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ADVANCING SPACE SUSTAINABILITY: THE UNIVERSITY OF PADOVA'S CONTRIBUTIONS TO SAFER ORBITS AND INNOVATIVE TECHNOLOGIES

Abstract

The exponential growth in spacecraft launches into Earth's orbit, driven by reduced access costs

and expanding commercial opportunities, has raised significant concerns within the scientific community regarding the sustainability of current space practices. Malfunctions and orbital breakups contribute to space debris accumulation, whereas uncontrolled re-entries pose risks to both the upper atmosphere and Earth's surface. While various stakeholders are exploring mitigation strategies and sustainable approaches, the absence of a global authority to enforce comprehensive coordination and regulation of space activities remains a challenge, with only regional organizations taking steps toward binding initiatives.

In response to these challenges, the University of Padova (UNIPD) is actively engaged in numerous initiatives and collaborations aimed at promoting a more sustainable approach to the use of near-Earth orbits. These efforts include academic research partnerships to develop safer in-orbit technologies and end-of-life strategies, industry collaborations to foster innovation in space sustainability, and initiatives to support international cooperation in the space sector.

For reference, the E.T.PACK initiative, started in 2019 with an EU H2020 project, aims to develop ElectroDynamic Tether (EDT) technologies in Europe to promote sustainable space usage by preparing and commercializing propellant-less propulsion and power generation products. The E.T.PACK-F project is developing a flight-ready deorbit device (TRL 8) by 2025, with an In-Orbit Demonstration planned for 2026. Additionally, the new E.T.COMPACT project targets TRL 4 for a miniaturized EDT-based device, while also advancing a bare-photovoltaic tether based on PVK/CIGS thin-film solar cells.

Among other EU projects carried out at UNIPD, ReDSHIFT involved 13 institutes in 7 countries to define novel holistic approaches to the sustainable demise of spacecraft. In parallel, the research on proximity operations has been conducted through different projects, including collaborations with ESA (e.g. the development of the docking mechanism for the Space Rider Observer Cube, research activities on robotics for in-orbit servicing) and with ASI (with dedicated activities on rendezvous, docking and capture of both collaborative and non-collaborative targets), fostering the partnerships with national and international institutions and industries. Regarding international cooperation, personnel from UNIPD are also actively involved in the IADC as ASI representatives for Working Group 3, supporting information exchange and facilitating actions for a sustainable space sector.

This paper highlights these ongoing activities, detailing the University's contributions and outlining a roadmap for the next generation of sustainable spacecraft and reliable in-orbit operations.