

# Nanosatellites and space technology education in Finland

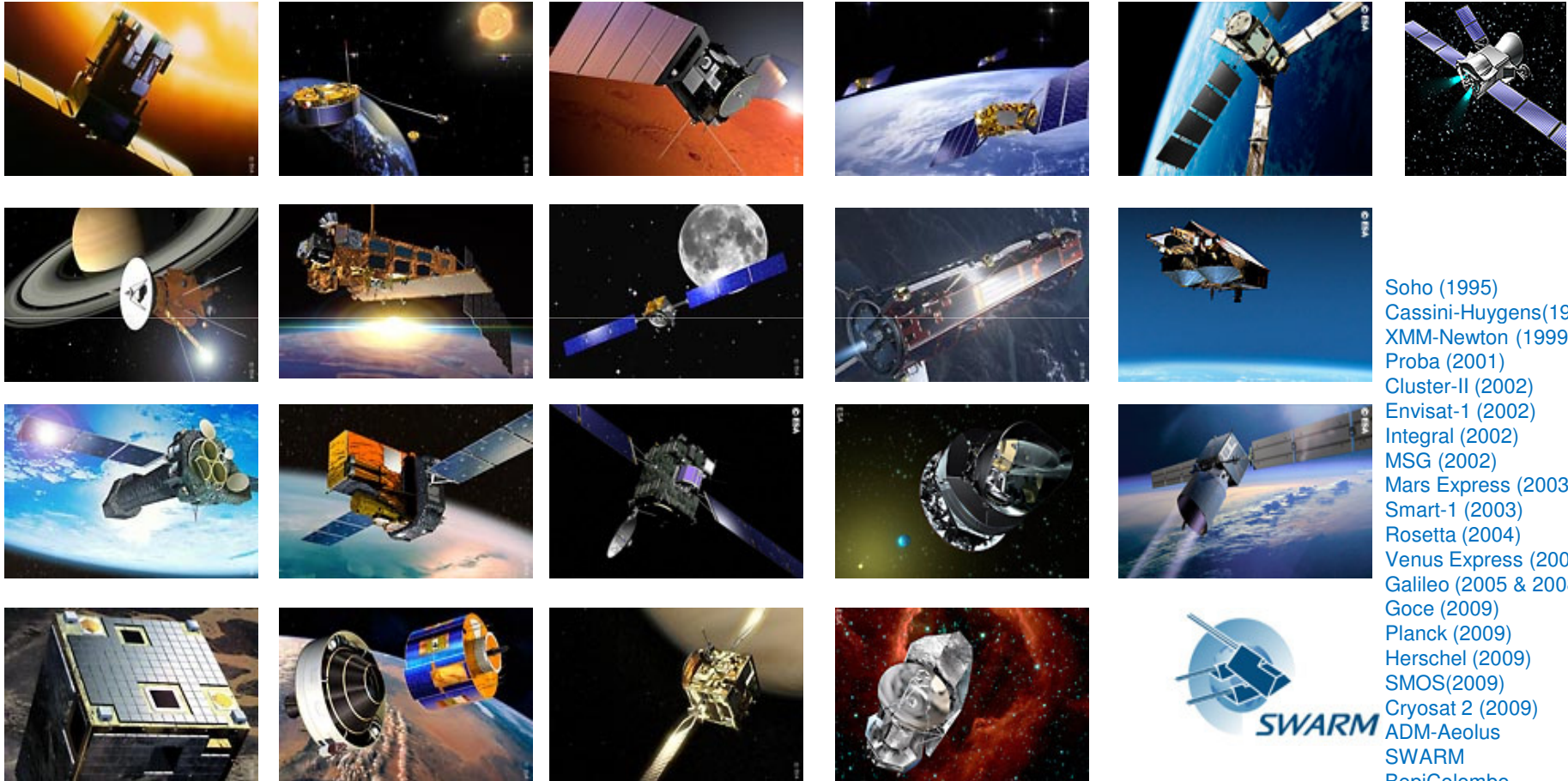


Jaan Praks, Dr.Sc.

Department of Radio Science and  
Engineering  
Aalto University

**Aalto-1**  
The Finnish Student Satellite

# Full member of ESA for 19 years

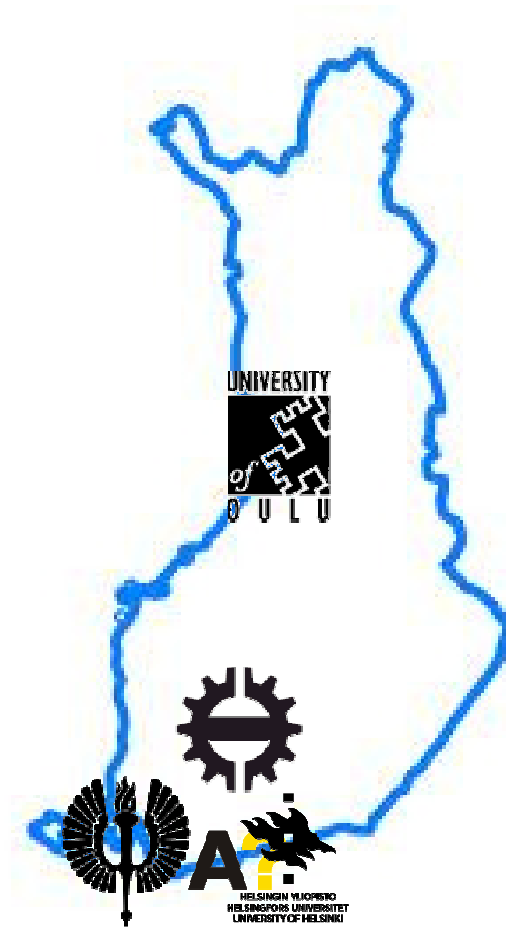


- Soho (1995)
- Cassini-Huygens(1997)
- XMM-Newton (1999)
- Proba (2001)
- Cluster-II (2002)
- Envisat-1 (2002)
- Integral (2002)
- MSG (2002)
- Mars Express (2003)
- Smart-1 (2003)
- Rosetta (2004)
- Venus Express (2005)
- Galileo (2005 & 2008)
- Goce (2009)
- Planck (2009)
- Herschel (2009)
- SMOS(2009)
- Cryosat 2 (2009)
- ADM-Aeolus
- SWARM
- BepiColombo



# Space topics at Finnish Universities

- Aalto University
  - Space Technology and Science
  - Robotics
  - Erasmus Mundus SpaceMaster programme
- Helsinki University
  - Master's Degree Programme in Space Sciences
- University of Turku and Tuorla Observatory
  - Astronomy and space physics
- University of Oulu
  - Space physics
- Tampere Technical University
  - Some courses in Space Technology



A?



# Aalto starts new Master programmes in 2015



A new Master programme on **Nano and Radio Sciences** starts in autumn **2015**.

- New **Space Sciences and Technology** Major.
- Tight integration with radio- and nanosciences.
- Collaboration with Joint European ERASMUS MUNDUS Space Master programme.
- Collaboration with Nordic Five Tech.

mobile communications  
student satellite  
space weather  
radio science  
solar panels  
cubesat  
nanotechnology  
integrated circuits  
antennas  
Aalto-1  
sensors  
wireless  
microfabrication  
radio astronomy  
electromagnetic

**New professors on  
Space topics at  
Aalto University  
Department of Radio  
Science and  
Engineering**



Aalto University

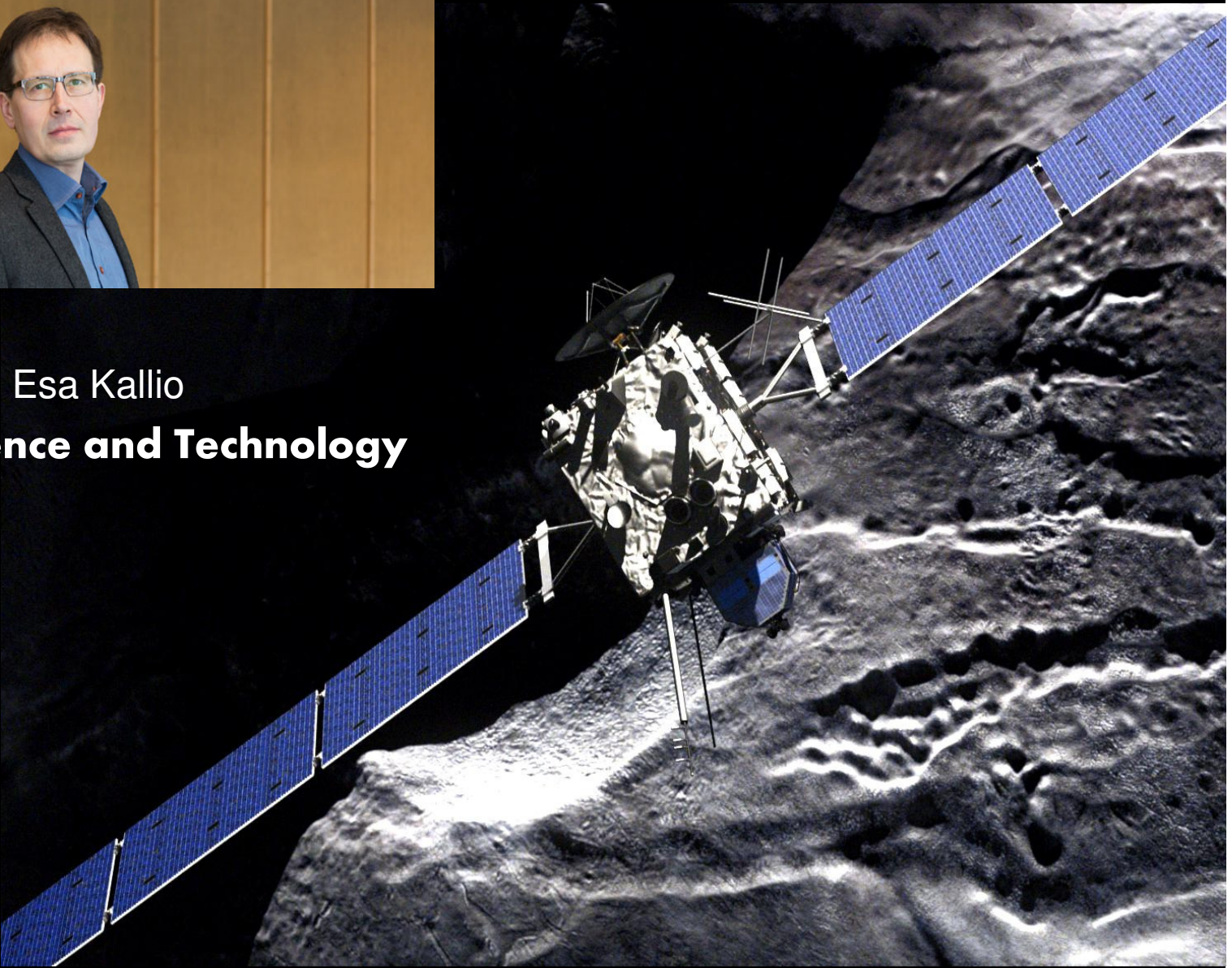
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Tuija Pulkkinen

**Space Science**



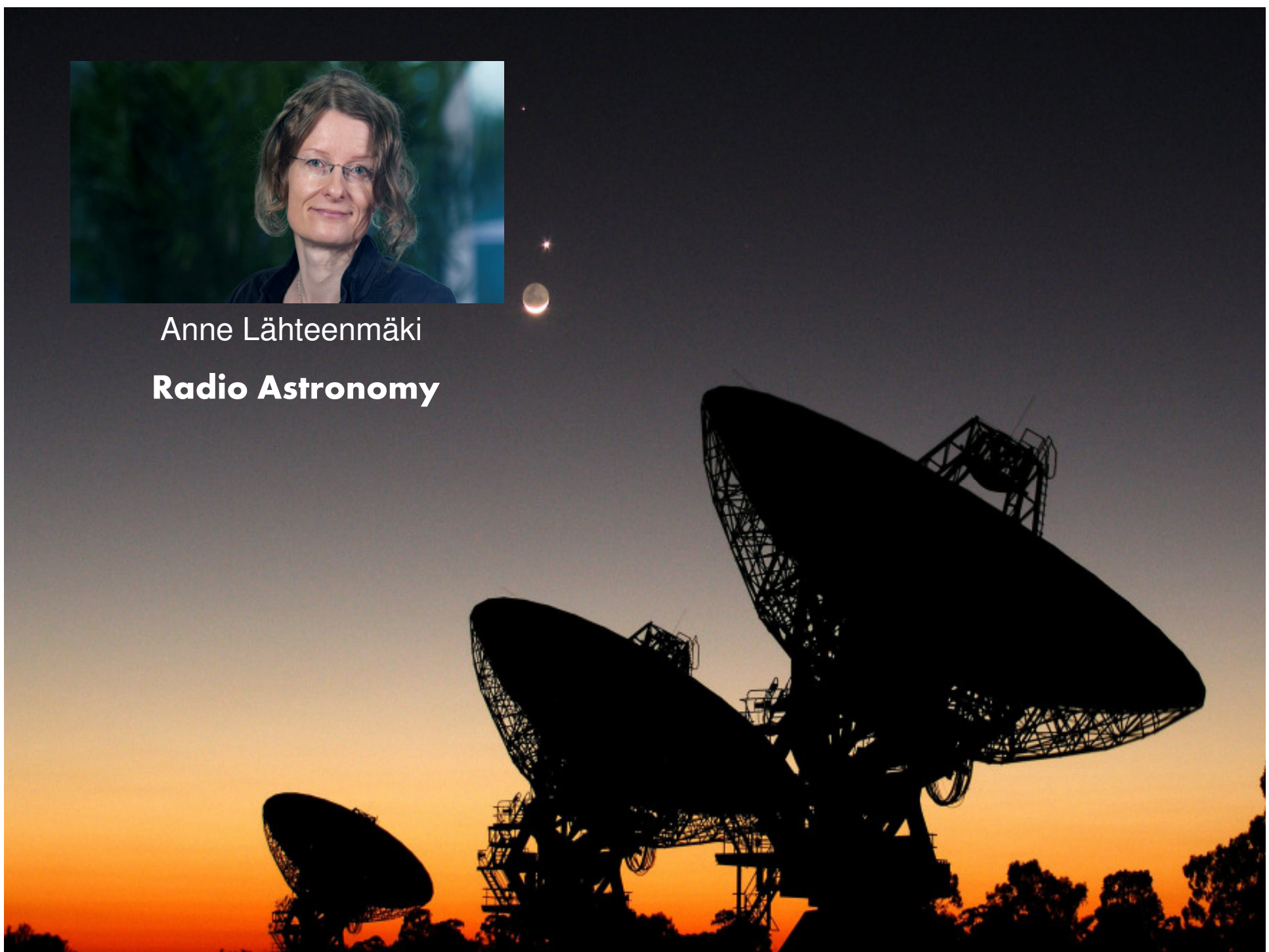
Esa Kallio  
**Space Science and Technology**







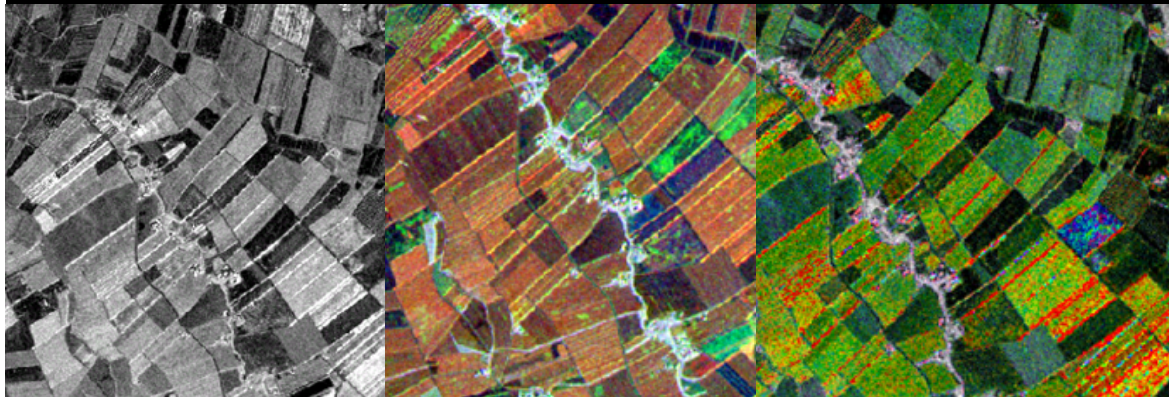
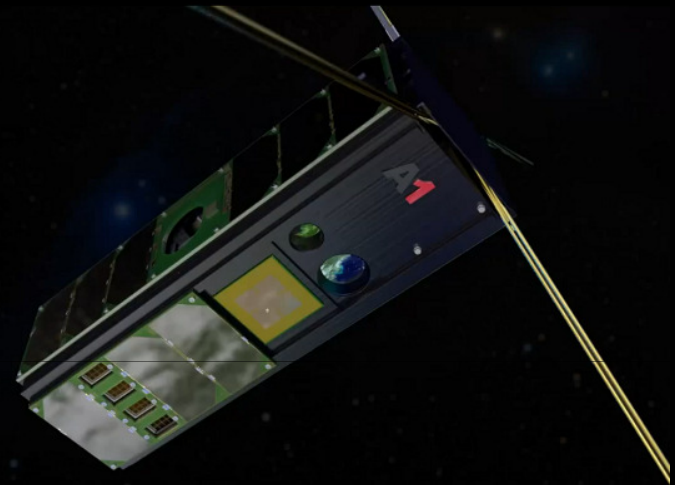
Anne Lähteenmäki  
**Radio Astronomy**





Jaan Praks

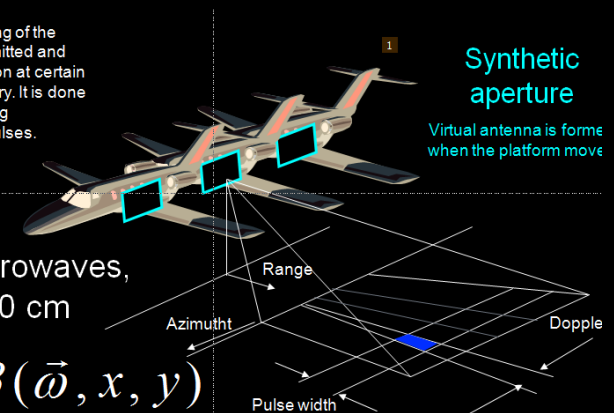
## Microwave Remote Sensing



Backscattering of the  
direction of transmitted and  
polarization at certain  
incidence geometry. It is done  
by receiving  
reflected EM pulses.

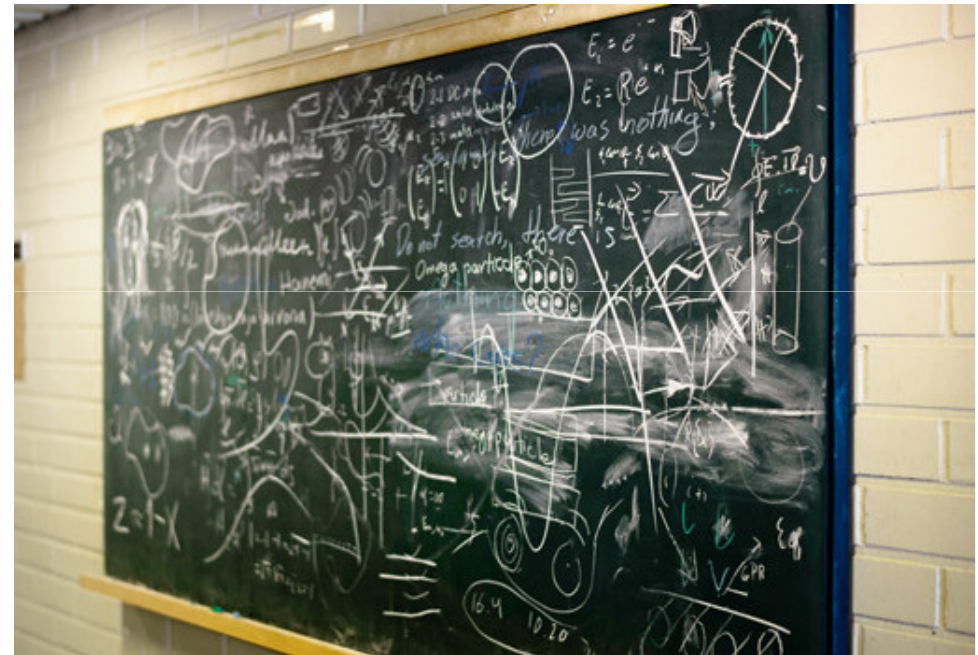
microwaves,  
wavelength 10 cm

$$\beta(\vec{\omega}, x, y)$$



# Space related research topics at Department of Radio Science and Engineering

- Space weather
- Ionosphere
- Planetary atmosphere
- Asteroids
- Nanosatellites
- Microwave instruments
- Satellite sensors
- Radio astronomy
- Nanosatellite platforms
- Airborne microwave remote sensing
- Millimeter wave technology



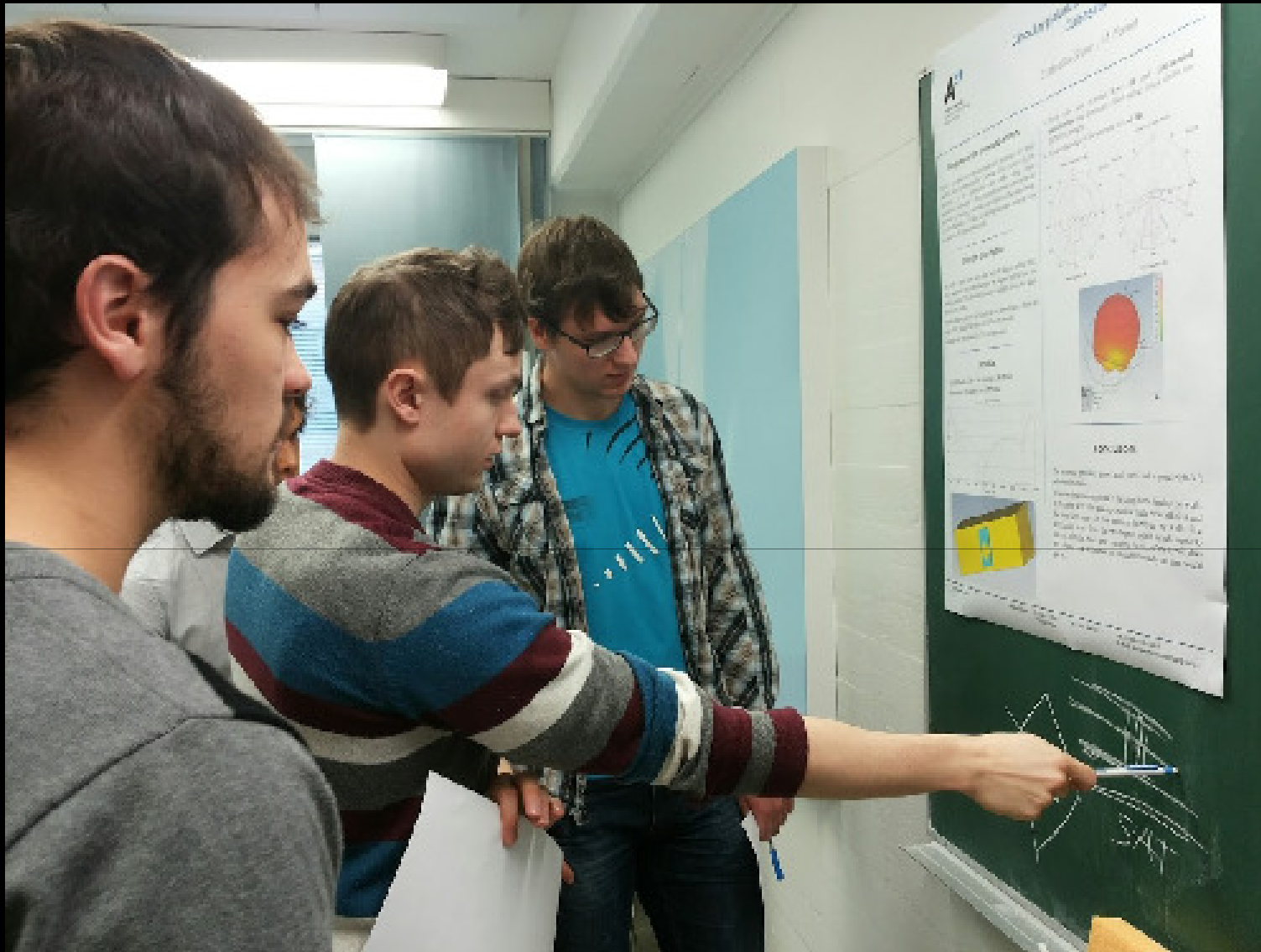
# Education: Learning by doing



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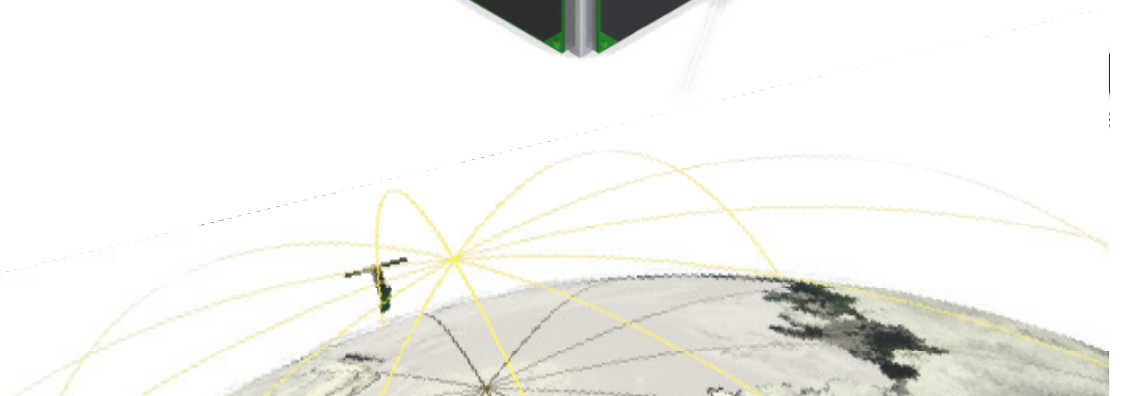
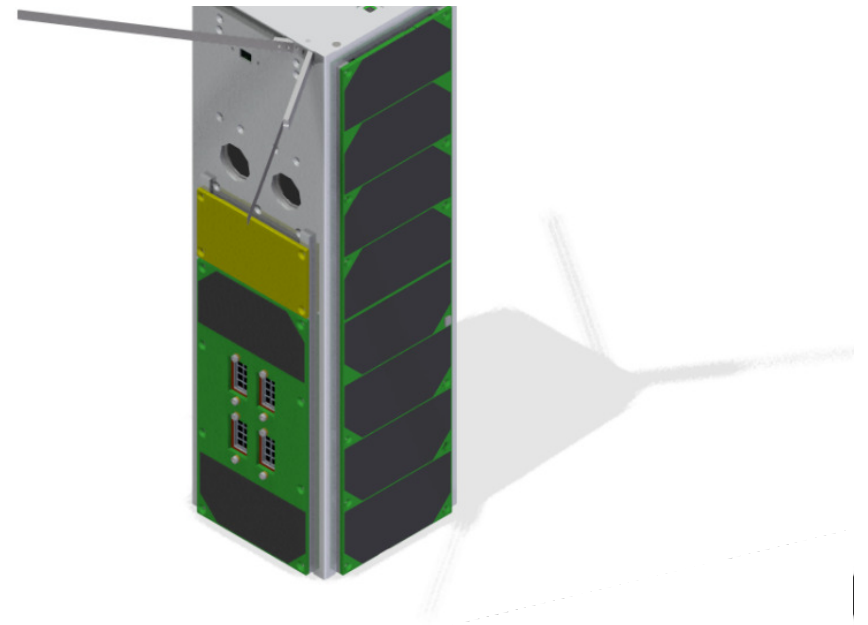
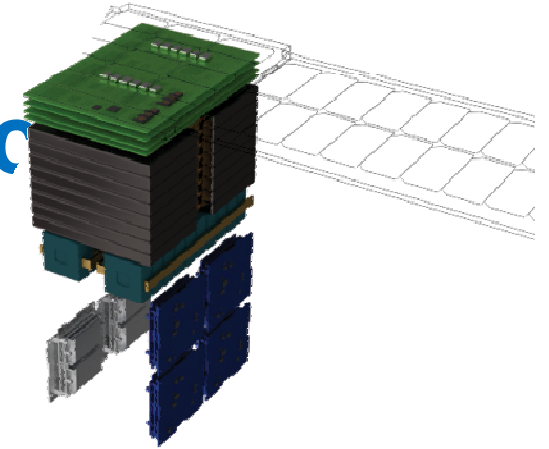
LUMA program for gymnasiums

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# Current small satellite projects at Aalto University

- Aalto-1 CubeSat
- Aalto-2 CubeSat
- ICEYE spin-off project



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University of  
Helsinki



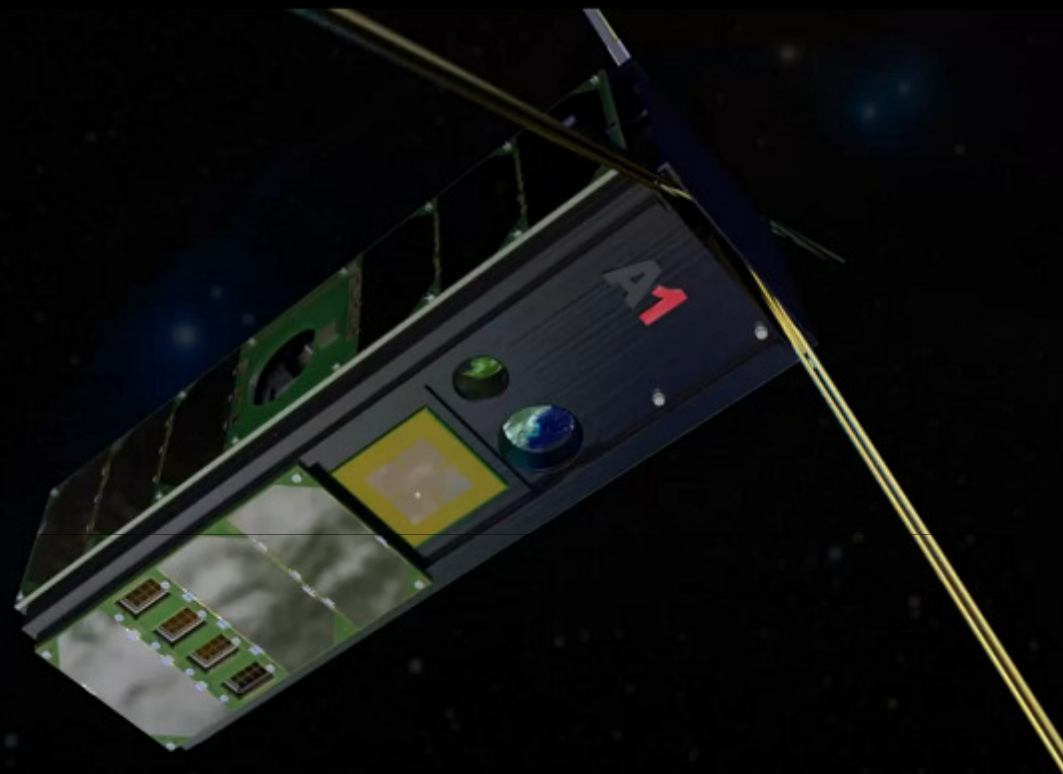
UNIVERSITY OF JYVÄSKYLÄ



**Aalto University**  
Multidisciplinary Institute of  
Digitalisation and Energy



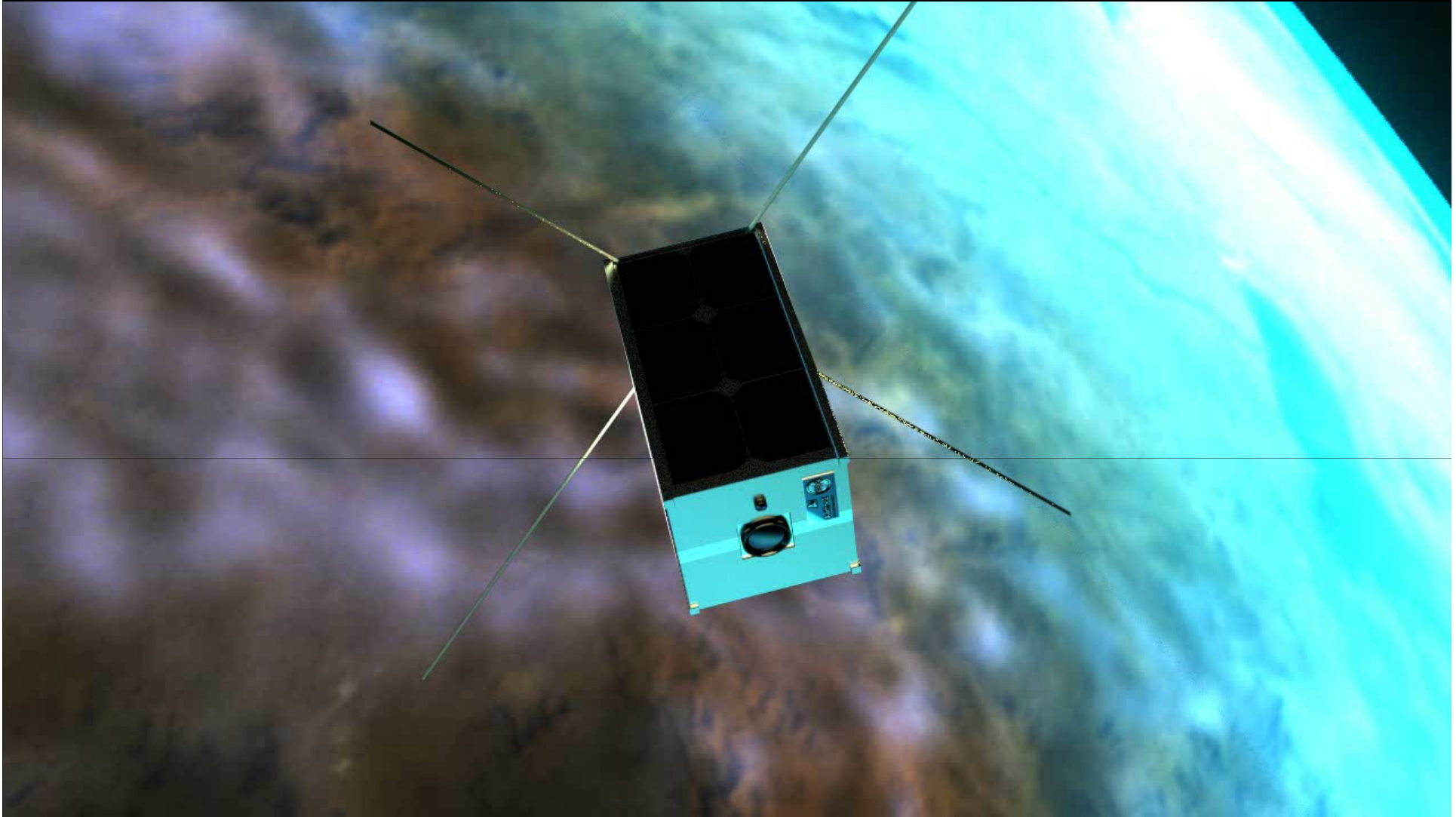
Turun yliopisto  
University of Turku



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# Aalto-2



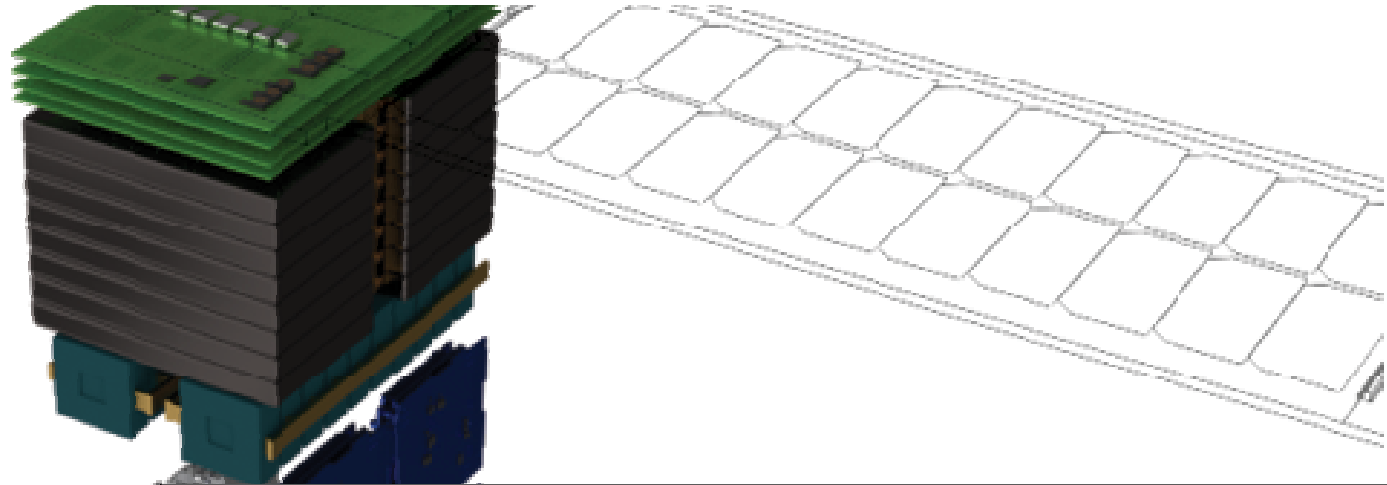


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**ICEYE**  
Arctic Intel

UUTISET: Joka kymmenes lapsi tekee töitä

# Kauppalehti

ISSN 1456-3497  
DINONUMERO 2.604, YHÄTTUNÄ 1.336/PV 169 90 / 2014  
WWW.KAUPPALLEHTI.FI / MOBIILE: M.K.L. / APP: KAUPPALLEHTI  
PERUSTETTU VUONNA 1998

TIISTAINA  
13. TOUKOKUUTA 2014



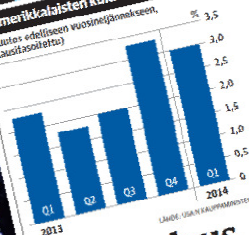
## Matkalla avaruuteen

Antti Kestilän, Pekka Laurilan ja Rafael Modrzewskin yritys on ensimmäisenä suomalaisena lähdössä kaupallisille satelliittimarkkinoille. Arktista jääinformaatiota tarjoava yritys tähtää satojen miljoonien eurojen liikevaihtoon.

OMA YRITYS » 16-17

### A UUTISET

Amerikkalaisten kulutuskykyä  
mittaus edelliseen vuosiin (tammi-kuu)



USA:n talous voi yllättää iloisesti

### B REPORTAASI



Japani käynnistää varovasti ydinvoimaloitaan

### C PÖRSSI

Netflixiä naitetaan Applelle

OMXH +0,72%



Tilaa oma Kauppalehti! Tutustu ajankohtaisiin tarjouksiin ja keuhkotilaajien etuihin osoitteessa [www.kauppalehti.fi/asiakaspalvelu](http://www.kauppalehti.fi/asiakaspalvelu). Tilaukset: Valtatie 010 665 101, Kauppalehti Asiakaspalvelu puh. 010 665 2100 sähköposti: [k.asiakaspalvelu@kauppalehti.fi](mailto:k.asiakaspalvelu@kauppalehti.fi)

**ICEYE**  
Arctic Intel

# Nanosatellites as education platform





# Increasing hands-on teaching



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Google

Drive

My Drive > Aalto-1 > Attitude & Orbit Control

TITLE	OWNER	LAST MODIFIED
A1-AOC-PL-02-v1-DRAFT Sun Sensor Test Plan and Procedures Shared	Tuomas Tikka	16:31 Tuomas Tikka
A1-AOC-TR-01-v1-DRAFT Sun Sensor Test Results Shared	Tuomas Tikka	16:29 Tuomas Tikka
A1-AOC-DD-03-DRAFT Sun Sensor Design Shared	Tuomas Tikka	21 May Maria Komu
A1-AOC-PL-01-DRAFT Sun Sensor Verification Plan Shared	Tuomas Tikka	21 May Maria Komu
BST-Aalto Skype meetings Shared	Tuomas Tikka	2 May Tuomas Tikka
Integration of a GPS subsystem into the Aalto-1 nanosatellite, master's thesis, Hannu Leppinen Shared	Hannu Leppinen	22 Apr Hannu Leppinen
plasma_brake_deployment_scenario_Janne_Heikinheimo Shared	Motta Pietro	16 Apr Motta Pietro
A1-AOC-DD-02-v1-DRAFT Design of the GPS subsystem Shared	Hannu Leppinen	24 Feb Hannu Leppinen
GPS subsystem FMECA Shared	Hannu Leppinen	15 Feb Hannu Leppinen
IAA-CU-12 Attitude Determination and Control System Implementation for the Aalto-1 Nanosatellite v2.pdf Shared	Tuomas Tikka	12 Feb Tuomas Tikka
GPS design presentation.pdf Shared	Tuomas Tikka	24 Jan Tuomas Tikka
A1-AOC-TR-02-DRAFT GPS Antenna Performance Test Report Shared	Hannu Leppinen	2 Jan Hannu Leppinen
simulation model for plasma break Shared	O.k .m	30/12/2012 Teemu Nie
gpseagle.zip Shared	Hannu Leppinen	30/12/2012 Teemu Nie
gps_circuit_schematic.vsd Shared	Hannu Leppinen	30/12/2012 Teemu Nie
Attitude_Dynamics_Analysis_of_aalto1_During_PBE.pdf Shared	O.k .m	30/12/2012 Teemu Nie
A1-AOC-TR-03-DRAFT GPS Signal Simulations Test Report Shared Document DRAFTS, Test Reports	Hannu Leppinen	30/12/2012 Teemu Nie
A1-AOC-TN-01-v1 ADCS Trade-Off.pdf Shared	Tuomas Tikka	30/12/2012 Teemu Nie
A1-AOC-DD-01-v5 Design of Attitude and Orbit Control System.pdf Shared Documents	Tuomas Tikka	30/12/2012 Teemu Nie
Aalborg Toolbox (original, backup) Shared	Hannu Leppinen	30/12/2012 Teemu Nie
Recommended GPS receiver parameters Shared	Hannu Leppinen	30/12/2012 Teemu Nie
Fastrax_GPS_application_design_2010_b.pdf Shared	Hannu Leppinen	30/12/2012 Teemu Nie
it03.lbr Shared Aalto-1	Hannu Leppinen	30/12/2012 Teemu Nie
Preliminary GPS simulations 3 (few satellites visible) Shared	Hannu Leppinen	04/12/2012 Teemu Nie
GPS antenna comparison Shared	Hannu Leppinen	05/11/2012 Teemu Nie
Preliminary GPS simulation results 2 (Low SNR) Shared	Antti Kestilä	31/10/2012 Teemu Nie
Preliminary GPS simulation results Shared	Antti Kestilä	31/10/2012 Teemu Nie
iADCS operation modes Shared	Tuomas Tikka	06/07/2012 Teemu Nie
GPS Link budget Shared	Hannu Leppinen	03/07/2012 Teemu Nie
Comparison of GPS antenna candidates Shared	Hannu Leppinen	02/07/2012 Teemu Nie

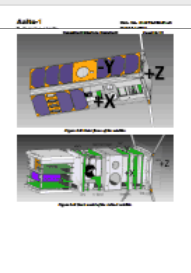
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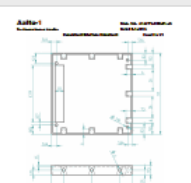
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10



# Aalto-1

The Finnish Student Satellite

Doc. No. A1-SYS-EID-01-v6

Date: 8.1.2013

Experiment Interface Document

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## Aalto-1 Experiment Interface Document

Aalto University

School of Electrical Engineering

	Name	Signature	Date
Prepared by	Antti Kestilä, Antti Näsilä, Maria Komu, Jaan Praks, Anssi Hakkarainen		08.01.2013
Checked by	Antti Kestilä		08.01.2013
Approved by	Antti Kestilä		08.01.2013

- Open access to results
- Self assessment
- Peer review
- Expert reviews

## Assessment Application

Applies to Aalto-1 project related work in courses

- S-92.3192 Spacial Assignment in Space Technology
- S-92.3200 Student Satellite Project

### Applicant details

Applicant Name	
Period under assessment	
Assessed work topic(s)	
Membership in team and names of other team members	

### Workload

Topic	Used hours
Background Research	
Meetings (inc. conference lectures)	
Software writing	
Hardware building and prototyping	
Testing	
Documentation writing	
Other (what?)	
Total	

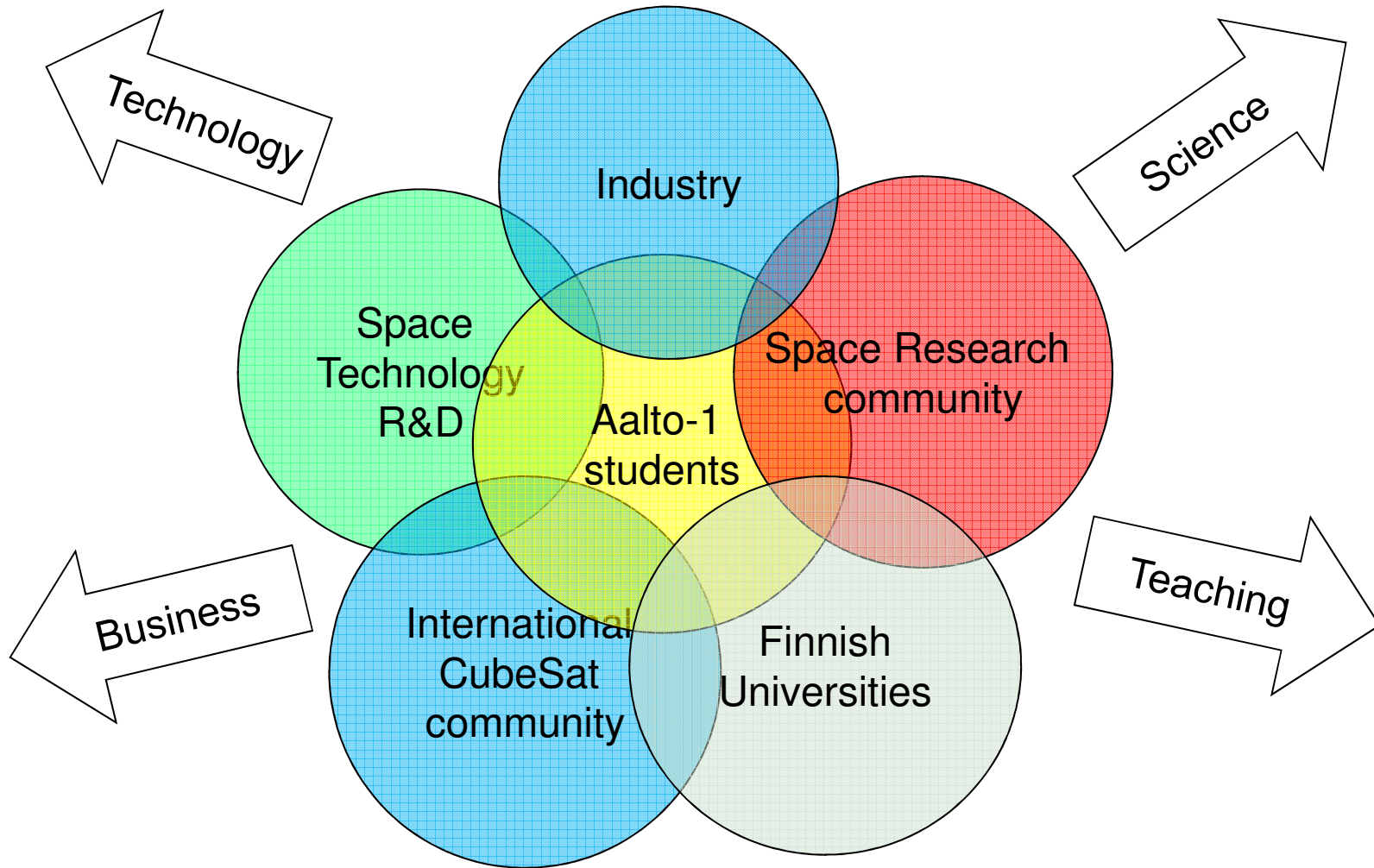
### Brief work description

Should contain:

- Conclusions
- Work definition and goal of the work
- Material (is this work based on previous work, book, other thesis etc)
- Methods (how the work is done, inc. software and tools used etc)



# Challenge and opportunities for students



# Small satellite development and test laboratory



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**Aalto-1**

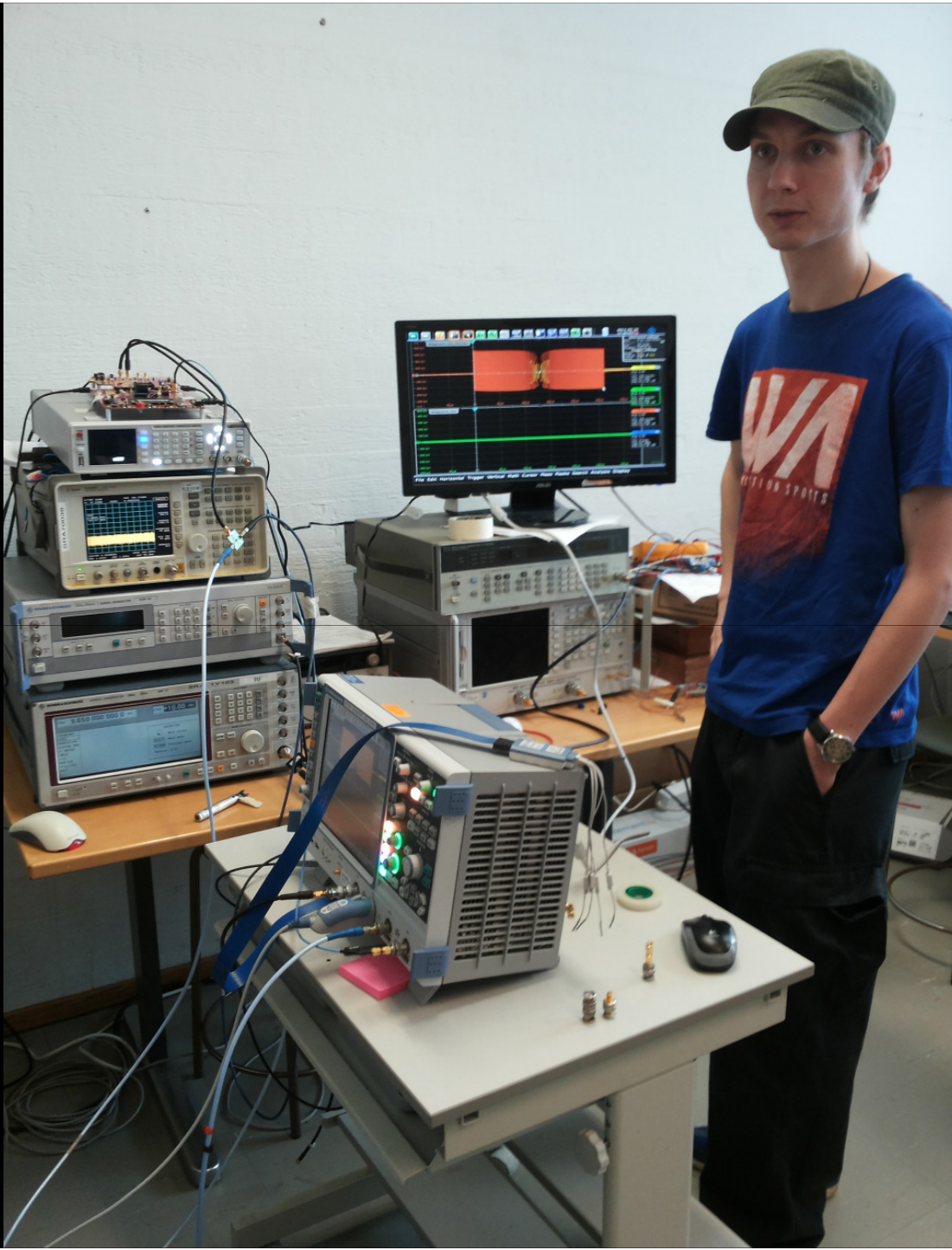
The Finnish Student Satellite







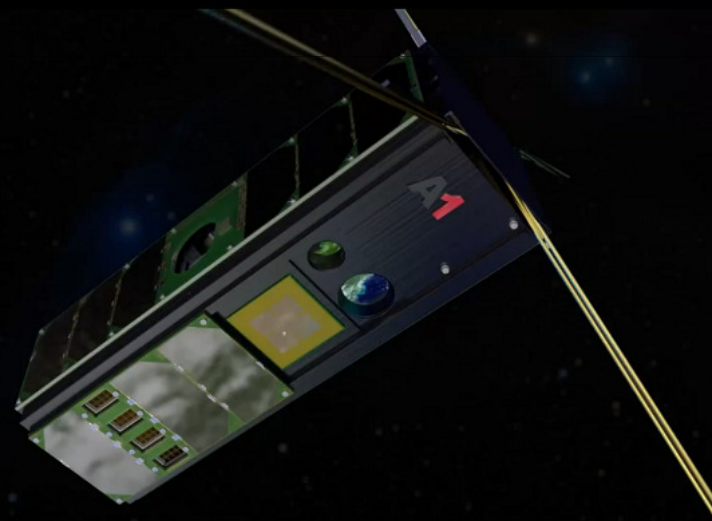
Thermal

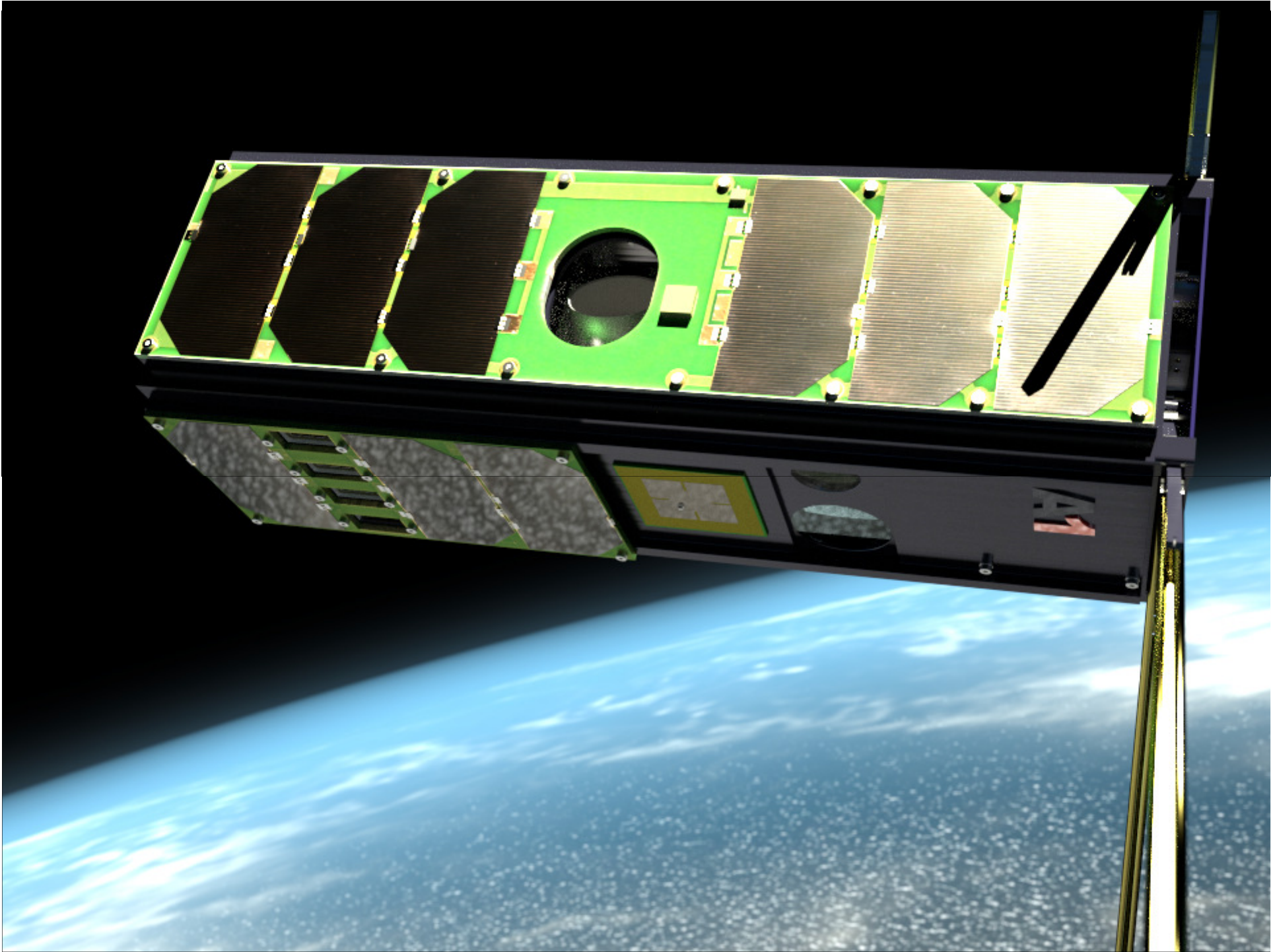


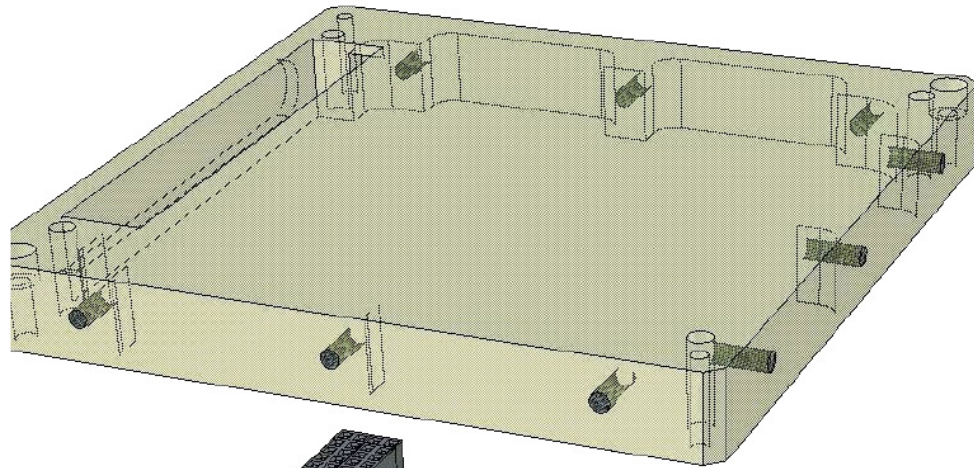




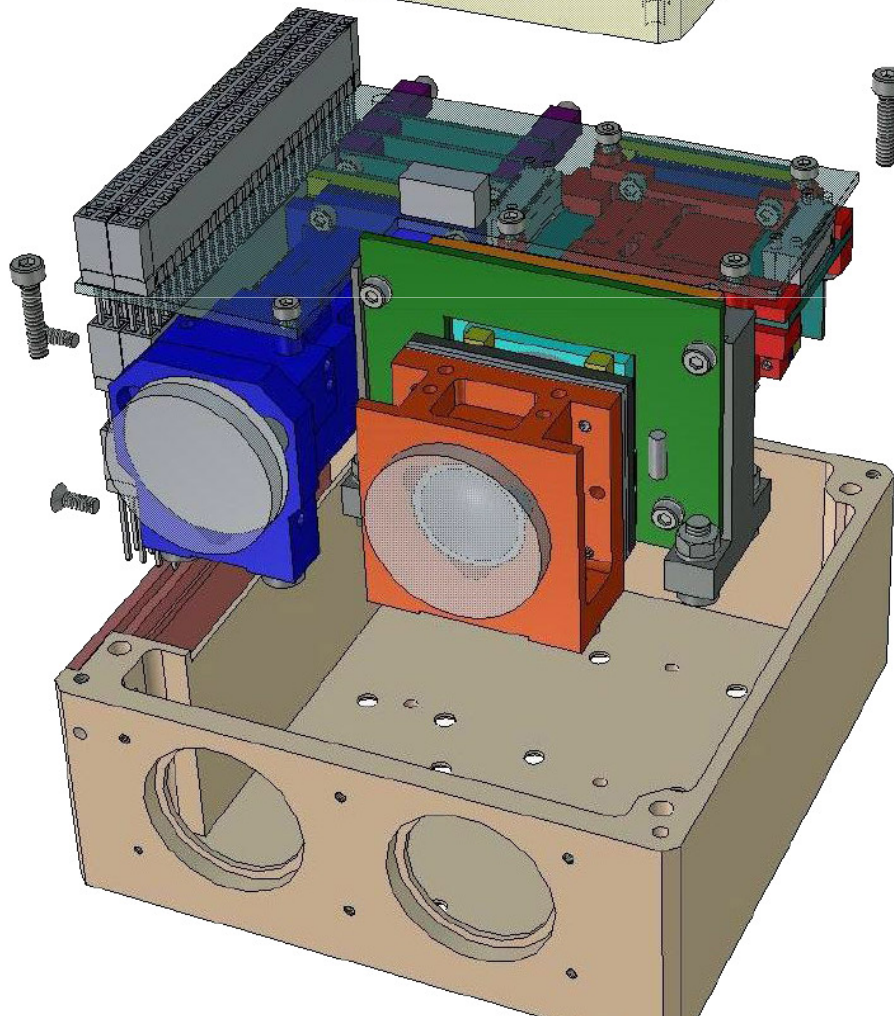
# Aalto-1 status

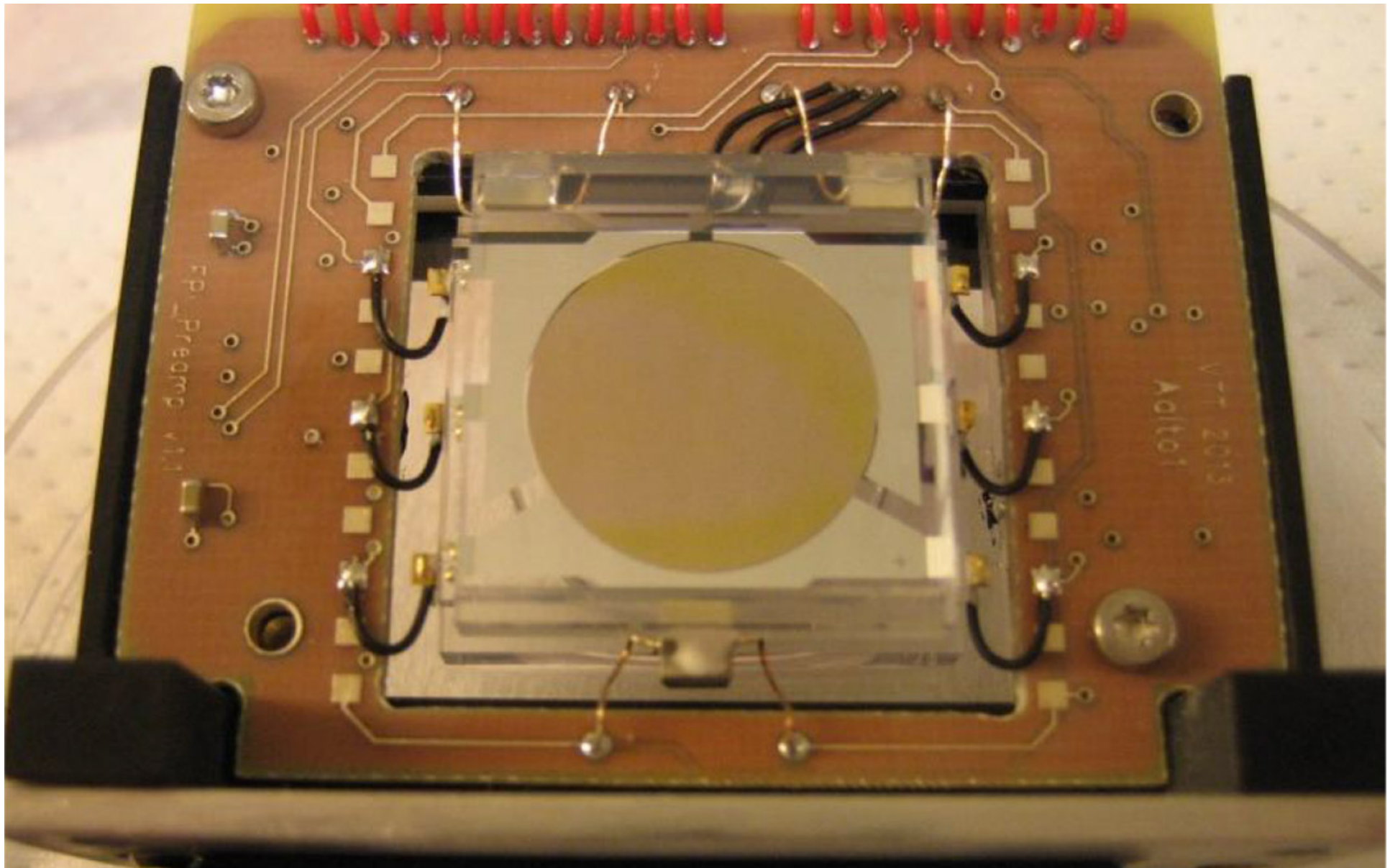




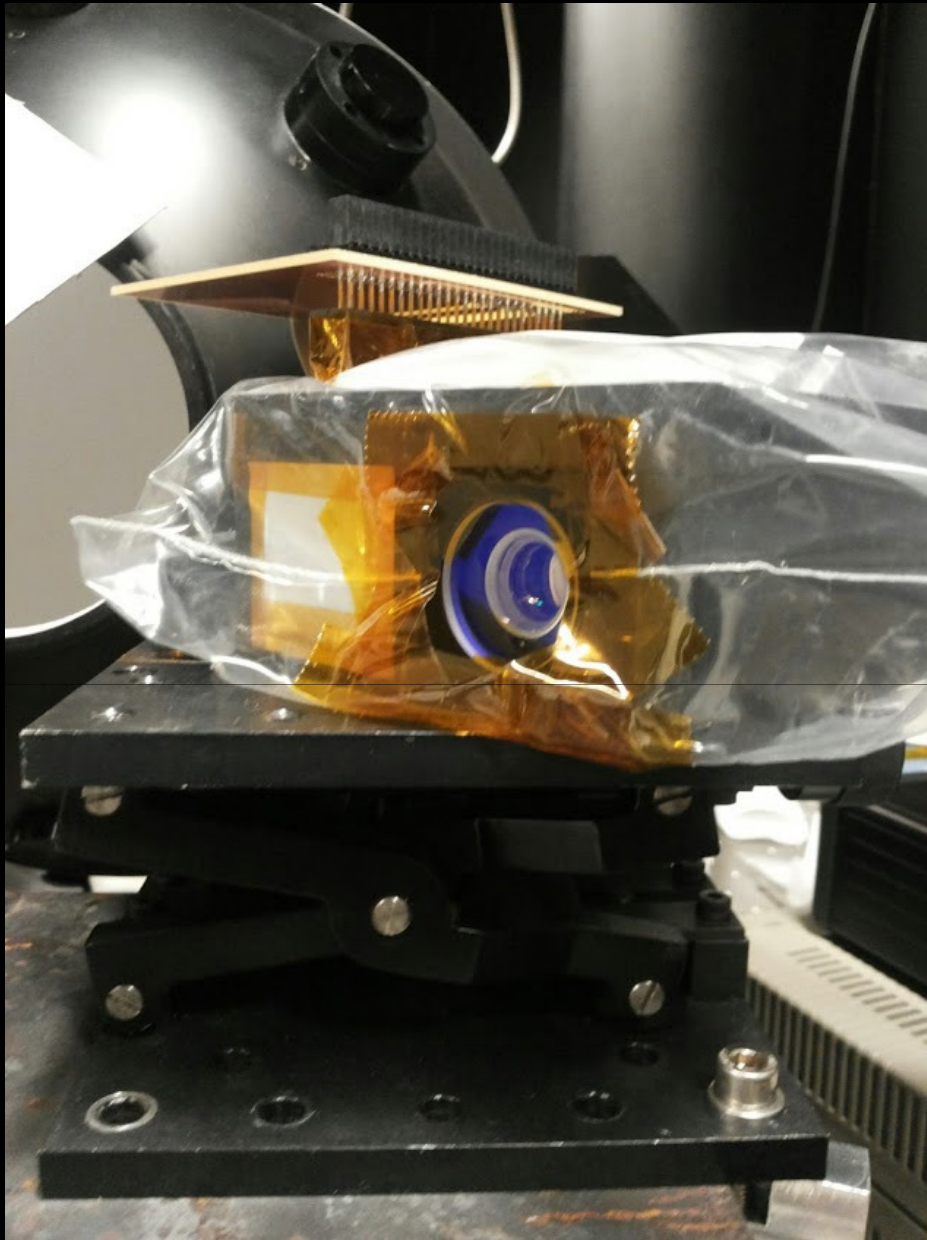


# AaSI – Fabry-Perot Spectral Imager

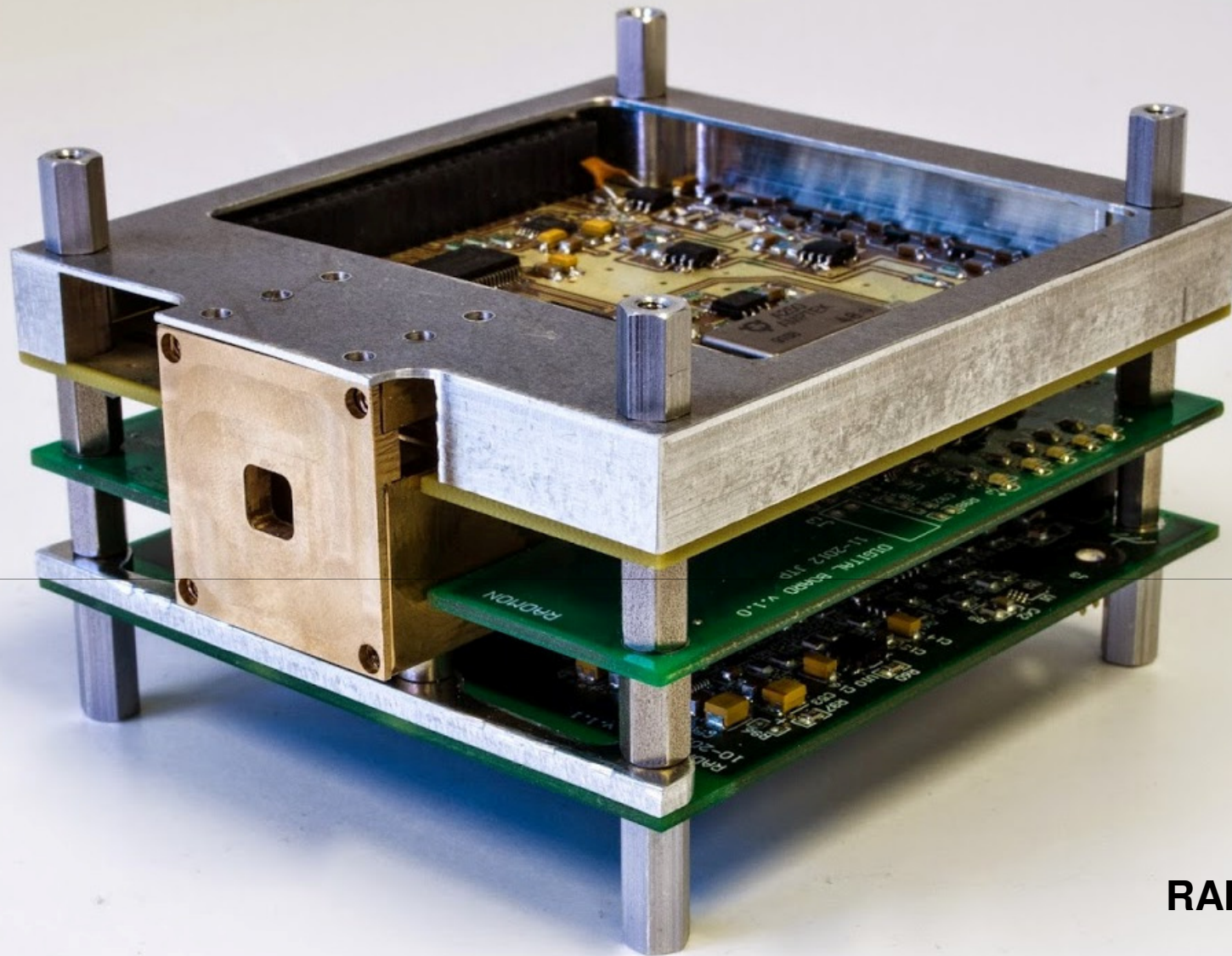








# AaSI Spectral Imager EM



**RADMON EM**



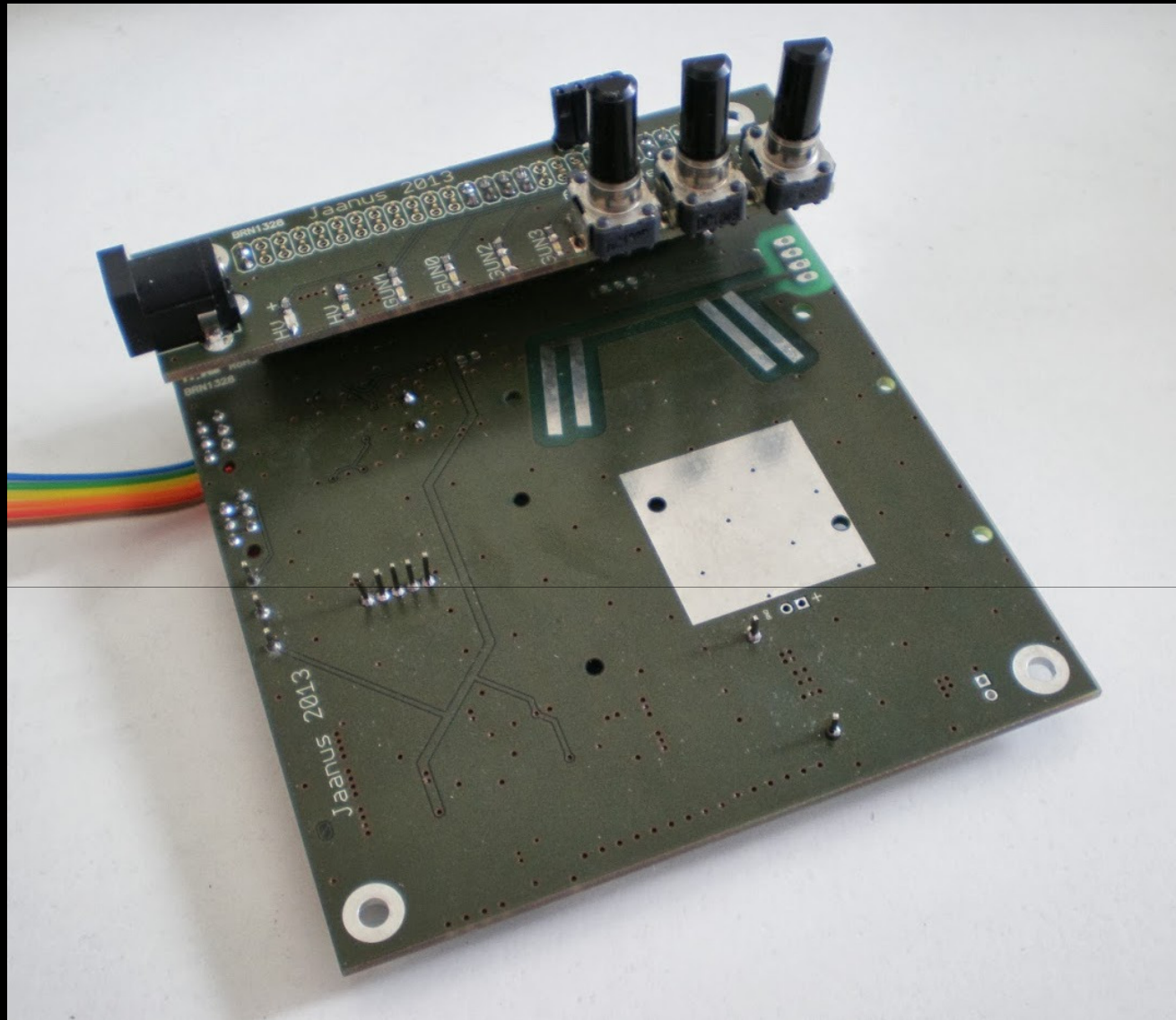
University of  
Helsinki



Turun yliopisto  
University of Turku

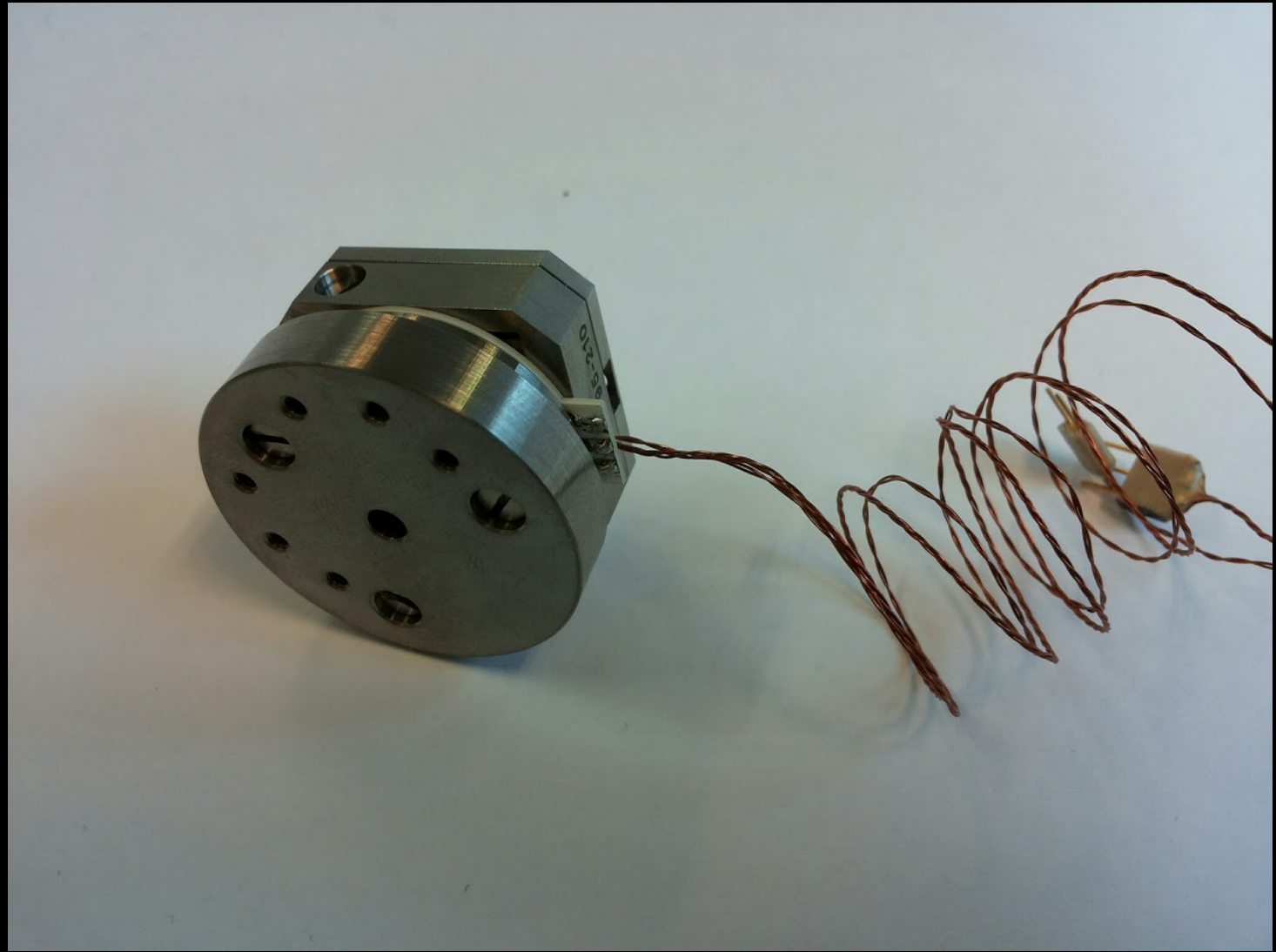


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The Finnish Student Satellite



Motor driver board, ESTCube



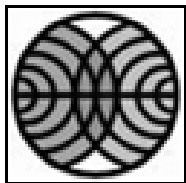
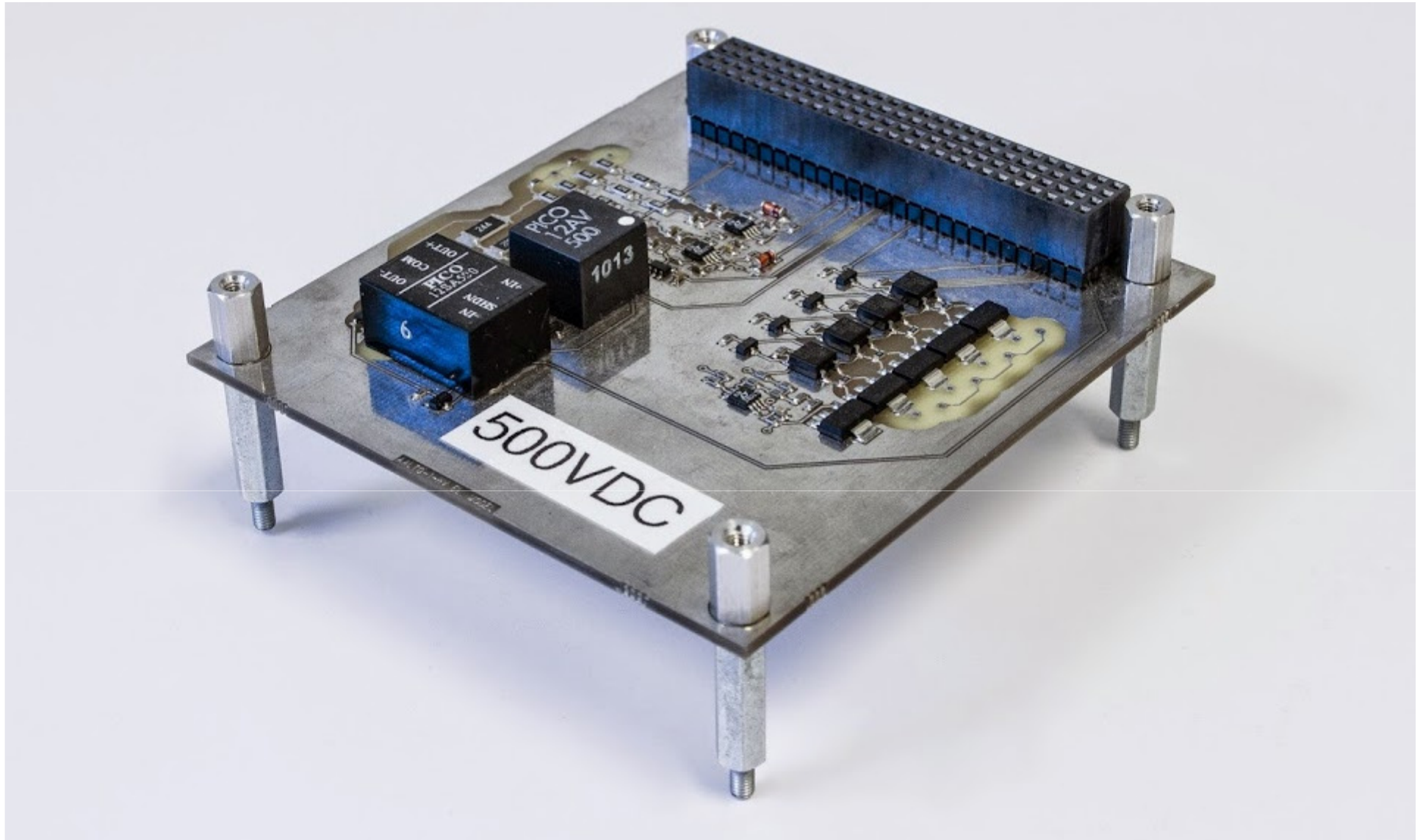


Reel motor by DLR



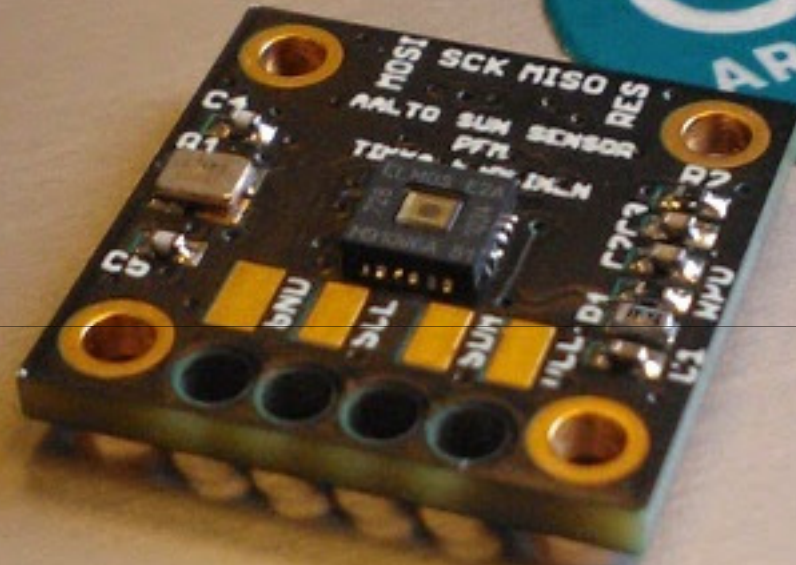
**Aalto-1**

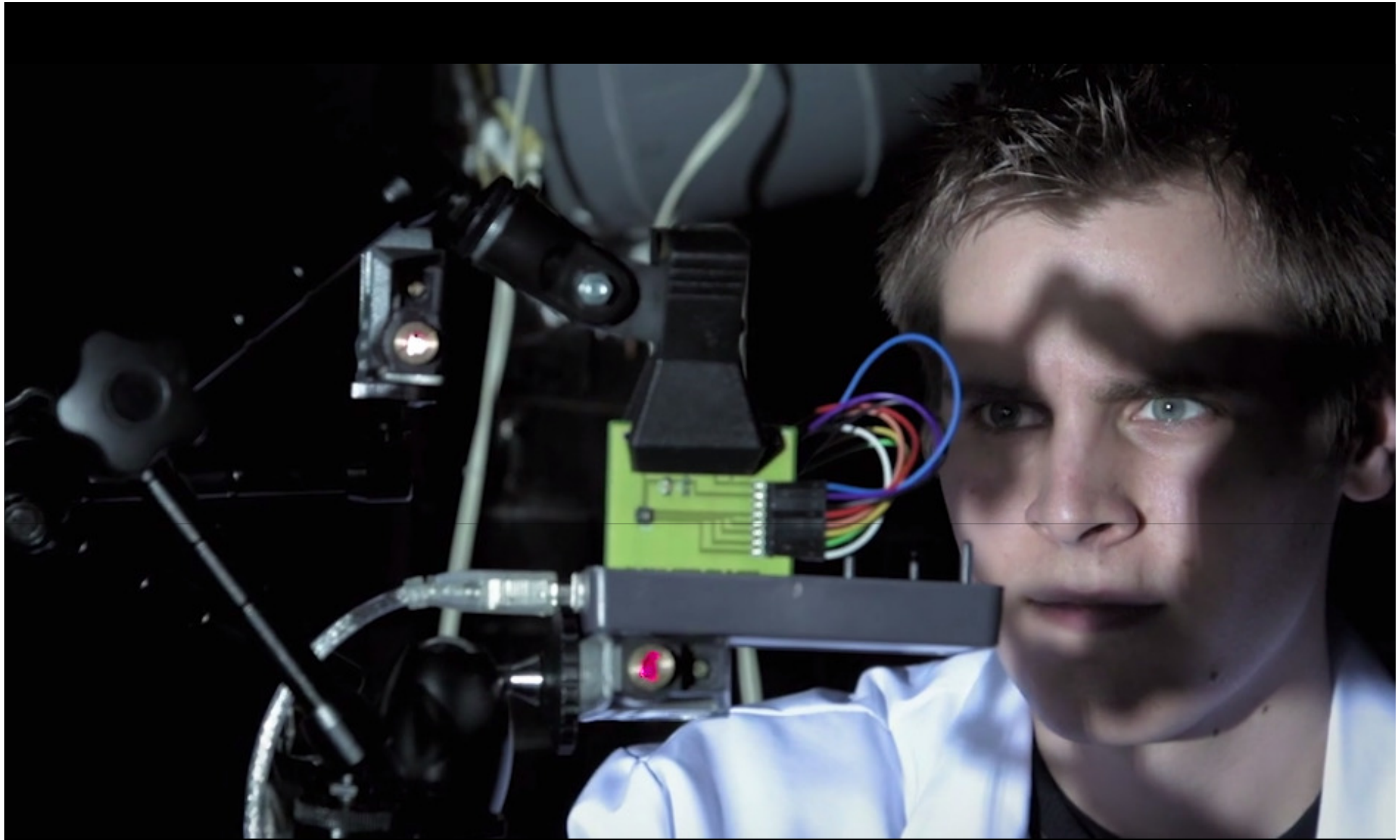
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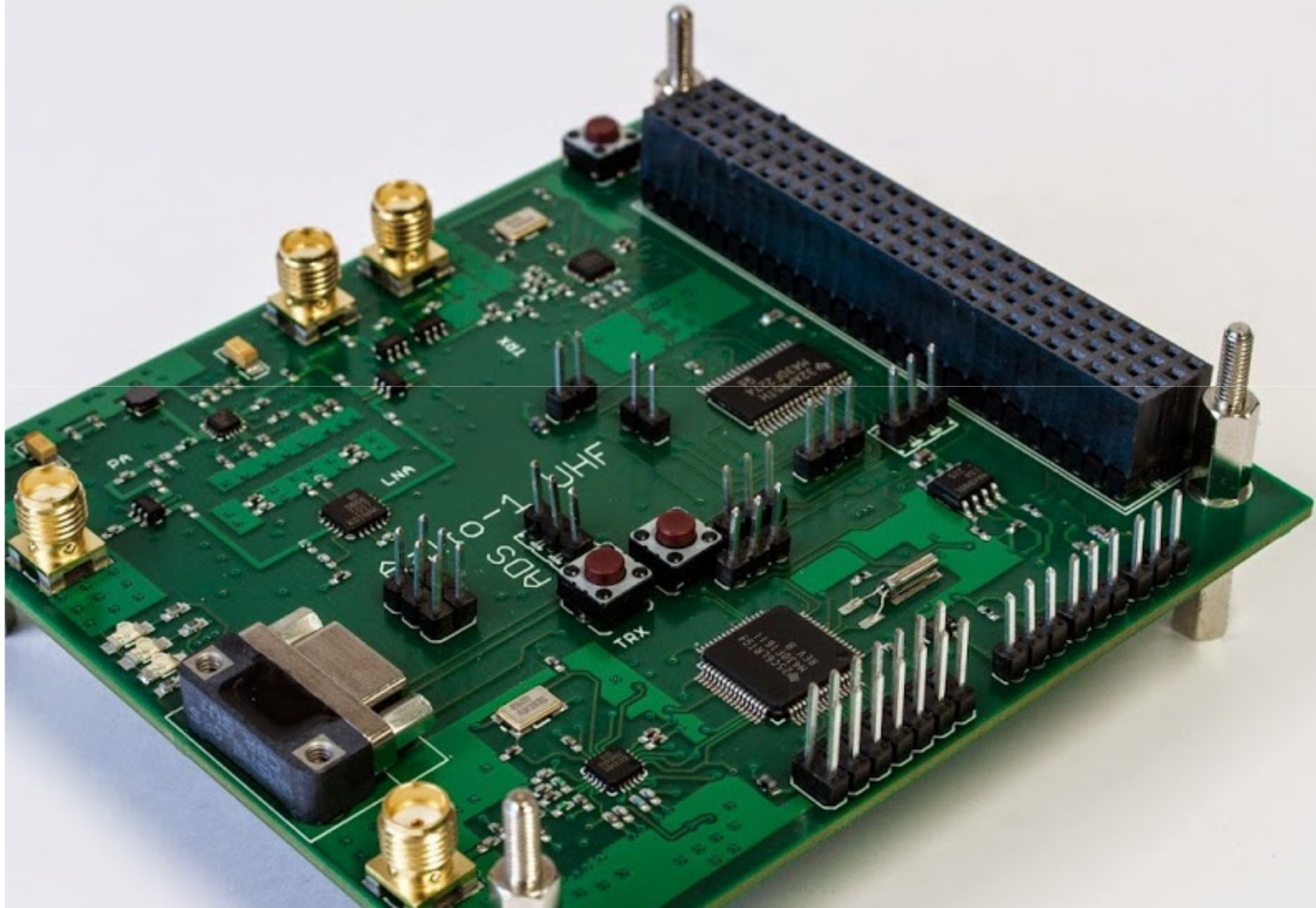
**Aalto-1**  
The Finnish Student Satellite

# Aalto Sun sensor PFM

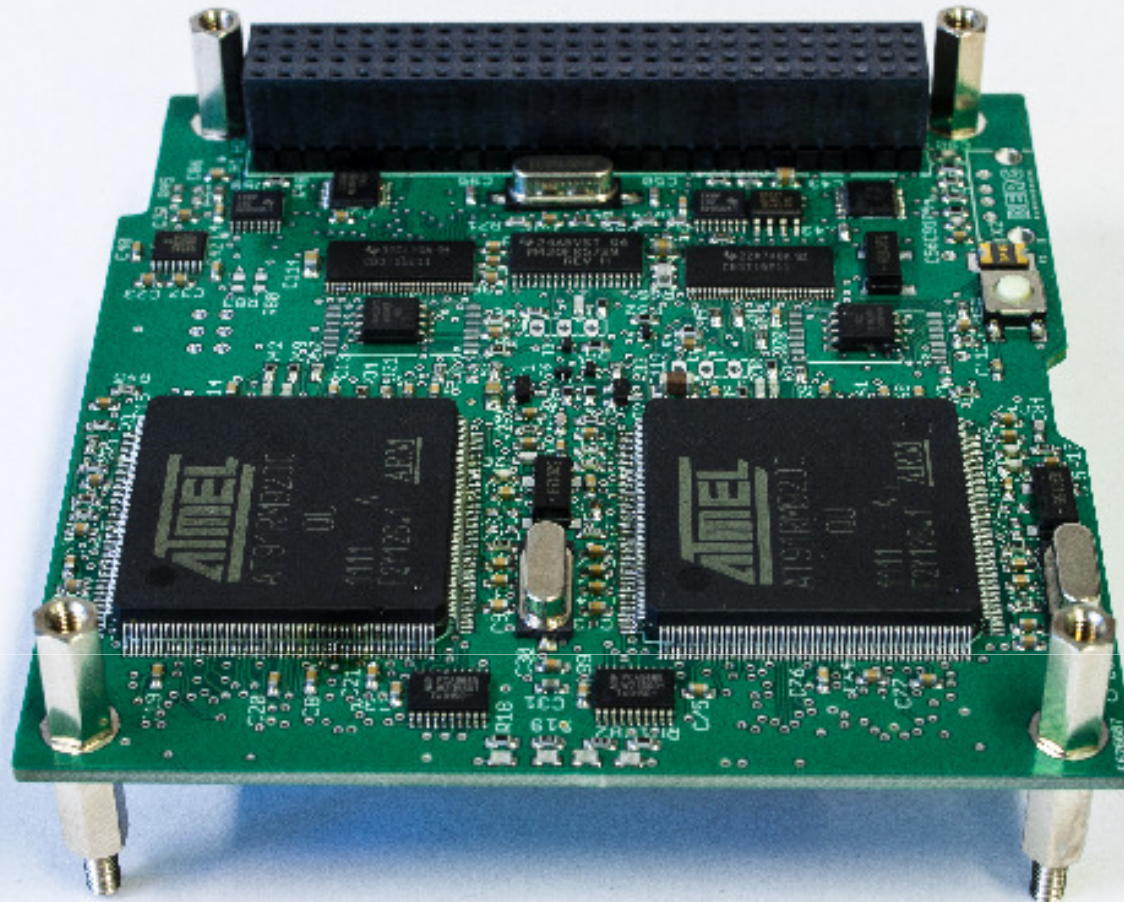




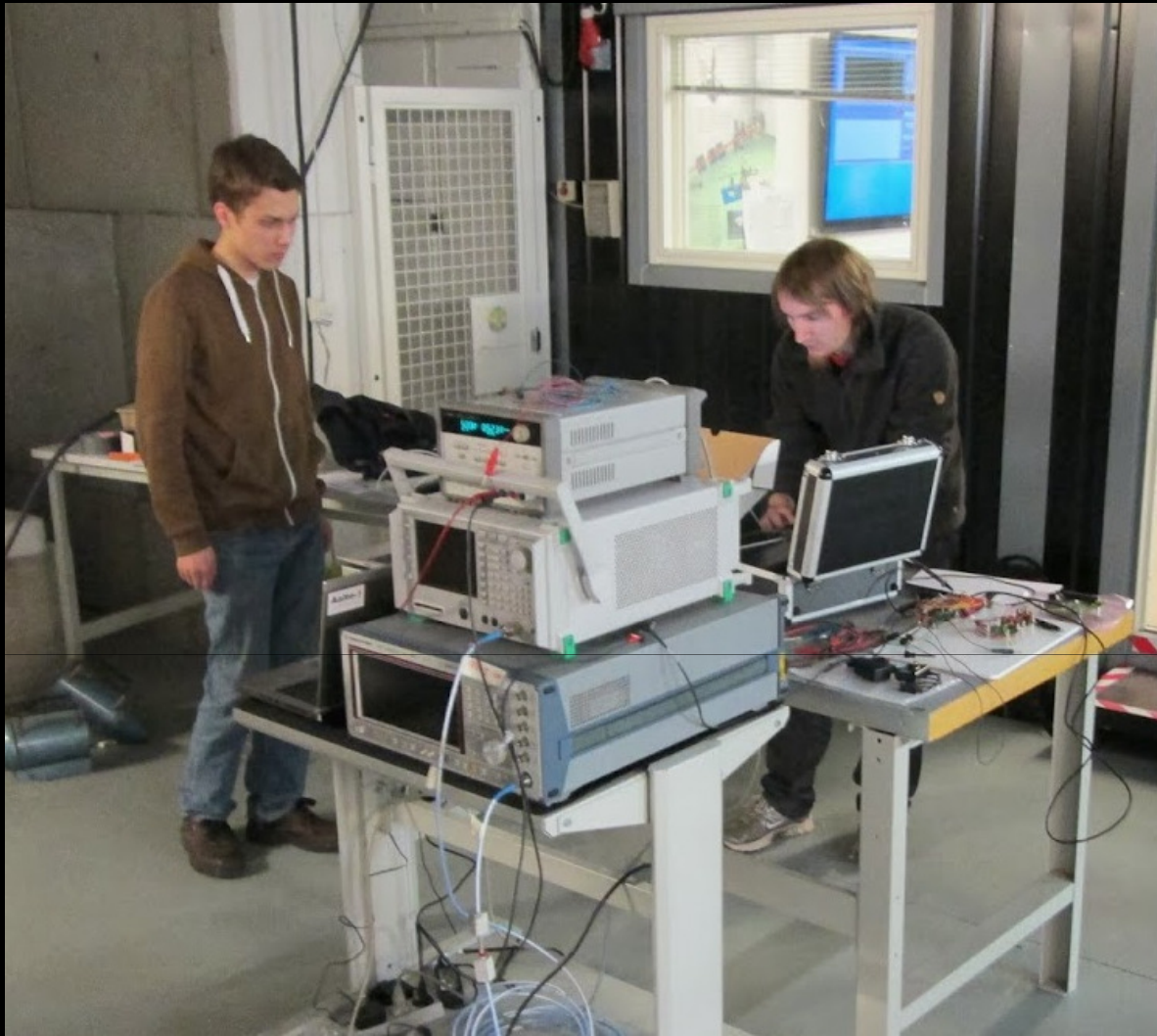
# Aalto-1 UHF Proto







Aalto OBC EM



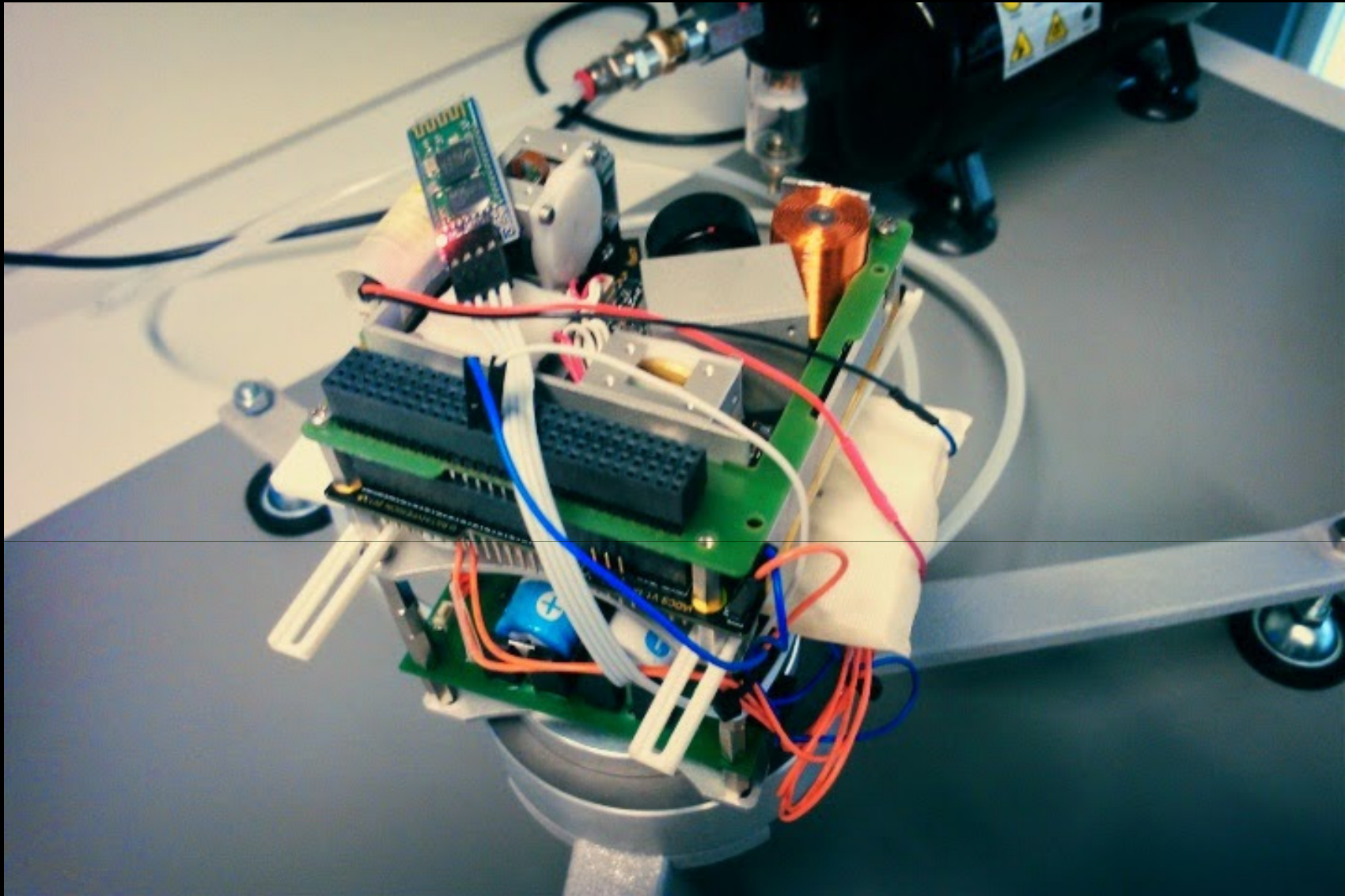




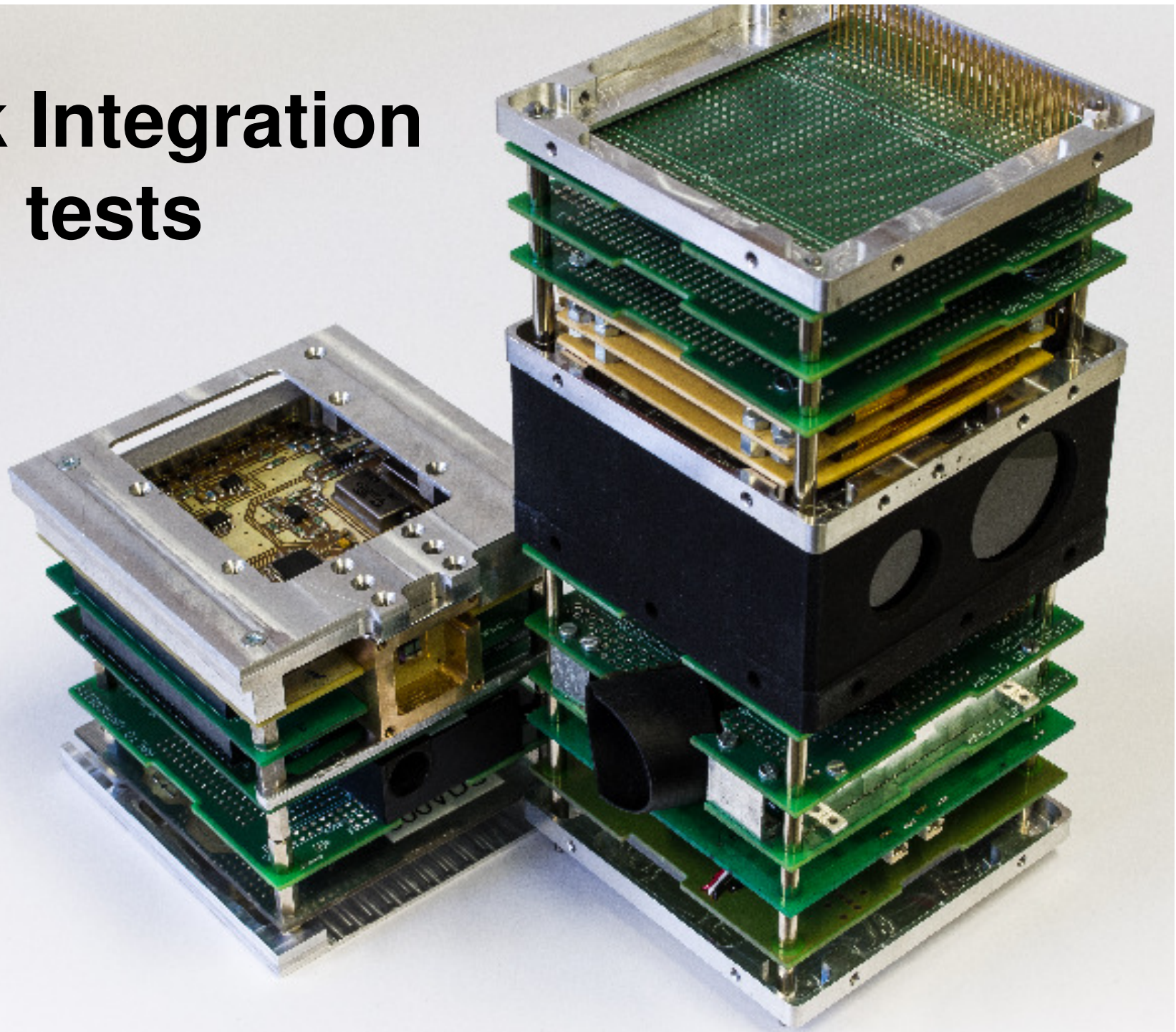
**Aalto-1**  
The Finnish Student Satellite

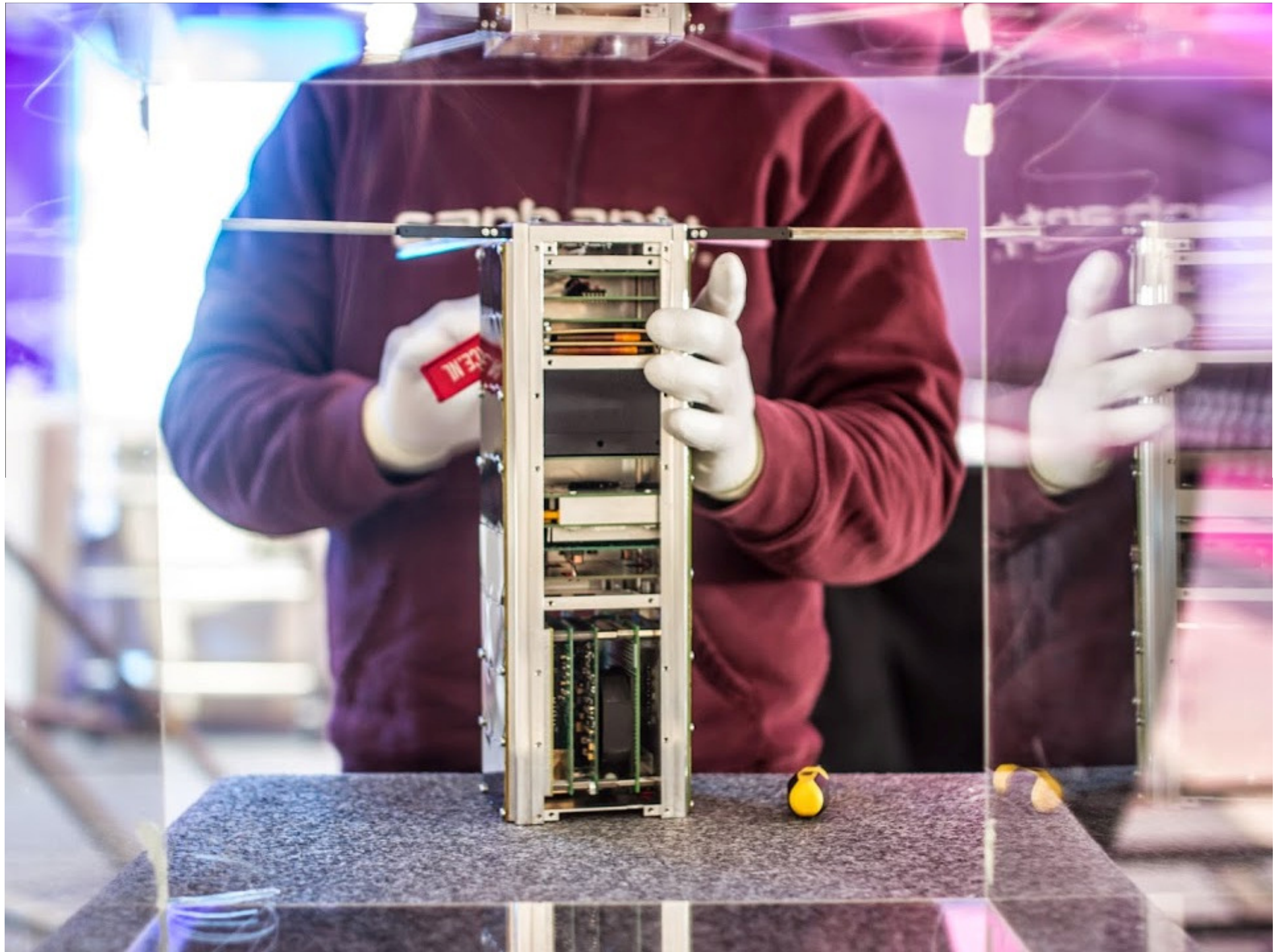
# EPS EM





# Stack Integration tests











## **Ground Station** OH2AGS

Address: Otakaari 5 A,  
Espoo, Finland.  
60.188732 N and  
23.830764 E

Capability:

- VHF
- UHF
- S-band

# Aalto-2 and ICEYE

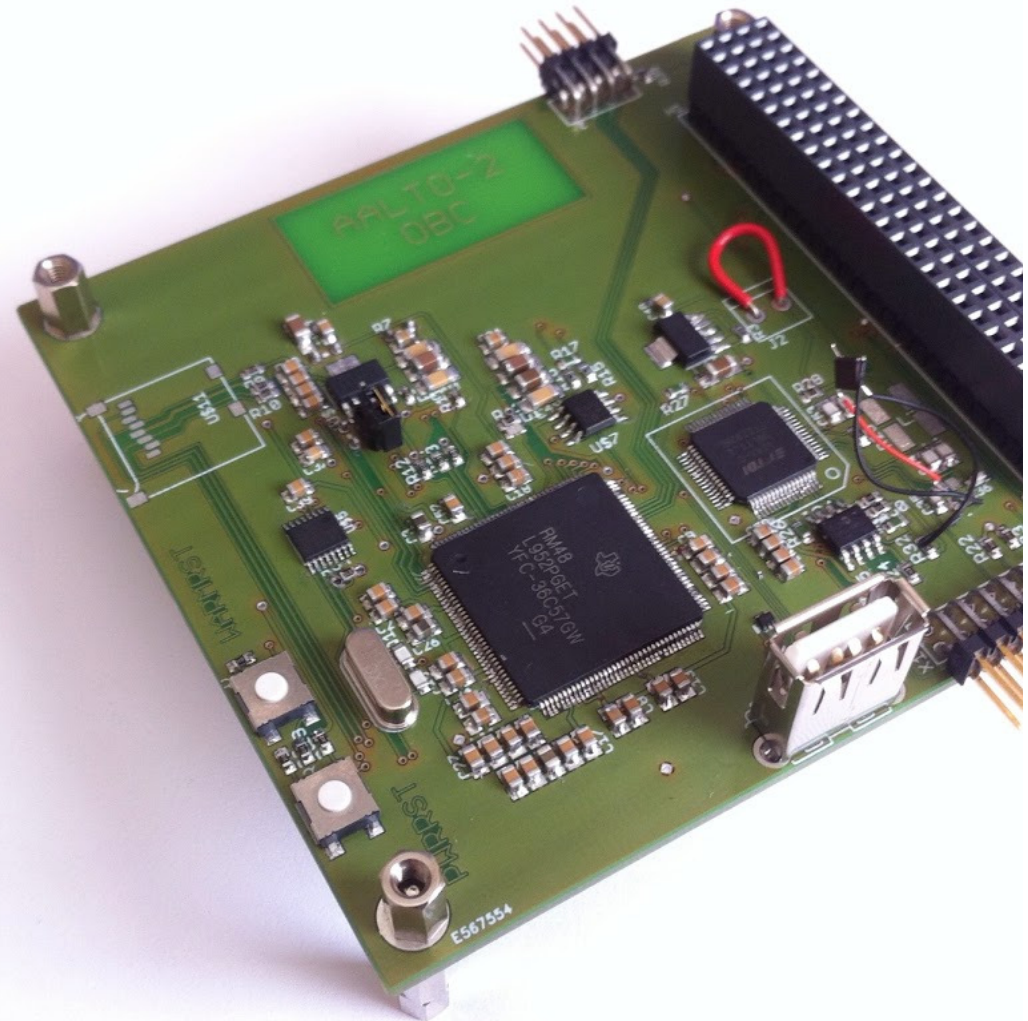
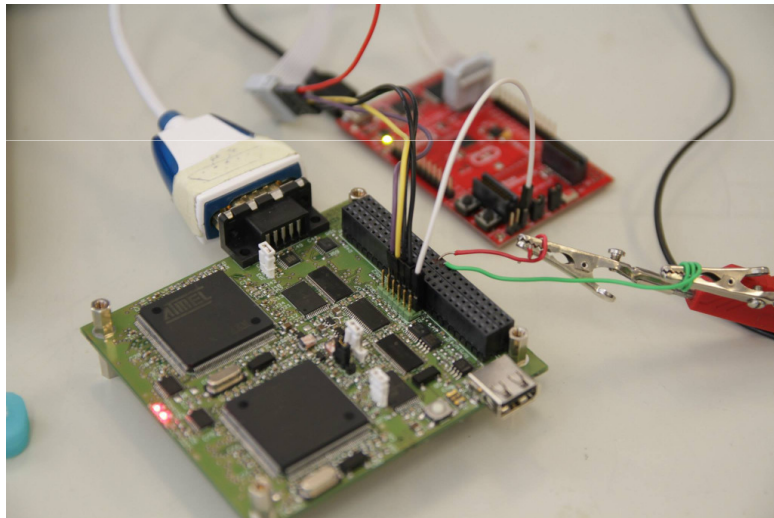


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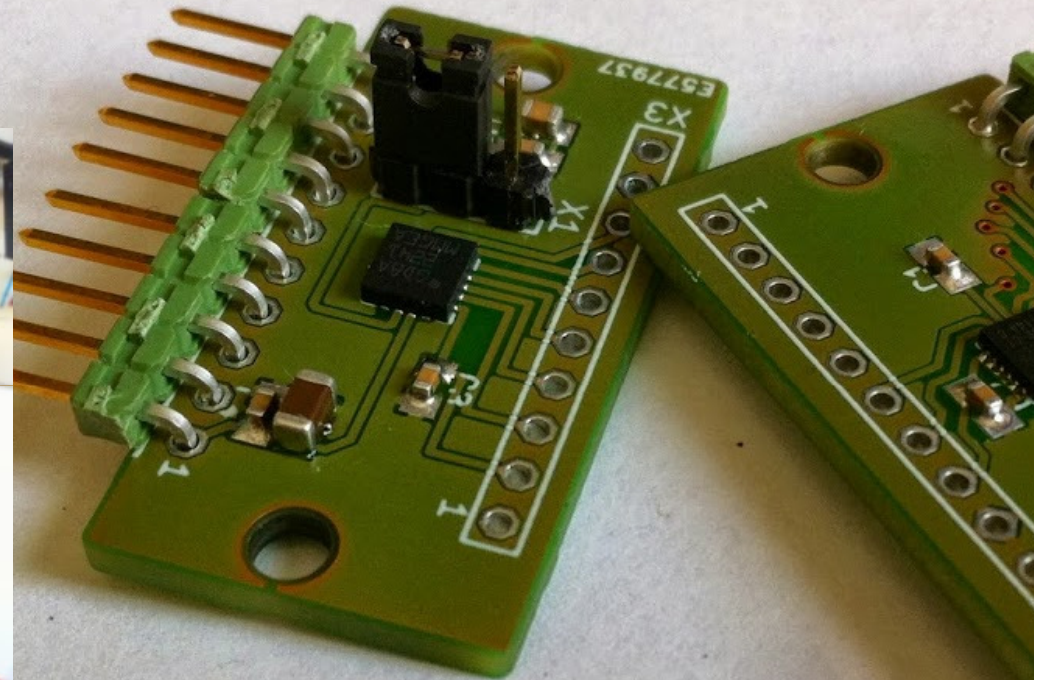
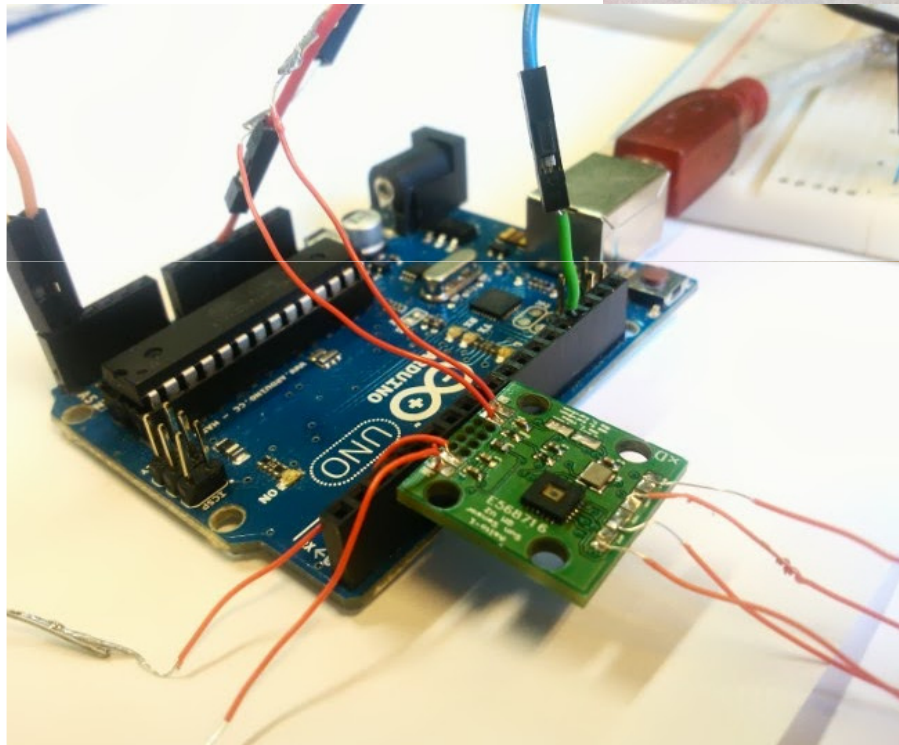
**Aalto-1**

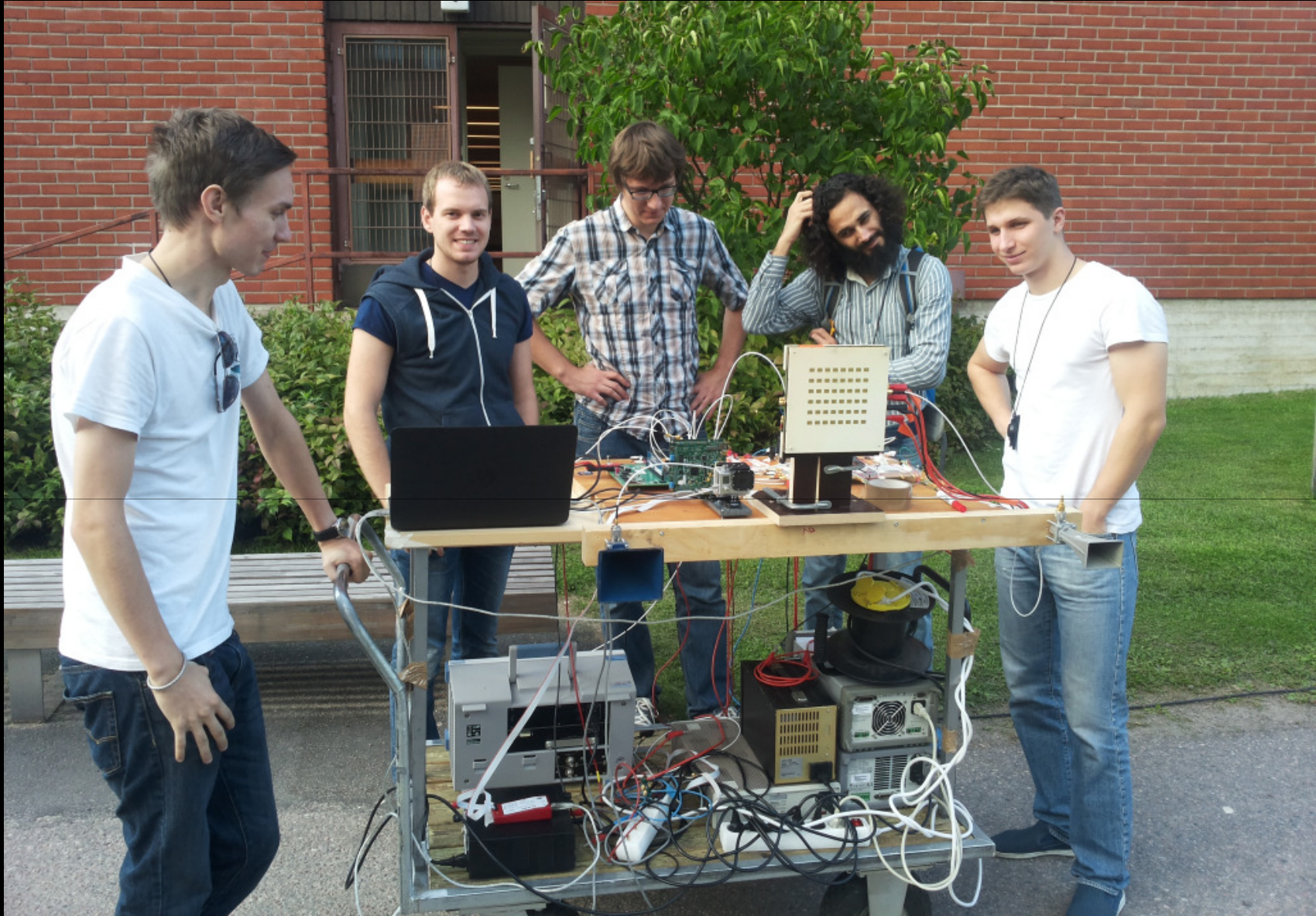
The Finnish Student Satellite

# On board digital signal processing and data handling



# Affordable sensors for spacecrafts



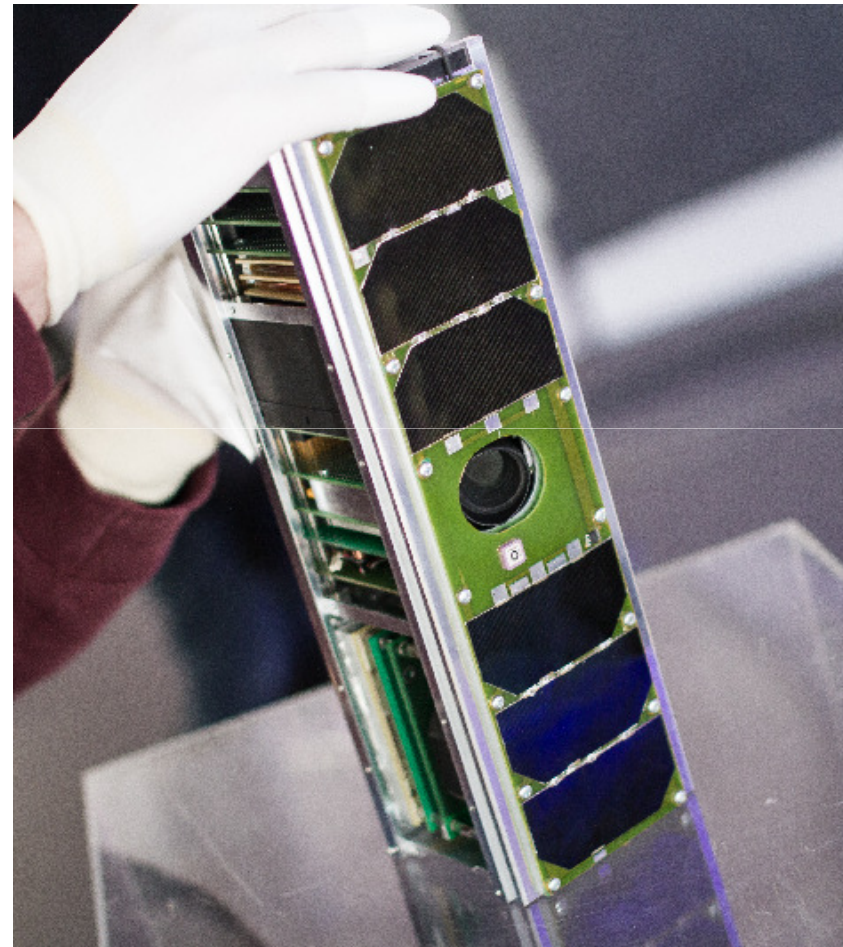


# Short Skyvan aircraft



# Testing and standardisation

- **Testing Center for small satellites at Aalto University**
- **Participation in international activities on nanosatellite testing and standardisation**





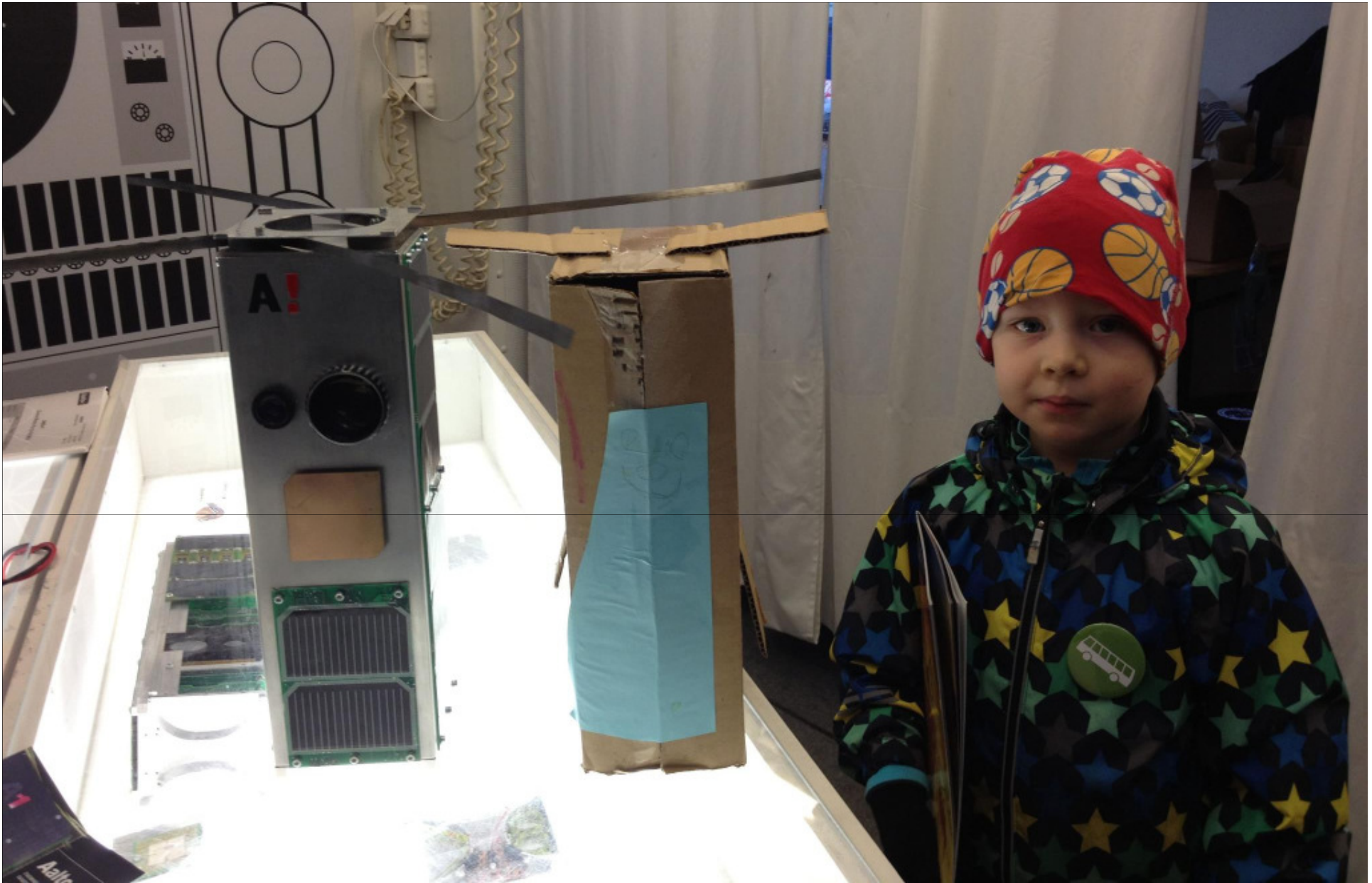


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# Outreach







**A!**

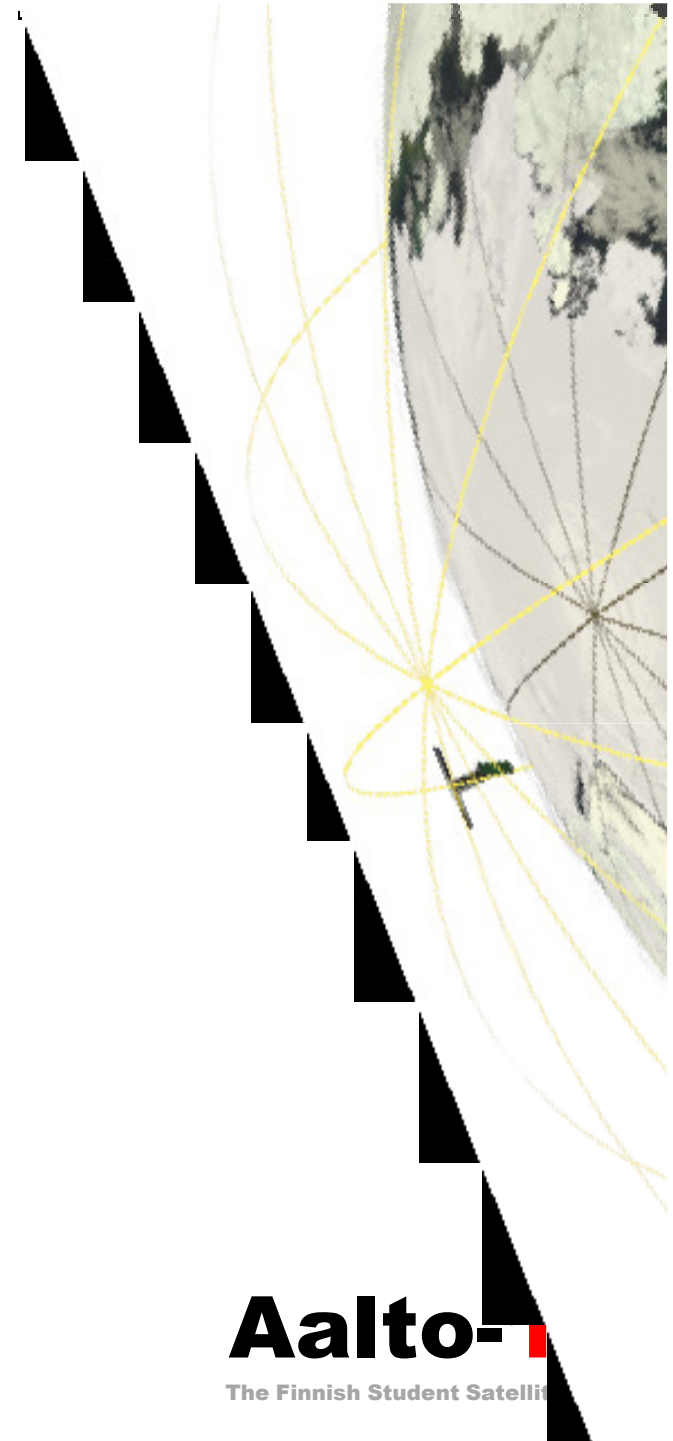
Aalto University

**Aalto-1**

The Finnish Student Satellite

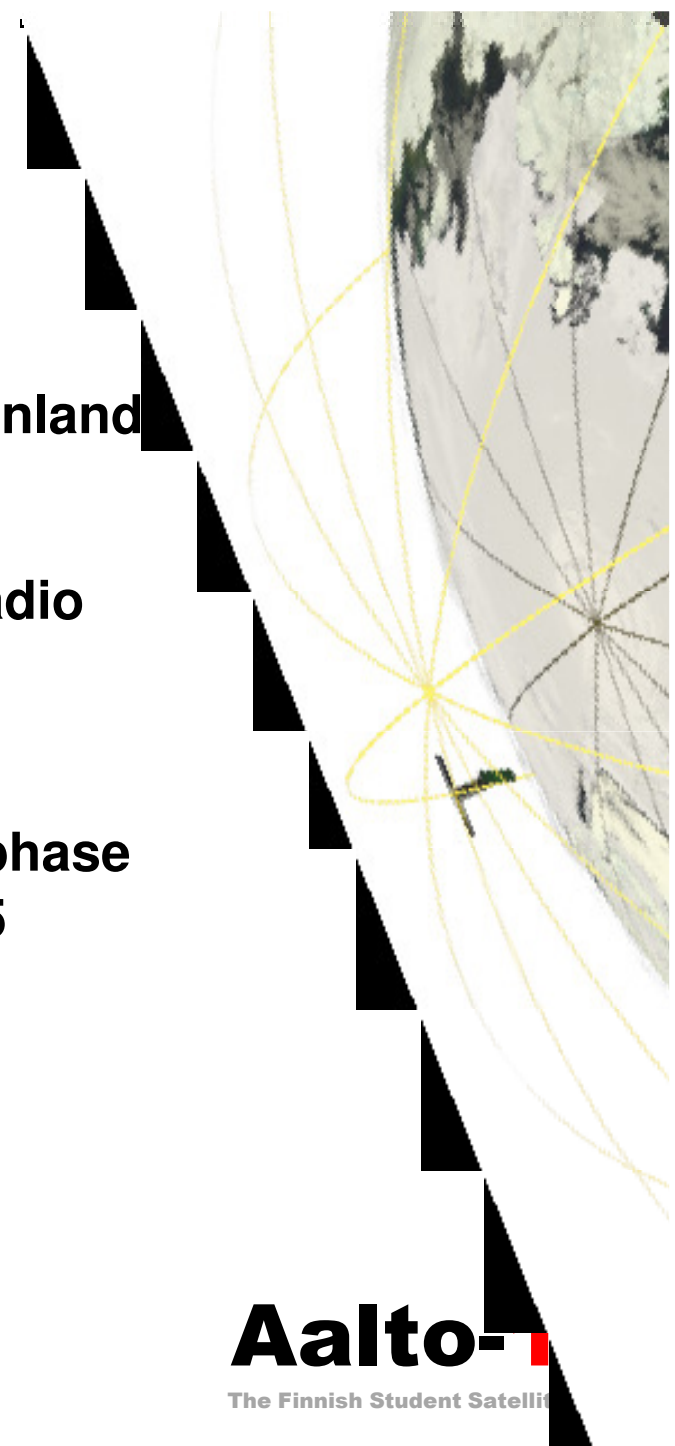
# Future directions

- **Nanosatellite instruments and science**
  - Microwave remote sensing
  - Radio Frequency Interference
  - Space Weather and Ionosphere
  - Novel concepts
- **Spin-off and entrepreneurship**



# Conclusions

- Space technology education growing in Finland
- Aalto University investing in future space technology
- New Master's Programme on Nano and Radio Sciences starting 2015
  
- Aalto-1 is in integration and qualification phase
- Aalto-1 looking for launch in summer 2015
- Aalto-2 is
- ICEYE radar installed to SkyVan aircraft
- Aalto-3 ideas on the table



**Thank you!**

**REMOVE BEFORE LAUNCH**

