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TOWARD SELF-DRIVING INTERPLANETARY CUBESATS: THE ERC-FUNDED PROJECT EXTREMA

Abstract

A new space era is fast approaching. In this decade, CubeSats have granted affordable access to space due to their reduced manufacturing costs compared to traditional missions. Although most of miniaturized spacecraft has thus far been deployed into near-Earth orbits, soon a multitude of CubeSats will be employed for deep-space missions as well. By conquering the interplanetary exploration, they will represent a step further in the democratization of space. The current paradigm for deep space mission is based on ground-based guidance, navigation, and control operations, and thus with human-in-the-loop operations. Although this is reliable, ground control slots will saturate soon, so hampering the current momentum in space exploration.

The EXTREMA (Engineering Extremely Rare Events in Astrodynamics for Deep-Space Missions in Autonomy) project aims to challenge and revolutionize the current paradigm under which spacecraft are operated. The goal is to enable self-driving CubeSats, capable of traveling in deep space without requiring any control from ground. The project has been awarded a European Research Council (ERC) Consolidator Grant, a prestigious acknowledgement that funds cutting-edge research in Europe. This work gives an overview of EXTREMA, highlighting methodologies and expected results; moreover, the impact on the space sector is also discussed.

EXTREMA is built up on three pillars: autonomous navigation, autonomous guidance and control, and ballistic capture. Pillar 1 envisions the development of an optical navigation technique that extracts

the line of sight of the celestial bodies to infer the state of the deep-space spacecraft. Pillar 2 deals with the development of a lightweight, robust closed-loop guidance algorithm. Finally, pillar 3 addresses the definition of the corridors for ballistic capture, an extremely rare phenomenon that allows for planetary capture without any energetic effort. The flawless integration of the outcomes from the three pillars into an Orbital Simulation Hub will eventually mark the accomplishment of the EXTREMA objectives.

The impact of EXTREMA is expected to be immediately transferrable to bigger, monolithic spacecraft as well, as these are usually equipped with better-performing on-board systems. Thanks to their more generous mission budgets, the impact of the technological transfer is projected to open up new opportunities for the exploitation of interplanetary resources and the exploration of the furthest corners of the Solar System.