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Assuring a Safe, Secure and Sustainable Environment for Space Activities (4)

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FROM CRADLE TO GRAVE: ESA CLEAN SPACE'S APPROACH TO SPACE SUSTAINABILITY

**Abstract**

Space activities require a sustainable approach to ensure their continuity and minimize impacts on the environment, both on Earth and in space. Sustainability in space starts here on Earth, where the design of space missions takes place. That is why the European Space Agency has been committed to embedding sustainability within its space activities. ESA established its Clean Space initiative in 2012, aiming to assess the environmental impacts of its endeavours in order to mitigate and remediate them. Since its inception, Clean Space has expanded its focus into three main branches: EcoDesign, End-of-Life Management, and In-orbit Servicing. EcoDesign is the branch focused on the impacts of space activities on the Earth environment. It aims to assess these impacts by adapting the ISO-standardized Life Cycle Assessment (LCA) methodology to space activities. Through its LCA database and handbook, ESA has created a framework to guide the European space industry to assess the environmental impacts of their activities, identify their highest environmental impacts – also known as hotspots – , and carry out studies to design greener alternative technologies or processes to reduce them. As such, several efforts in this branch contribute to the UN's Sustainable Development Goals. The End-of-Life Management branch is focused on the development of technologies that will support and ensure the full compliance with the Space Debris Mitigation (SDM) guidelines. This includes controlled re-entry, design for demise and removal, power and propulsion passivation, and de-orbiting technologies. Additionally, the In-orbit Servicing (IOS) branch focuses on space debris remediation, whether by servicing existing satellites or by performing Active Debris Removal (ADR). The objective is to ensure the safety of the space environment by removing objects that present high collision probabilities to avoid cascading impacts. Activities within this branch include the ClearSpace-1 mission, which is the first mission of its kind aiming to remove a piece of debris from orbit, as well as the development of On-orbit Manufacturing, Assembly, and Recycling (OMAR), and robotic and robust Guidance, Navigation and Control technologies for IOS. In the long term, space debris mitigation and remediation activities will help mitigating the space debris problem and will therefore reduce the burden of STM activities. The ESA Clean Space initiative enables the long-term safety and sustainability of space activities, by ensuring that environmental considerations are at the forefront of the European and Canadian space sector and pushing these actors to tend towards a cleaner and safer space environment.