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Author: Dr. Vittorio Giannetti
Scuola Superiore Sant'Anna, Italy

Dr. Eugenio Ferrato
Scuola Superiore Sant'Anna, Italy
Prof. Tommaso Andreussi
Scuola Superiore Sant'Anna, Italy

DEVELOPMENT OF A NOVEL CUBESAT-SCALE AIR-BREATHING ELECTRIC PROPULSION SYSTEM

Abstract

Very Low Earth Orbit (VLEO) missions would provide significant advantages. First, operating closer to Earth's surface greatly benefits communication missions, thanks to the reduction in latency and transmission power, and Earth observation missions, thanks to the improvement of reconnaissance conditions. In recent years, air-breathing electric propulsion has emerged as a potential enabling technology for long-duration space missions in VLEO. The concept of air-breathing electric propulsion relies on an intake situated in front of the spacecraft to gather the same atmospheric particles that generate the drag. Utilizing electric power derived from solar arrays or batteries, an electric thruster then ionizes and accelerates these particles to generate thrust. By leveraging these limited yet renewable resources, it becomes possible to decouple the spacecraft's lifetime from the availability of propellant, enabling extended mission durations at low altitudes until other life-limiting factors become dominant (such as ATOX exposure). Several concepts have been proposed for air-breathing electric thrusters in the literature [1]; however, ground tests have highlighted difficulties in the efficient ionization of the VLEO atmosphere. Moreover, most, if not all, concepts targeted platform sizes in the range 100-1000kg. Such large platforms would incur in significant cost and development time to perform the In-orbit experiment of a high risk/high reward technology such as air-breathing propulsion. Celeste S.r.l., supported by the plasma physics expertise of the Scuola Superiore Sant'Anna, is pursuing the development of a novel CubeSat-scale electric propulsion thruster. The device, denominated VOLTA, is based on novel technological solutions specifically tailored to enable the miniaturization of the system and to improve its efficiency at low chamber pressures, making it particularly suited for both stored propellant high Isp operation and for air-breathing operation. The system is designed to be hosted in a 2U CubeSat form factor ensuring a rapid and cost-effective avenue for the deployment in the real operative environment. This work presents the main design features of the device as well as the main component-level tests performed. Additionally, preliminary ground test results of the assembly will be presented, focusing on the operating envelope of the device and on the representativeness of the test conditions. The experimental results obtained show how the VOLTA technology, once matured, could pave the way towards the sustainable utilization of VLEO assets and enable innovative CubeSat applications with improved payload performance.

[1] Andreussi T., Ferrato E., Giannetti V. (2022), Journal of Electric Propulsion 1 (31)