable some impact reductions that can be isolated by explicit conventions. The transatlantic transport phase or the propellant consumption during testing and fueling causes non-negligible impacts that could be mitigated through the adoption of frugal or technology innovations. Overall, the study highlights a potential reduction of almost 50% of total impacts on climate change and on resource depletion over one year of operations with respect to a not-ecodesigned baseline. It shows that such parametric early-phase LCA can provide valuable insights to improve the environmental performance of future space systems. However, while it is commonly assumed that reusability reduces lifecycle impacts, the study suggests that the reality is more complex since the conclusions drawn from the comparison of launcher's environmental performance depend on conventions, market parameters, operating schemes, and environmental impact categories.