World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:15, No:02, 2021

Sustainability in Space: Material Efficiency in Space Missions

Authors : Hamda M. Al-Ali

Abstract : From addressing fundamental questions about the history of the solar system to exploring other planets for any signs of life have always been the core of human space exploration. This triggered humans to explore whether other planets such as Mars could support human life on them. Therefore, many planned space missions to other planets have been designed and conducted to examine the feasibility of human survival on them. However, space missions are expensive and consume a large number of various resources to be successful. To overcome these problems, material efficiency shall be maximized through the use of reusable launch vehicles (RLV) rather than disposable and expendable ones. Material efficiency is defined as a way to achieve service requirements using fewer materials to reduce CO2 emissions from industrial processes. Materials such as aluminum-lithium alloys, steel, Kevlar, and reinforced carbon-carbon composites used in the manufacturing of spacecrafts could be reused in closed-loop cycles directly or by adding a protective coat. Material efficiency is a fundamental principle of a circular economy. The circular economy aims to cutback waste and reduce pollution through maximizing material efficiency so that businesses can succeed and endure. Five strategies have been proposed to improve material efficiency in the space industry, which includes waste minimization, introduce Key Performance Indicators (KPIs) to measure material efficiency, and introduce policies and legislations to improve material efficiency in the space sector. Another strategy to boost material efficiency is through maximizing resource and energy efficiency through material reusability. Furthermore, the environmental effects associated with the rapid growth in the number of space missions include black carbon emissions that lead to climate change. The levels of emissions must be tracked and tackled to ensure the safe utilization of space in the future. The aim of this research paper is to examine and suggest effective methods used to improve material efficiency in space missions so that space and Earth become more environmentally and economically sustainable. The objectives used to fulfill this aim are to identify the materials used in space missions that are suitable to be reused in closed-loop cycles considering material efficiency indicators and circular economy concepts. An explanation of how spacecraft materials could be re-used as well as propose strategies to maximize material efficiency in order to make RLVs possible so that access to space becomes affordable and reliable is provided. Also, the economic viability of the RLVs is examined to show the extent to which the use of RLVs has on the reduction of space mission costs. The environmental and economic implications of the increase in the number of space missions as a result of the use of RLVs are also discussed. These research questions are studied through detailed critical analysis of the literature, such as published reports, books, scientific articles, and journals. A combination of keywords such as material efficiency, circular economy, RLVs, and spacecraft materials were used to search for appropriate literature.

Keywords : access to space, circular economy, material efficiency, reusable launch vehicles, spacecraft materials
Conference Title : ICSD 2021 : International Conference on Space Debris
Conference Location : Amsterdam, Netherlands
Conference Dates : February 08-09, 2021