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CONDUCTING RADIATION BELT SCIENCE WITH CUBESATS: SATELLITE DESIGN FOR FORESAIL-2 AND 3

Marius Anger[(1)], **Bruce Clayhills**[(1)], **Kiril Cheremetiev**[(1)], **Petri Niemelä**[(1)], **Mayank**[(1)], **Ville Lundén**[(1)], **Anton Fetzer**[(1)], **Minna Palmroth**[(2)], **Emilia Kilpua**[(2)], **Rami Vainio**[(3)], **Pekka Janhunen**[(4)], **David Fischer**[(5)], **Andris Slavinskis**[(6)], and **Jaan Praks**[(1)]

[(1)]*Aalto University, Maarintie 8, Espoo, Finland*

[(2)]*University of Helsinki, Helsinki, Finland*

[(3)]*University of Turku, Turku, Finland*

[(4)]*Finnish Meteorological Institute, Helsinki, Finland*

[(5)]*Space Research Institute, Austrian Academy of Sciences, Graz, Austria*

[(6]*Space Technology Department, Tartu Observatory, University of Tartu, Estonia*

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ABSTRACT

Even though the Earth's radiation belts have been studied intensely since the 1950s in terms of their shape, particle contents and mechanics, their seeding effects and the dynamics of the outer belt are still under investigation. The fluxes of energetic particles can increase dramatically, by several orders of magnitude, within time scales of less than one day. Ultra-low frequency (ULF) waves have a major importance for the dynamics of the outer radiation belt. Understanding these needs very precise measurements of the magnetic field and proton and electron fluxes.

Though CubeSat missions have been mostly limited to low Earth orbit (LEO), where radiation levels are modest, small satellites are proposed to be deployed in highly elliptical orbits such as the geostationary transfer orbit (GTO) to conduct further space weather observations. The Finnish Centre of Excellence in Research of Sustainable Space (FORESAIL) aims to demonstrate the capability of small satellites to perform science missions under the challenging conditions of a highly elliptical orbit through elevated radiation environments. The Foresail-2 and 3 CubeSats will study Earth's radiation belt region and space weather dynamics with the COSPAR CORBES mission.

The main drivers are the magnetic cleanliness required by the payloads and the compact size. Additionally the long communication distance at apogee and the high fluxes of energetic particles, that the spacecraft will encounter when crossing the densest regions of the radiation belts, impact the design.

The main payload is the Magnetometer Aboard the ForeSail2 cubesaT (MAST), developed by the Austrian Space Research Institute. Due to magnetic cleanliness the measurements head is mounted on a

two fold boom which has to be deployed. Additional payloads are the Relativistic Electron and Proton Experiment (REPE) by University of Turku and the Coulomb Drag Experiment (CDE), developed by the Finnish Meteorological Institute.

The preliminary design of the two identical science spacecraft in a 6U form factor includes a fully in house build attitude determination, electrical power and communication system. As the payloads require a spinning spacecraft an attitude control with 6 degrees of freedom from an external supplier is integrated. The communication system will use S-Band frequencies in full duplex mode. An in-house build antenna feed system integrated with a 3m̃ diameter dish antenna will serve as a home ground station.