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Author: Mr. Erik Kulu
University of Tartu, Estonia, erikkulu@gmail.com

Mr. Silver Lätt
Tartu University, Estonia, silver.latt@ut.ee
Mr. Urmas Kvell
University of Tartu, Estonia, urmas.kvell@estcube.eu
Mr. Andris Slavinskis
University of Tartu, Estonia, andris.slavinskis@gmail.com
Mr. Mihkel Pajusalu
University of Tartu, Estonia, mihkel.pajusalu@ut.ee
Mr. Henri Kuuste
University of Tartu, Estonia, henri.kuuste@estcube.eu
Mr. Kaspars Laizans
University of Tartu, Estonia, kaspars.laizans@estcube.eu
Mr. Andres Vahter
University of Tartu, Estonia, andres.vahter@gmail.com
Mr. Erik Ilbis
University of Tartu, Estonia, erik.ilbis@estcube.eu
Mr. Viljo Allik
University of Tartu, Estonia, viljo.allik@ut.ee
Mr. Tõnis Eenmäe
University of Tartu, Estonia, tonis_ee@aai.ee
Dr. Jouni Envall
Finnish Meteorological Institute, FMI, Finland, jouni.envall@fmi.fi
Mr. Jouni Polkko
Finnish Meteorological Institute, FMI, Finland, jouni.polkko@fmi.fi
Dr. Pekka Janhunen
Finnish Meteorological Institute, FMI, Finland, Pekka.Janhunen@fmi.fi
Dr. Mart Noorma
University of Tartu, Estonia, mart.noorma@ut.ee
Mr. Kaupo Voormansik
University of Tartu, Estonia, kaupo.voormansik@estcube.eu

# ESTCUBE-1 NANOSATELLITE FOR ELECTRIC SOLAR WIND SAIL TECHNOLOGY DEMONSTRATION IN LOW EARTH ORBIT

**Abstract**

ESTCube-1 is a single unit CubeSat that is planned to be launched into 680 km altitude sun-synchronous polar orbit in April 2013 onboard the Vega launcher. Its primary mission is to measure the Coulomb drag force exerted by a natural plasma stream on a charged tether and thus to perform

the basic proof of concept measurement and technology demonstration of electric solar wind sail (E-sail) technology.

The E-sail is a propellantless propulsion system concept invented in 2006. It uses thin charged electrostatic tethers for turning the momentum flux of a natural plasma stream such as the solar wind into spacecraft propulsion. A full-scale E-sail spacecraft would consist of one hundred 20 km long tethers made of four interconnected 25-50 micrometre aluminium wires and it would produce 1 N of average thrust in the solar wind at 1 au while weighing 100-200 kg. Among other low thrust propulsion systems such as ion engines and photonic sails, the solar wind based E-sail has potentially a revolutionarily high total impulse capability versus its own mass.

ESTCube-1 takes the first step in realising E-sail technology by demonstrating centrifugal deployment of a 10 m long near final type tether and by measuring the magnitude of the resulting micronewton scale E-sail force. For deployment of the tether the satellite is spun up to 1 revolution per second with the spin-axis parallel to Earth's rotation axis. After deployment, the electron gun is turned on and off synchronously with the satellite's spin. Changes in the satellite's spin rate resulting from the Coulomb drag interaction with the moving ionospheric plasma are monitored by gyroscopes. The plasma flow is due to the satellite's orbital motion.

The attitude determination and control system (ADCS) of ESTCube-1 is capable of spinning up the satellite within two orbits by using magnetic torquers and it includes magnetometers, gyroscopes, and sun sensors for measuring attitude. The command and data handling system interfaces with the ADCS sensors and runs the software while having redundant and fault-tolerant design. A tether end mass imaging system is used to verify tether deployment during unreeling. The high-voltage board generates 500 V for the electron guns. The employed cold cathode electron guns are based on electron eld emission from a nanographite surface. A piezoelectric motor is used for rotating the tether reel. Also a negative 500 V source is included for measuring the negative polarity Coulomb drag force in a separate experiment.