53rd IAF STUDENT CONFERENCE (E2)
Student Team Competition (3-GTS.4)

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TOWARDS A CIRCULAR SPACE ECONOMY: SUSTAINABLE STRATEGIES FOR SPACE DEBRIS MANAGEMENT

Abstract

As space activities expand, the increasing accumulation of defunct satellites and debris presents growing challenges to long-term sustainability. This project explores innovative approaches to space debris mitigation, focusing on retrieval, processing, and resource reutilization to promote a circular economy in space. By integrating modular infrastructure with advanced debris management solutions, it aims to enhance the efficiency and sustainability of space operations.

This research was carried out as a collaborative effort by our student team, where each member contributed to different aspects of the study, working both individually and in smaller sub-teams to develop key components of the final solution. Our approach involved specialized task divisions, including propulsion and capture technologies, material processing and repurposing, economic and regulatory assessments, and advanced space environment modeling. Through continuous coordination, knowledge exchange, and iterative testing, we integrated these elements into a cohesive and innovative strategy for space debris management.

Key aspects of our work include the adoption of advanced propulsion and capture technologies to enable controlled debris retrieval and repurposing. Once collected, these materials can be processed and transformed into usable resources, supporting in-space manufacturing and infrastructure development. The potential application of recycled materials for future space habitats and operational systems further reduces reliance on Earth-based supply chains.

In addition to technical advancements, we examined economic and regulatory frameworks that facilitate the adoption of sustainable space practices. This includes evaluating new business models, fostering international collaboration, and implementing modular standards to extend the lifespan of space assets.
Through advanced simulations and dynamic modeling of the space environment, our team identified optimal strategies for infrastructure placement and long-term sustainability. By transforming debris into resources, this approach contributes to responsible space resource management and supports the future of exploration and development beyond Earth.
This project represents the work of a student team, where each member played a crucial role in different aspects of research and development. Our collaborative effort underscores the importance of cooperation in addressing challenges in space sustainability.
This study is carried out in the framework of the Space Exploration and Development Systems XVI (SEEDS XVII) II Level Master's programme, a project born from the collaboration between the Politecnico di Torino (PoliTo), the Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), and the University of Leicester, with the participation of Agenzia Spaziale Italiana (ASI), Centre National D'Etudes Spatiales (CNES), European Space Agency (ESA), Thales Alenia Space, and Altec.