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SPACE MOBILITY OPTIMIZATION AND CONCURRENT ENGINEERING FOR MODULAR MICRO-PROPULSION SYSTEMS WITH 360 BY IENAI SPACE

Abstract

Space propulsion offers many benefits, such as increased satellites mobility and lifetime or higher sustainability through decommissioning and collision avoidance, being rightfully recognized as an enabling technology. However, propulsion is still struggling to keep up with other subsystems advancements, due to difficulties in miniaturizing the technologies, while satisfying the extremely tight requirements typical of small satellites.

ienai SPACE is working on solving this problem with **ATHENA™**, a high-efficiency micro-propulsion system based on a micro-fabricated electrospray technology. The system follows a deeply modular and customizable philosophy, with the ambitious goal of providing a tailored solution for satellites ranging from picosats to nanosatellites. However, a modular system, while offering great flexibility and adaptability for any potential mission, adds complexity at the design stage and the need for a framework capable of generating realistic and optimized solutions. This task is particularly intricated for propulsion since the system design is strongly coupled with orbital dynamics and subject to complex constraints coming from other subsystems and operations.

360™ is an advanced mission analysis tool developed by **ienai SPACE**, conceived to solve this problem, exploiting the critical advantage of a fully integrated mission optimization/system design philosophy for spacecrafts equipped with a modular propulsion system. The software is based on a genetic algorithm coupled with a feedback control law for multi-revolution low-thrust maneuvers optimization. A rapid estimation of near-optimal propulsive transfers covering the whole mission, concurrently with optimized thruster configurations is provided at an early stage of the mission design, enabling quick exploration of a wide design space for the propulsion system itself, its requirements, and the impact on the other subsystems and operations.

Additionally, the framework can perform concurrent engineering with correlated subsystems, such as the EPS and ADCS, yielding global solutions that are optimized at a spacecraft/mission level, drawing the highest benefits from the use of propulsion. Complex operational constraints, such as eclipses, visibility and pointing needs, are included as well, ensuring realism and balance of the solutions obtained.

Designers are given the power to iterate rapidly and effectively a vast and multi-domain design space, comprising variables from several subsystems and to obtain solutions optimized with respect to multiple objectives. The joint optimization of maneuvers and subsystems and the resulting preliminary trade-offs allow for improved mission and system-budget management from early iterations up to detailed design phases, providing a clear insight of the impact of a tailored propulsion system on the whole architecture and mission.