E.T.PACK: Developing a deorbit kit based on electrodynamic tether technology

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Extended Abstract

The "Electrodynamic Tether technology for PAssive Consumable-less deorbit Kit" (E.T.PACK) is a 45 months FET-OPEN project, funded with 3M€ by the European Commission and started in March 2019 [1]. The objective of E.T.PACK is to develop a Deorbit Kit (DK) with TRL equal to 4 and based on an electrodynamic tether (EDT), i.e., a long metallic tape.

Unlike chemical and electrical thrusters and drag augmentation devices, an EDT uses a passive and propellant-less mechanism known as the Lorentz drag. In particular, EDTs use the space environment resources (ambient plasma, geomagnetic field, and solar radiation), to exchange momentum with the Earth's magnetosphere without using propellant. In Low Earth Orbit (LEO), an EDT deorbits the spacecraft in a passive manner, thus converting the orbital energy into useful electrical energy for on-board use. If onboard power is available, an EDT can re-boost the spacecraft. In 1993, both modes of operation were proven by NASA in the Plasma Motor Generator (PMG) mission [2]. Recent progress, like using tapes instead of wires [3], the Low Work-Function Tether (LWT) [4,5] and the bare-photovoltaic EDT [6] concepts, raised EDT performance, compactness, simplicity and robustness to a level that was unconceivable a few years ago.

E.T.PACK's DK is fully focused on a follow-up In-Orbit Demonstration flight, whose main goal will be testing the critical technologies in space and evaluating the DK performances. In particular, the DK will be a fully autonomous system installed before launch on customer satellites and activated from ground at the end of the operational life. The DK will be self-powered and use a robust attitude control system to remove spacecraft residual angular velocity to acquire the proper attitude for tether deployment. After deployment, the Lorentz drag on the tether will dissipate the orbital energy, thus producing the deorbit of the spacecraft. The DK will be able to send Telemetry and receive Telecommand to interrupt the deorbiting and perform collision avoidance maneuvers.

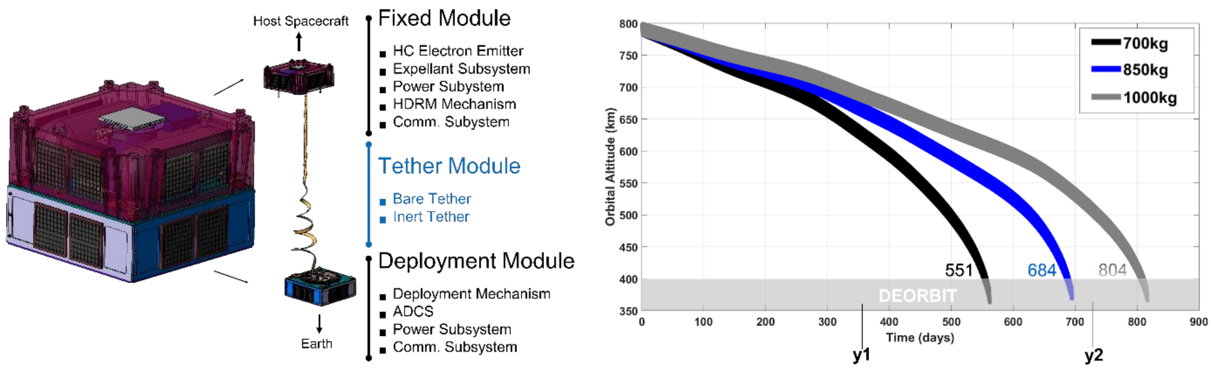

Figure 1. Deorbit kit and its main elements (left) and simulation result of the altitude versus time for a 700-kg spacecraft equipped with a 35-kg deorbit kit.

Studies performed during the project indicate that a commercial DK with mass below 35 kg will deorbit a 700kg-S/C from a 800km altitude sun-synchronous orbit in less than 1.5 years. Even better performances can be achieved in non polar orbits.

This work will present the most important result achieved from the start of the project. They include a preliminary design and performances of a Deorbit Kit Demonstrator (DKD) fitting a 12U cubesat [7]. DKD will be launched in 600 km altitude orbit and will re-enter in less than 100 days. The DKD goal is to demonstrate in orbit the deorbit kit technologies paving the road for the commercialization of the kit.

DKD is composed by two independent modules; the Deployment Mechanism Module is in charge of deploying a 500m long tether while the Electron Emitter Module is responsible for emitting back to the plasma the electrons collected by the bare tape. The selected emitter is a heatherless hollow cathode to fit the tight power requirements. Passive electron emission will be demonstrated on a tether segment coated with the $C12A7e^-$ electride

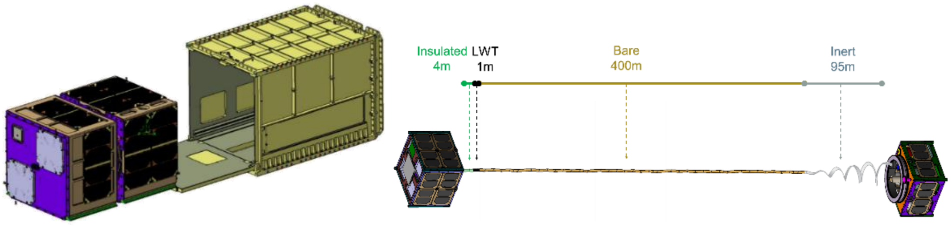

Figure 2. Details of the DK and the longitudinal structure of the tether

Detailed models of the DKD mission have been generated and simulated with 3 different simulators to verify requirements and assess design correctness. The DKD performances are in lines with the expected and the team is now starting the manufacturing of a breadboard. E.T.PACK will terminate in 2022 reaching TRL4, the demonstration mission is foreseen in 2024 and start the production of the DK in 2025.

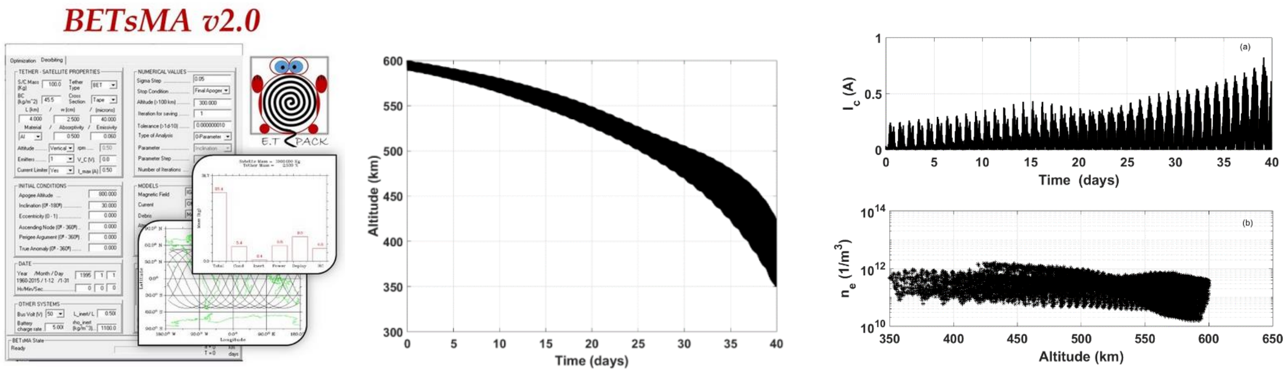

Figure 3. The mission analysis software BETsMA v2.0 and some simulation results of the DKD. An on-line service of the BETsMA v2.0 software is at https://betsma.uc3m.es.

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