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FORESAIL-1: Energetic particle and de-orbiting experiments with a CubeSat

Rami Vainio and the FORESAIL-1 Team
University of Turku, Space Research Laboratory, Department of Physics and Astronomy, Turku, Finland (rami.vainio@utu.fi)

The Finnish Centre of Excellence for Research of Sustainable Space (FORESAIL) is an eight-year project (2018-2025) led by the University of Helsinki, Finland, set to investigate the Earth's radiation environment and develop technological solutions that on one hand help the survival of CubeSats in space radiation and on the other demonstrate the revolutionary Coulomb drag mechanism enabling electric solar wind sailing as well as de-orbiting satellites reliably after their use. The centre will launch three CubeSat missions to Low Earth Orbit (LEO), Geostationary Transfer Orbit and beyond, respectively. Here we describe the first mission, FORESAIL-1, set for launch in the turn of 2019-2020.

The FORESAIL-1 mission will be a 3-unit CubeSat launched to polar LEO. The spacecraft bus is based on a modular avionics stack, developed for higher reliability. The stack hosts an on-board computer, based on two cold-redundant ARM R4 based micro-controller units, an UHF radio communication system, an attitude determination and control system based on magnetorquers, and an electrical power system. The mass of the spacecraft is 4.0 kg.

FORESAIL-1 will carry a Particle Telescope (PATE), which has the primary objective of accurately measuring the 80-800 keV electrons precipitating in the atmosphere. For this, it needs an angular resolution good enough to separate the particles that are in the bounce loss cone from those that are not. This will be achieved by using two telescopes, one pointing along the spin axis of the satellite while the other scans the directions perpendicular to it at a rate of 4 rpm. The secondary science target is to observe energetic hydrogen (ions and atoms) at energies 0.3-10 MeV.

FORESAIL-1 will test an innovative application of space weather physics, namely de-orbiting of the satellite by means of Coulomb drag with the ionospheric plasma. FORESAIL-1 deploys a long, thin and negatively charged plasma brake tether, which disturbs the plasma ram flow to create braking thrust. The tether is so thin that it does not form a threat to other satellites. The baseline plan is to use the plasma brake in an early phase of the mission for going from synchronous to a somewhat lower drifting orbit so that the local time sampling characteristics of PATE are improved. The experiment demonstrates the capability of a plasma Coulomb drag device to modify the orbit and to de-orbit a satellite.

We will present the structure and goals of the FORESAIL-1 mission and give a status report on the development activities.