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IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Sustainable Approaches and Impact of Space Transportation Solutions on Earth + Space Environment and on General Safety (9-D6.2)

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LIFE CYCLE SUSTAINABILITY ASSESSMENT OF MONOPROPELLANT PROPULSION SYSTEMS: ADVANCING THE COMPARISON BETWEEN CONVENTIONAL AND NOVEL MONOPROPELLANTS

Abstract

Within the field of monopropellant chemical propulsion, hydrazine has been the industry standard for over 50 years. During the past three decades, this has been challenged by the development and adoption of so-called novel monopropellants, which feature a lower propellant toxicity while delivering equal or improved performance compared to hydrazine. This replacement of hydrazine is aimed at reducing the operational hazards and costs related to propellant fuelling and handling and is additionally motivated by the uncertain regulatory future of hydrazine in Europe.

At this point, several novel monopropellants have been proven in orbit to provide performance improvements with respect to hydrazine at a lower overall cost. Still, the comparison of these technologies remains mostly limited to propellant toxicity, performance and total system cost, neglecting other elements which may greatly influence the sustainability of the entire propulsion system. This constitutes a significant knowledge gap, not only because of the space industry's ambition to move towards eco-design and more sustainable practices in general, but also because of the advances within life cycle assessment (LCA) methodologies in the space industry, which facilitate more multifaceted and detailed sustainability comparisons. As such, this research investigates the impact of propellant choice on the environmental, economic and social life cycle impact of a monopropellant propulsion system for a minisatellite use case. Using the Strathclyde Space Systems Database (SSSD) and newly constructed life cycle inventories, a comparative life cycle sustainability assessment (LCSA) is performed for four propulsion systems, using either hydrazine, LMP-103S, ASCENT or 98% concentrated high test peroxide, which are designed at a conceptual level taking propellant-specific requirements into consideration.

The results of this research provide new insights into the environmental, economic and social hotspots of conventional and novel monopropellant propulsion systems, at the level of their constituent components, aiding future designers and researchers in developing more sustainable propulsion technologies. From a methodological perspective, this research investigates the feasibility of performing LCSA studies for monopropellant propulsion systems in early design phases using publicly available data and considers how this may provide advantages for early design trade-offs. As one of the first studies to publicly present an in-depth life cycle inventory analysis of monopropellant propulsion systems, the research also provides valuable recommendations for the construction of life cycle inventories of propulsion system components in future LCA studies.