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Advancements of a VLEO satellite system study utilizing an RF Helicon-based Plasma Thruster

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To achieve a feasible lifetime of several years, most satellites are deployed in orbits higher than 400 km. Drag of residual atmosphere causes a slow orbit decay, resulting in the deorbit of the spacecraft. Optical instruments or communication devices would, on the other hand, greatly benefit from lower altitudes either to gain better resolution or to reduce cost. For an orbit range of 150-250 km, atmosphere-breathing electric propulsion (ABEP), which utilizes the residual atmosphere as propellant, could be a potential solution. The Institute of Space Systems (IRS) developed an advanced electrode-less RF Helicon-based plasma thruster (IPT) within the EU Horizon 2020 project DISCOVERER and the follow-on ESA project RAM-CLEP, which aims to fully compensate drag [1]. The system was successfully ignited and stable operated at power levels in the range of 50-150 W with the propellants argon, nitrogen, and oxygen [2]. Recently developed instruments to measure performance and magnetic field in the plume now allow for in-depth characterization. The momentum flux probe allows thrust measurements and mapping of the plume, while the B-dot probe allows characterization of the magnetic field in 3-axis [3]. The latter is crucial in confirming that the Helicon wave mode is indeed triggered, which is suggested by preliminary thrust measurements.
Furthermore, various intake (particle collectors) designs were investigated, opening the possibility to conduct studies on potential satellite platforms. Specular parabolic as well as diffuse intake designs were developed at IRS and in combination with the IPT design, two satellite platforms were emerged. The slender body design features a single, large propulsion system, whereas the flat body design consists of several small propulsion systems allowing attitude control via the ABEP system and providing less drag inducing surfaces. For both designs, drag coefficient simulations were run with ADBsat [4]. A design study for an Earth Observation and Telecommunication satellite operating at 150-250 km with an extended mission lifetime is carried out. The first system assessment focused on the comparison of different spacecraft configurations (“slender body” and “flat body”) and intake designs (specular or diffuse) with regard to overall drag and ABEP performance requirements. Moreover, thermal control systems and the effect of the atmospheric particles’ thermal velocity on the intake efficiency are considered and their effects on the drag and platform design are discussed.
In this contribution, results of the intake study and the advanced platform model, displaying the geometry, I_{SP}, and altitude dependencies will be shown in combination with an overall performance evaluation of the thruster characterization with relevant propellants and diagnostics.

References

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