

# Aalto-1 nanosatellite project

## Project responsible leader:

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## Aalto-1 is the first Finnish nanosatellite project

Aalto-1 is a student satellite project, the first in Finland. The Aalto-1 project started in the beginning of 2010, when a group of students made a feasibility study of the satellite in the framework of the Space Technology special assignment course. Since then the project has created significant excitement among students and teachers alike. New teaching methods have been applied and a significant interdisciplinary co-operation network inside Aalto University has been created. The team has now members from five different departments of Aalto University. Additionally, a consortium of Finnish universities and space industry has been formed to support the satellite project and international relations with several foreign universities have been created.

The satellite project is coordinated by Department of Radio Science and Engineering and supported by Space Technology teaching. In the project participate also Aalto University Department of Automation and Systems Technology, Department of Communications and Networking, Department of Applied Mechanics and additionally Department of Physics of University of Helsinki (HY), Department of Physics and Astronomy of University of Turku (UTU), VTT, Finnish Meteorological Institute, Aboa Space Research Oy, Oxford Instruments Analytical Oy and other Finnish companies. The consortium will expand in the future.

## Project status

Aalto-1 satellite has been delivered in early 2016 and it is waiting for launch aboard SpaceX Falcon 9 rocket. The launch has been scheduled for May 2016. Before delivery Aalto-1 successfully passed all test campaigns which included vibration and shock tests, thermal vacuum tests, link tests and software testing for example. After launch Aalto-1 will be tested in orbit and then begin its scientific missions.

## Scientific mission

Although the satellite is built according to student satellite concept, the scientific mission of the satellite is significant and contributes to space and space technology research in many areas.

### Imaging Fabry-Perot spectrometer

VTT has developed a new concept based on the MEMS or Piezo actuated Fabry-Perot Interferometer to enable recording of 2D spatial images at the selected wavelength bands simultaneously and to reduce the size of the hyperspectral spectrometer to be compatible with light-weight UAV and small satellite platforms. In the spectrometer the multiple orders of the Fabry-Perot Interferometer are used at the same time matched to the sensitivities of the image sensor channels. For example in a Bayer pattern RGB sensor or in a three CCD video camera based on a wavelength separation prism there are different types of pixels for three wavelength channels. The operational wavelength range of the built prototypes can be tuned in the range 400 – 1100 nm and spectral resolution is in the range 5 – 10 nm @ FWHM. The hyperspectral imager records simultaneously a 2D image of the scene at three narrow wavelength bands determined by the selected three orders of the Fabry-Perot Interferometer which depend on the air gap between the mirrors of the Fabry-Perot Cavity. The air gap value is determined using a capacitive measurement and changed under closed loop control with three Piezo or MEMS actuators. The effective aperture the Fabry-Perot interferometer is 7 mm in diameter and the air gap can be controlled in the range 0.8 – 3.5  $\mu\text{m}$  enabling the use of the wide range of interferometer orders.

The subsystem was manufactured by VTT.

### Electrostatic plasma brake

The electric solar wind sail is a space propulsion method, invented in Finland at FMI (<http://www.fmi.fi>). The electrostatic plasma brake is a variant of the concept which consists of a single gravity-stabilized tether intended to deorbiting a satellite, to avoid leaving it in orbit as space debris after the mission. The Electric Sail Experiment onboard Aalto-1 is intended (1) to demonstrate the deployment of a conducting thin multiline tether, (2) to measure the electrostatic force exerted on the tether by the ram flow of the ionospheric plasma in different positive and negative tether voltages and finally, if all goes well, (3) to bring down the satellite and so to demonstrate the usefulness of the plasma brake as a satellite deorbiting device.

To measure the expected micronewton scale electrostatic force, the voltage is turned on always in the same phase of the tether's rotation (e.g. always when the tether is moving towards the ram flow). After several spins, the effect accumulates enough to cause a detectable change in the tether's and satellite's spin rate, from which the force can be calculated. Over longer timescale, the effect of the force can be deduced from a lowering of the satellite orbit.

A first version of the electric sail experiment flew on ESTCube satellite in 2013. The purpose of ESTCube was to measure the force, but not yet to demonstrate the deorbiting of the satellite. The Aalto-1 experiment has a longer tether so that a more significant electrostatic drag force can be produced which is enough for deorbiting.

The subsystem was manufactured by a consortium led by FMI.

### Compact radiation monitor (University of Turku and University of Helsinki)

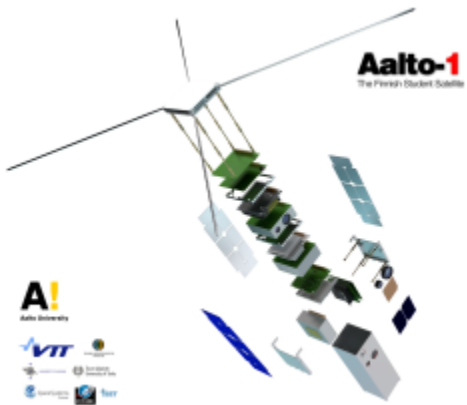
A novel readout concept of the radiation monitor instrument allows a light-weight, low-power detector design with large enough dynamic range to be useful in various radiation environments from low-Earth orbits to geosynchronous orbit. The main goal of the project is to demonstrate that the proposed concept, minimizing the amount of power-consuming and slow analog amplifier electronics, is suitable for space applications.

A space radiation monitor needs to measure the fluxes of ionizing corpuscular radiation present in the near-Earth space inside radiation belts and during solar particle events. The monitor, at minimum, should be able to record the spectrum of linear energy transfer (LET) of the particles hitting the detector. The radiation flux is highly variable in space and time, so the dynamic range of the instrument (in terms of its capability to measure both high and low fluxes) needs to be considerable.

At present, a typical energetic charged particle detector is a stack of semiconductor detectors, which records the ionization energy loss of the incident particles in the detector elements. The signal readout electronics typically consists of a pre-amplifier, a shaping amplifier, a peak-hold detector, an AD converter to produce a digitized signal of each particle incident on the detector, and a comparator circuit to determine when the detector is hit by a particle and to provide the timing of the amplifier chain.

We constructed a simple radiation monitor consisting of a stack of silicon detectors and a scintillator coupled to a photodiode, that are read out using a novel concept.

The subsystem was manufactured by consortium led by University of Turku and University of Helsinki.  
The Satellite



- CubeSat 3U design
- Main payload:
  - Imaging spectrometer (VTT)
- Secondary payloads:
  - Radiation Monitor (HY, UTU)
  - Electrostatic Plasma Brake (FMI)
- Weight: 4 kg
- Orbit: Polar Sun-synchronous 10 AM LEO
- Attitude: 3 axis stabilized
- Communication: UHF, S-band data transfer
- Solar powered, max power 8 W

Partners

Satellite Bus development



Imaging Spectrometer development



Electrostatic Plasma Brake





**TARTU OBSERVATORY**  
space research centre

**Radiation Monitor development**



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Turun yliopisto  
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**Software consulting**



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