

Space @ Aalborg University

**en uendelig rejse
for
de studerende**



Jens Dalsgaard Nielsen

Department of Electronic Systems

Aalborg University Studentspace

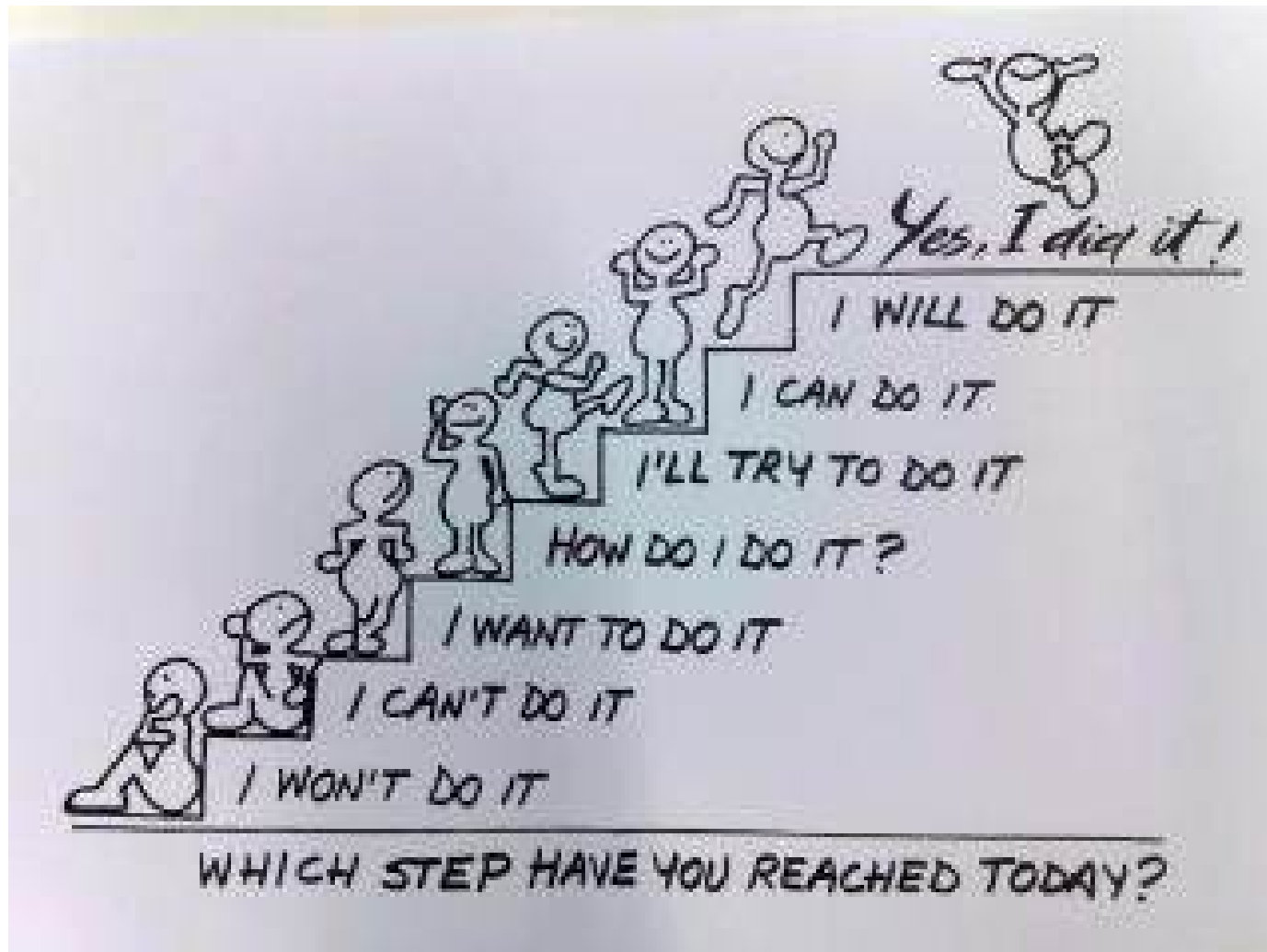
**If you have questions
so please raise your hand :-)
men husk der er begrænset tid**

YES!!

Rule #1/3 – det skal være sjovt



Rule #2/3 – intet kommer af sig selv

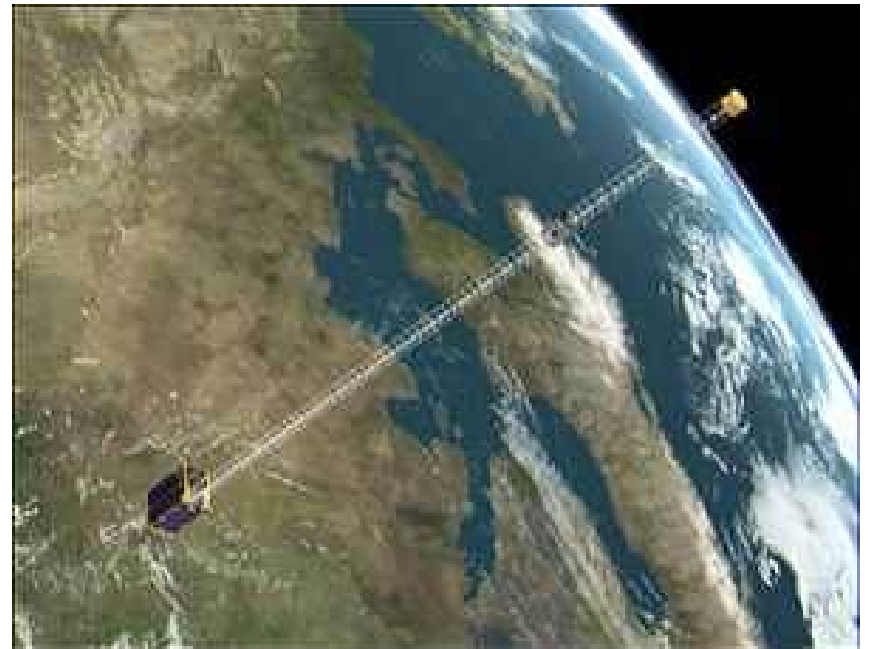
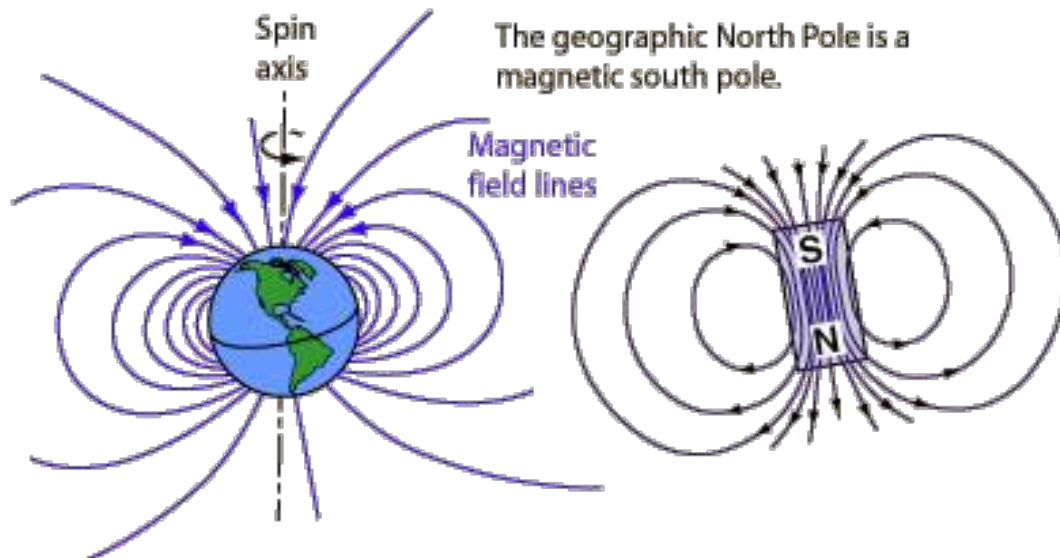


Rule #3/3 – der skal være godt og sjovt mål

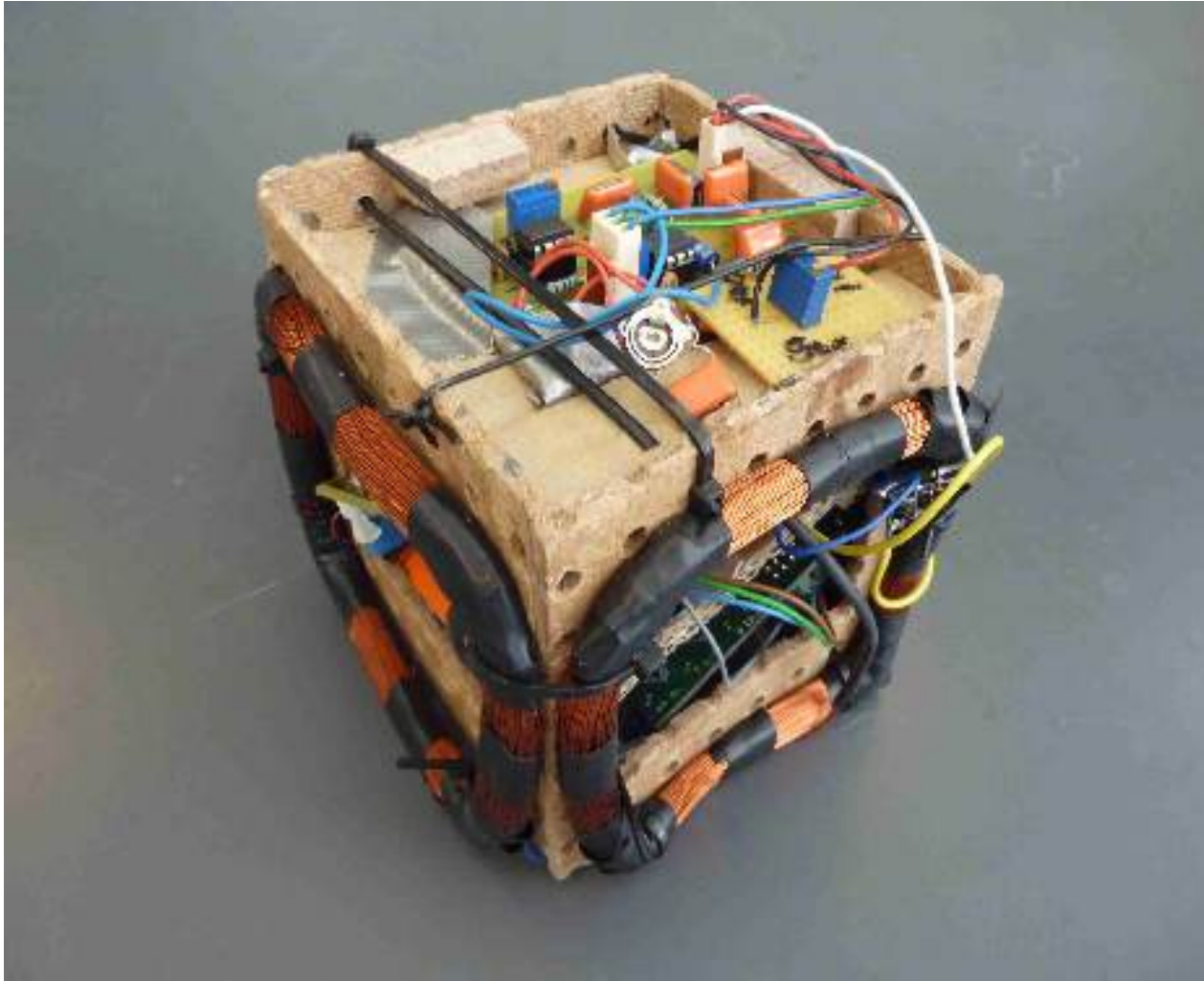


Ørsted Satellit - 1999

- ~ 61 kg
- ca 70 cm * 40 cm * 40 cm
- Forventet levetid < 2 år
 - Levetid > 14 år
 - Stor stor succes



1. semester studenter "satellit

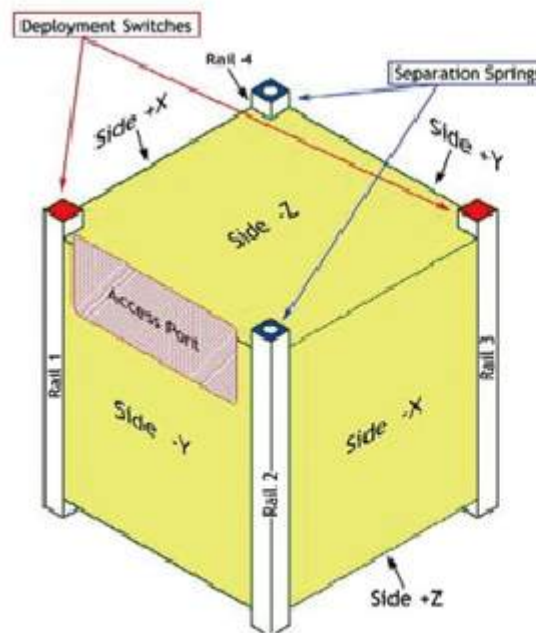


and now the show did start in 2000/2001

Electronic students :

- WE WILL BUILD A SATELLITE
- PLEASE LOOK TOWARDS USA prof BOB TWIGGS AND CUBESATs

The CubeSat standard was created by California Polytechnic State University, San Luis Obispo and Stanford University's Space Systems Development Lab in 1999 to facilitate access to space for university students.



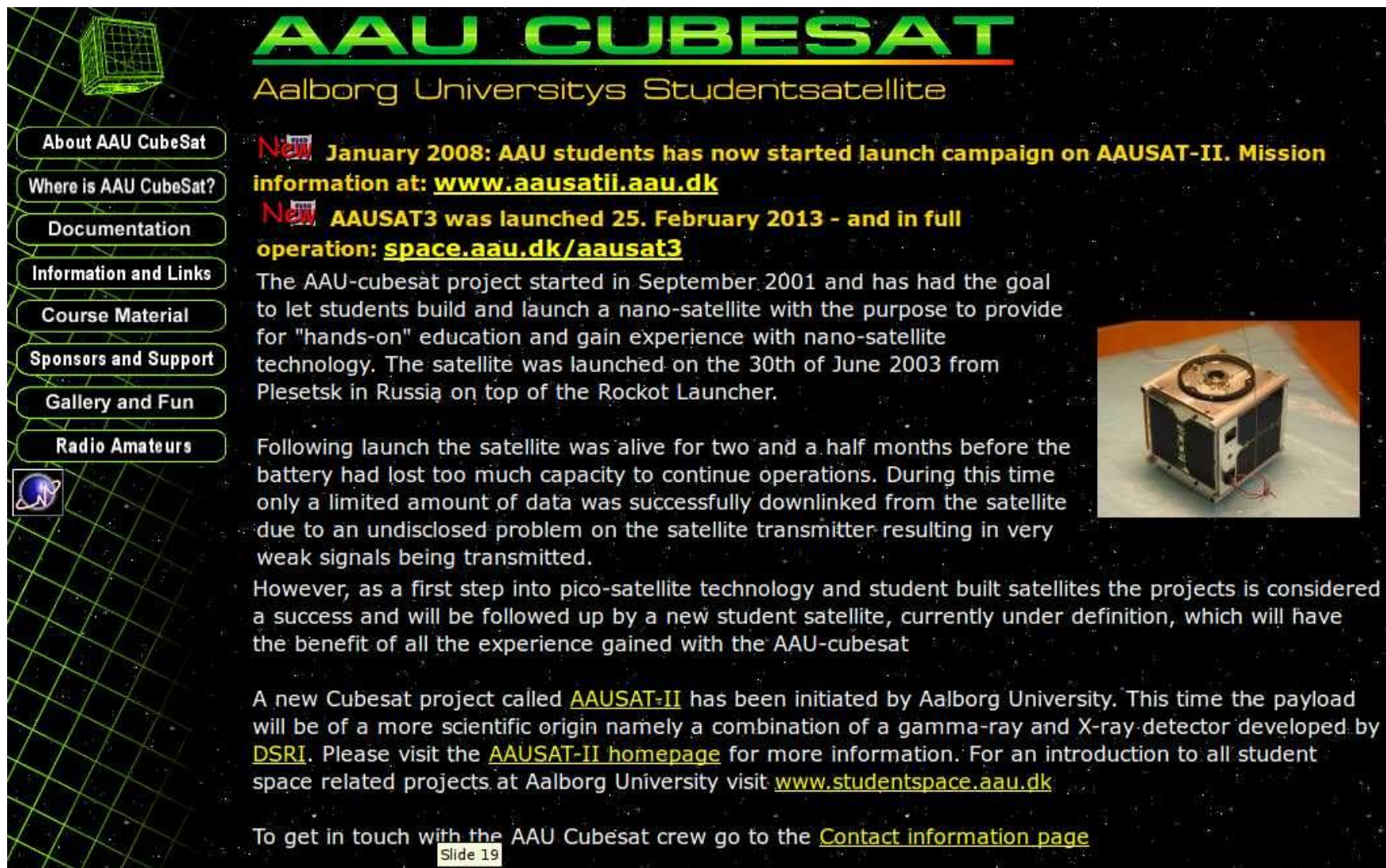
Additional Notes:

- No external components other than the rails may touch the inside of the P-POD.
- Must incorporate a Remove Before Flight pin OR launch with batteries fully discharged.
- Components on shaded sides may not extend more than 6.5 mm normal to the surface.
- Rails must be either hard anodized OR made of a material other than aluminum.
- Separation Springs (required) can be found at McMaster Carr (P/N: 84985A76)
- At least one (1) deployment switch must be incorporated on all CubeSats.
- CubeSats cannot weigh more than 1 kg.
- Center of gravity must be less than 2 cm from the geometric center.

CubeSat basic specifications (Source: Cal Poly)

- De studerende til universitetet – VI VIL (gerne) can hear what you are saying ...

well – let's just do it (cubesat.space.aau.dk)



AAU CUBESAT
Aalborg Universitys Studentsatellite

New January 2008: AAU students has now started launch campaign on AAUSAT-II. Mission information at: www.ausatii.aau.dk

New AAUSAT3 was launched 25. February 2013 - and in full operation: space.aau.dk/aausat3

The AAU-cubesat project started in September 2001 and has had the goal to let students build and launch a nano-satellite with the purpose to provide for "hands-on" education and gain experience with nano-satellite technology. The satellite was launched on the 30th of June 2003 from Plesetsk in Russia on top of the Rockot Launcher.

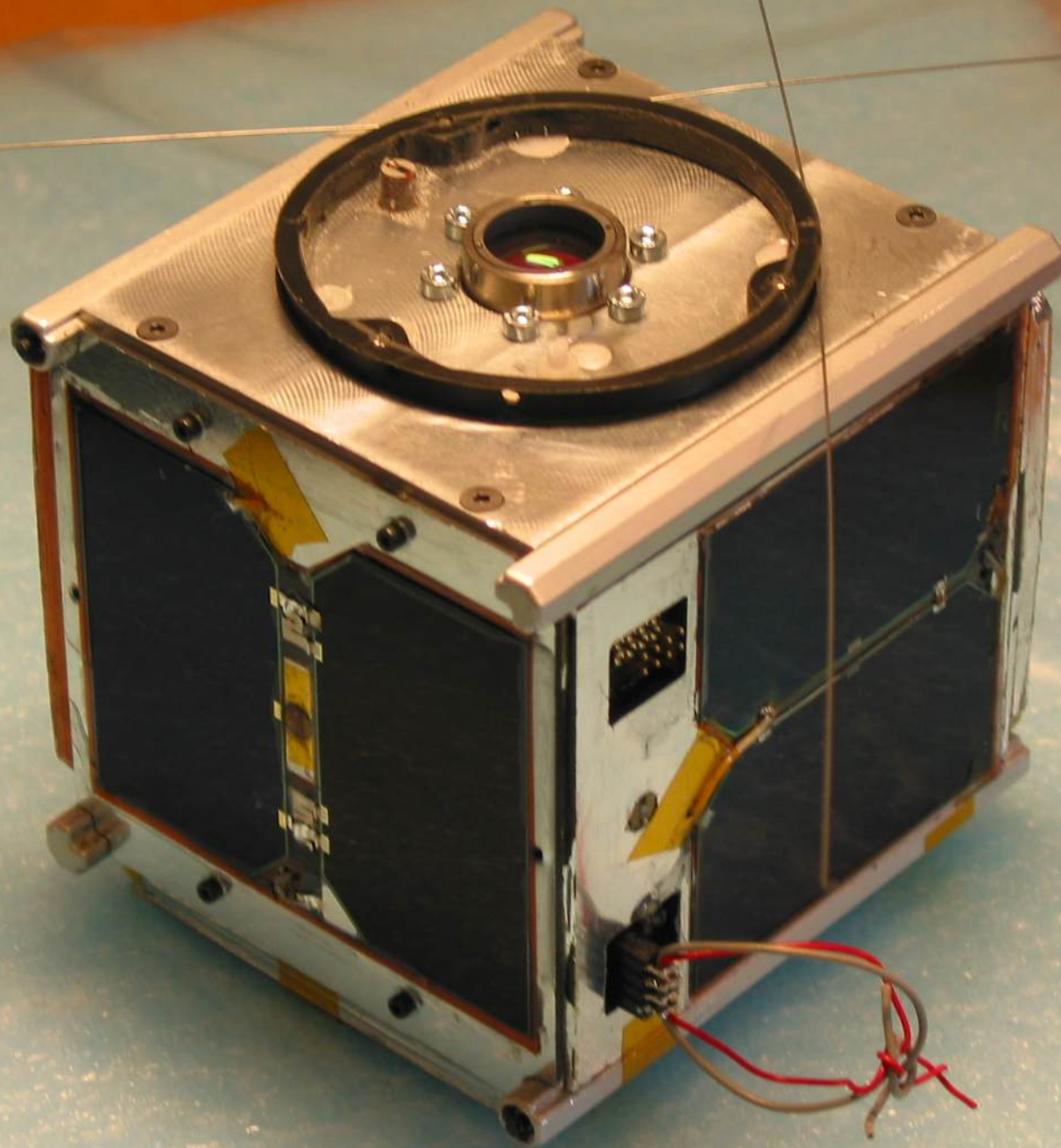
Following launch the satellite was alive for two and a half months before the battery had lost too much capacity to continue operations. During this time only a limited amount of data was successfully downlinked from the satellite due to an undisclosed problem on the satellite transmitter resulting in very weak signals being transmitted.

However, as a first step into pico-satellite technology and student built satellites the projects is considered a success and will be followed up by a new student satellite, currently under definition, which will have the benefit of all the experience gained with the AAU-cubesat

A new Cubesat project called [AAUSAT-II](#) has been initiated by Aalborg University. This time the payload will be of a more scientific origin namely a combination of a gamma-ray and X-ray detector developed by [DSRI](#). Please visit the [AAUSAT-II homepage](#) for more information. For an introduction to all student space related projects at Aalborg University visit www.studentspace.aau.dk

To get in touch with the AAU Cubesat crew go to the [Contact information page](#)

Slide 19



AAU CUBESAT

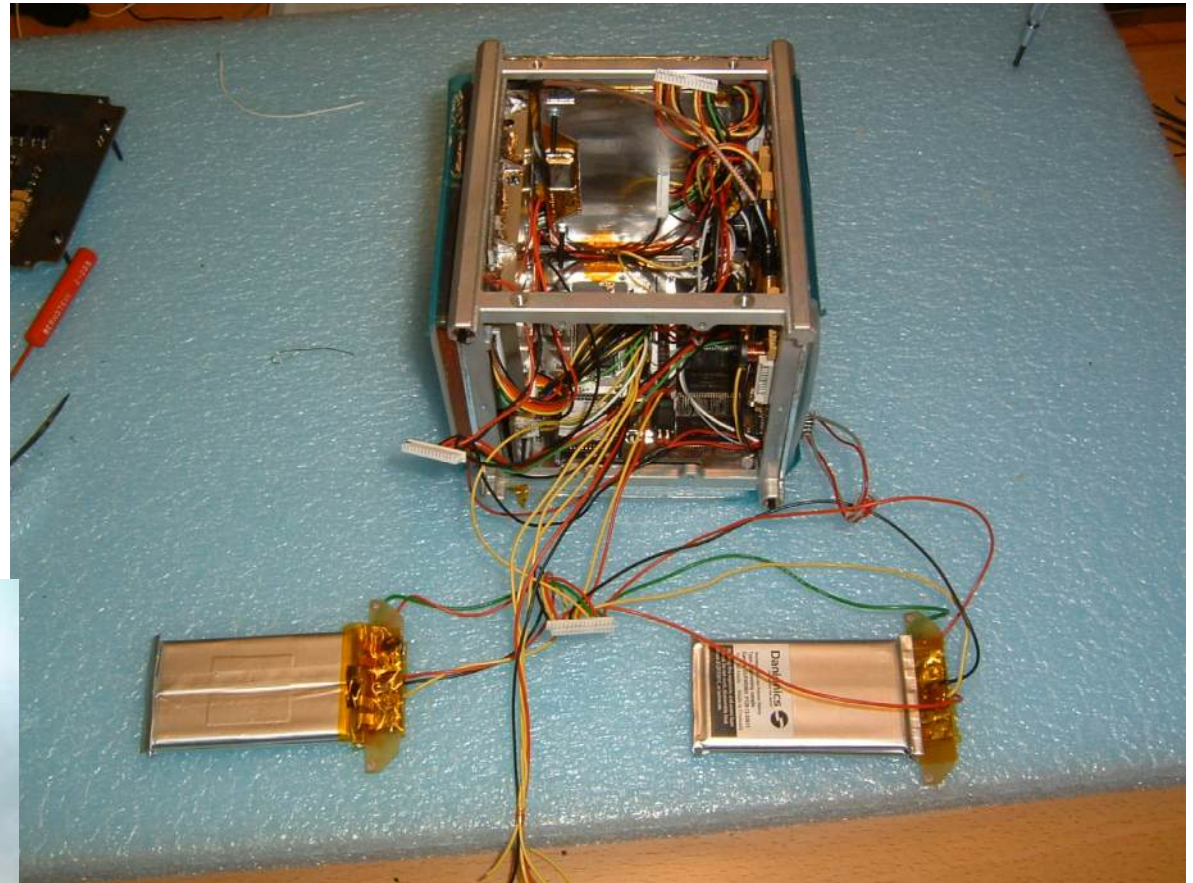
- Wild west days
-
- < 2 år far start til "vi flyver"
- næsten intet bureaukrati – den gang

• [Table of cubesat successrate:](#)

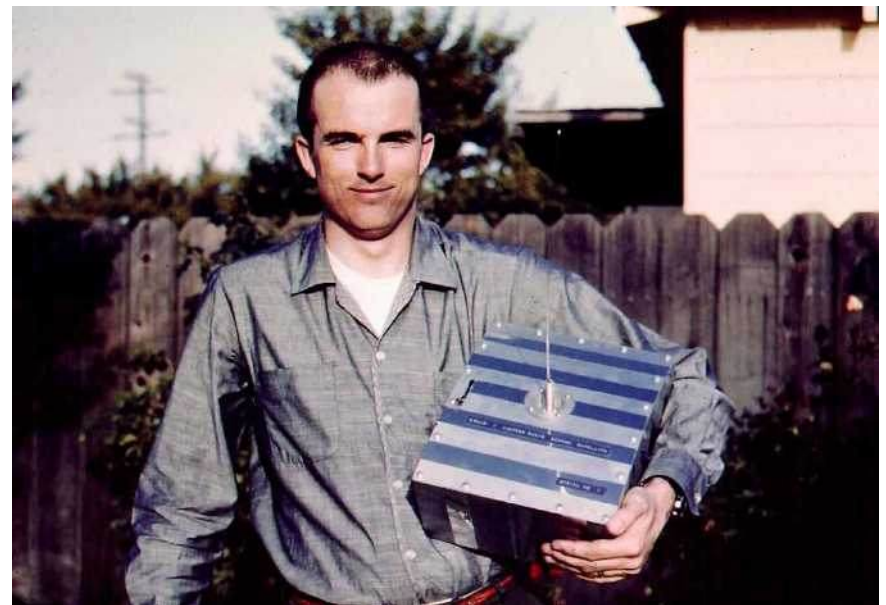
Batch #	LV Failure	No contact	Some contact	Full contact	Total
1 (June 2003)	0	2	1	2 + 1 triple	5+1 triple
2 (October 2005)	0	1	0	2	3
Solo (February 2006)	0	0	0	1 double	1 double
3 (July 2006)	13 + 1 double	0	0	0	13 + 1 double
Solo (December 2006)	0	0	0	1 triple	1 triple
4 (April 2007)	0	1	3 + 1 triple	2	6 + 1 triple
5 (April 2008)	0	0	0	3 + 1 double + 2 triple	3 + 1 double + 2 triple
6 (May 2009)	0	?	?	?	3+1 triple
7 (July 2009)	0	?	?	?	2 (1U?)
Total	13 + 1 double	4	4+1 triple	9 + 2 double + 4 triple	33 + 3 double + 6 triple

lessons learned

- Battery
- Antenna
- Helpfull people
 - Carsten Grøn
 - P-H Kamp



Mit og mine kollegers mål
lave gode ingeniører
og det er nemmest når det er sjovt



CV 2003-2015: 6/7 cubesats & 3 joint missions

- 1992-2006 Ørsted (first danish satellite – AAU provided world first magn ADCS)
- 2000-2002 *Rømer satellite (sucessor to Ørsted – Project cancelled 2002)*

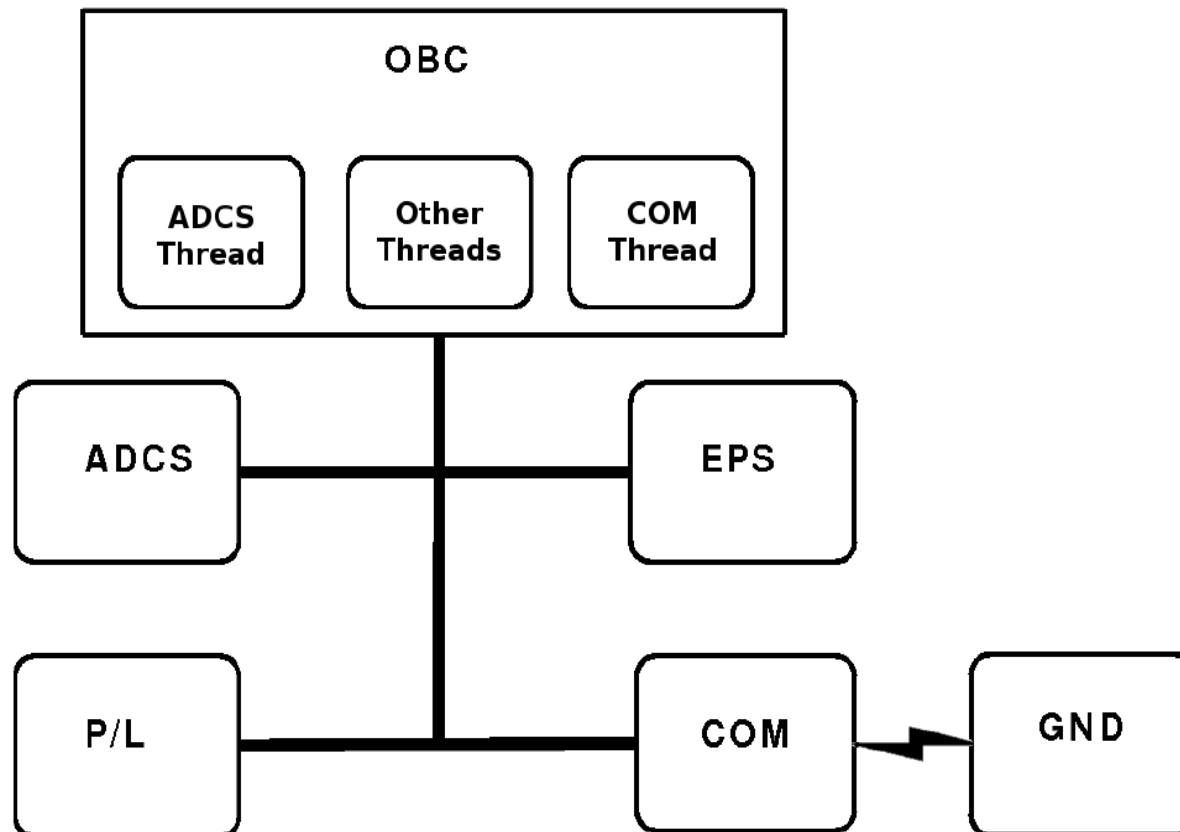
- 2001-2003 **AAU CUBESAT**
- 2003-2005 **ESA SSETI EXPRESS** (AAU: four subsystems)
- 2003-2009 **AAUSAT-II** (launch 30. June 2008)
- 2009-2010 AAUSAT-II operations
- 2004-2006 **Baumanetz OBC** (Uni of Moscow lost during launch)
- 2006-2011 GENSO (global ground station system)
- 2008-2009 AAUSAT3/BEXUS (ballon flight)
- 2007-2014 **AAUSAT3** (launch 2013 18 month operations)
- 2010-2012 **AAUSAT3.5/DLR-AISAT** (payload on DLRs AISAT)
- 2012-2016 **AAUSAT4** *(launch by FYS ESA Education)*
launched 25. April 2016
- 2012-2015 **AAUSAT5** (launched 5.Oct 2015)

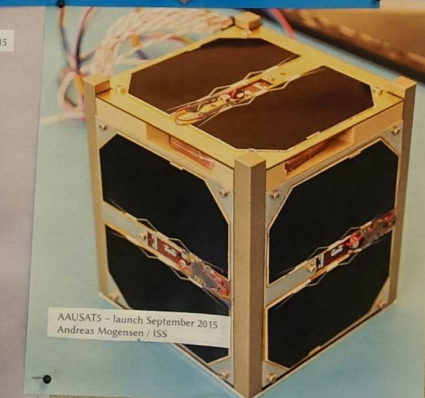
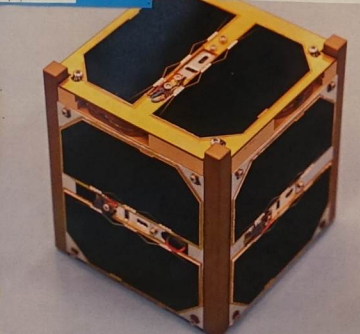
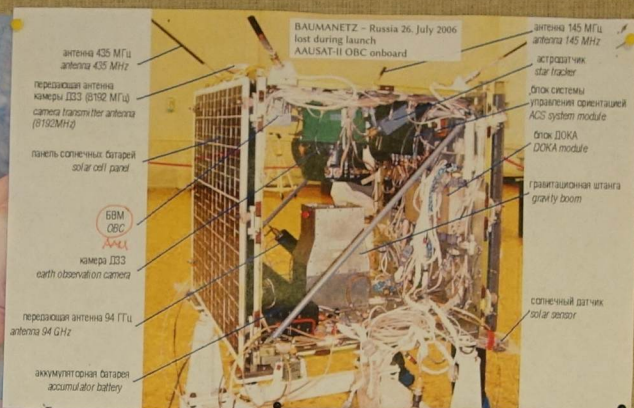
- 2002/2011 Best Summer School
- 2005 STEC 2005 ESA student satellite conference
- Five ESA parabolic flights – one invited



AAUSAT-II system structure

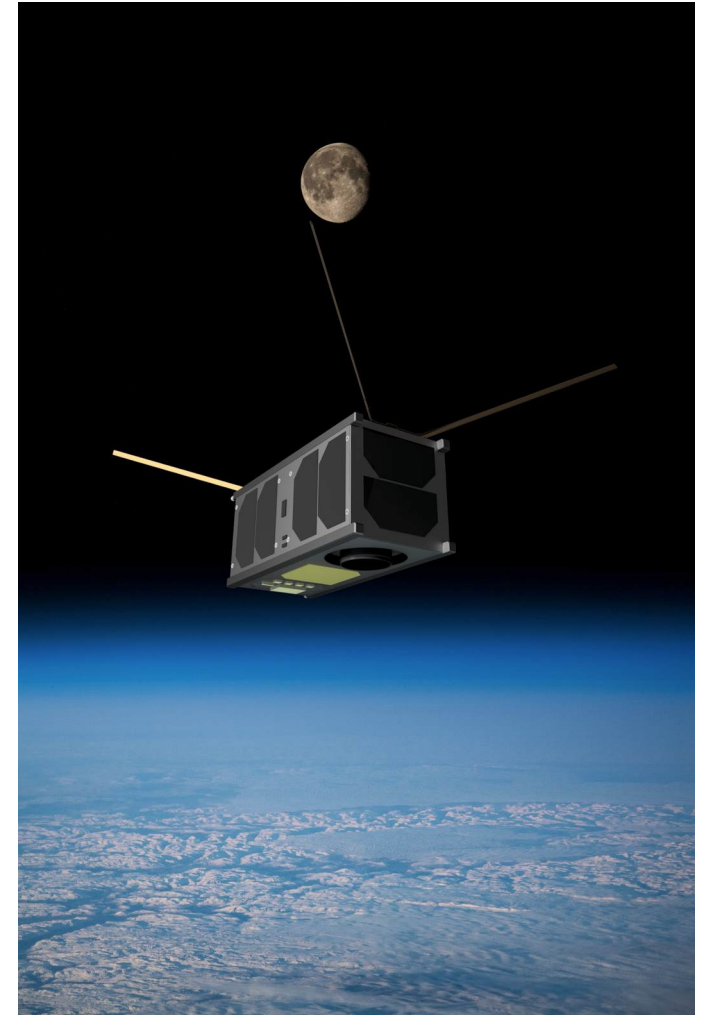
- Simple – 4 microcontrollers
- Homegrown comm stack

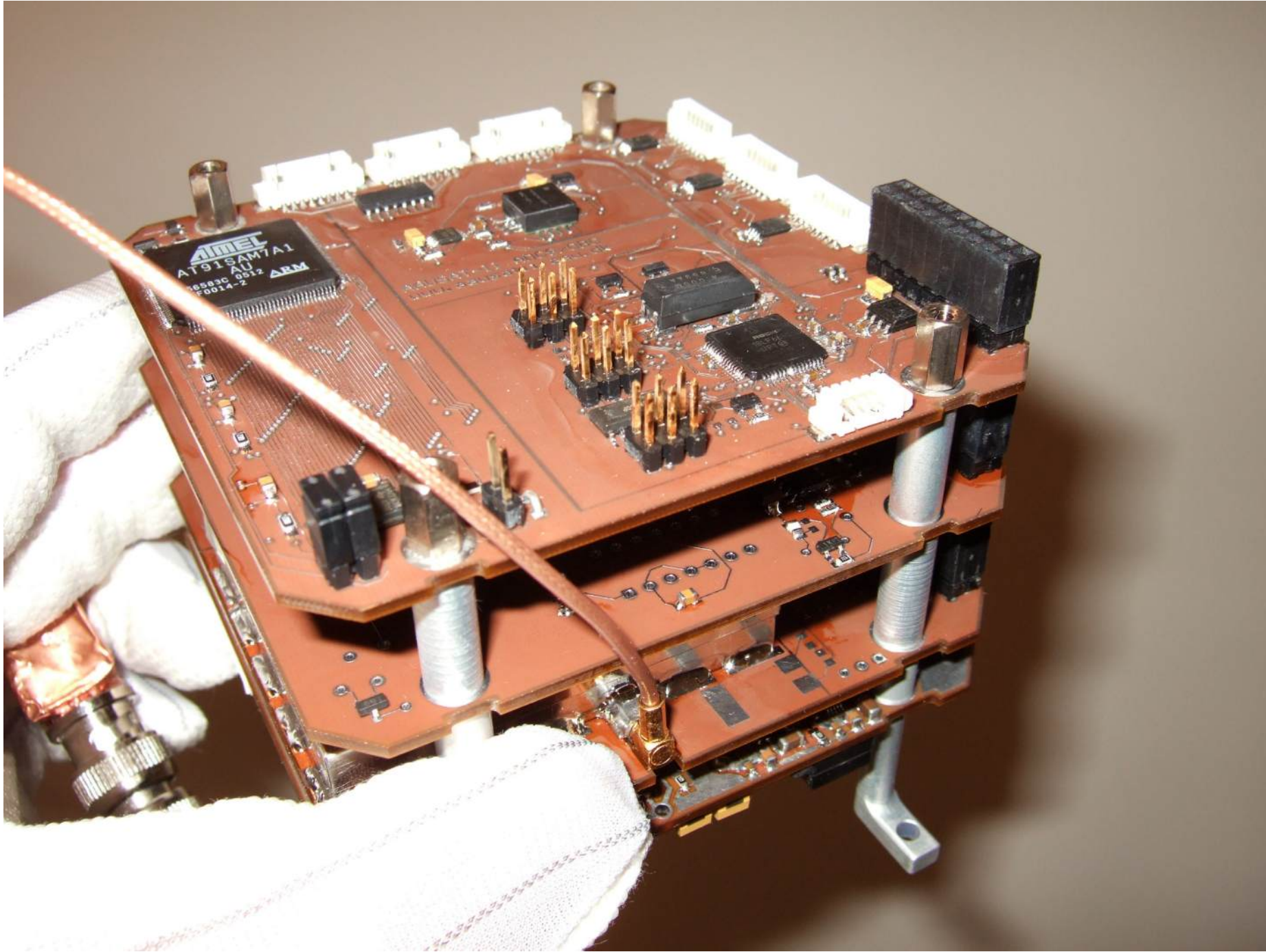




CV 2016- ?

- ▯ 2017-.. Start on AAUSAT6
- ▯ 2020 Corona
- ▯ 2023/2024 restart **AAUSAT6**
- ▯ **2025 First prototype design on way**
- ▯
- ▯
- ▯ **launch ?**
- ▯





AAUSAT-II MCC

Beacon

☐ Goto last

09-03-2009 20:27:10

10-03-2009 11:17:14

10-03-2009 11:20:11

10-03-2009 11:20:15

10-03-2009 20:43:36

10-03-2009 20:44:06

10-03-2009 20:44:36

10-03-2009 20:47:02

10-03-2009 20:47:04

11-03-2009 10:00:05

11-03-2009 10:00:35

11-03-2009 11:37:24

11-03-2009 21:03:33

11-03-2009 21:04:33

Receive time: 11-03-2009 21:04:33

Valid

☒ COM
☒ EPS
☒ LOG
☒ ADCS
☐ PL

Header

Bat

SW

HAM

8.2

DFL

OZ2CUB

Sponsor

Texas Instruments

CDH

SW

Boots

Temp0

Temp1

Uptime

0

0

50.12

48.28

7560

Current time

01-01-1970 03:06:00

Memory

Free

Largest free

1380896

1378848

LOG/Flash

Free

Stat

1507328

0

Time to next expected beacon:

00:00:00

Stop countdown

☐ TX
 ☒ RX

11-03-2009 21:02:53 (r29/EVENTS_ALL)

11-03-2009 21:03:02 (r29/EVENTS_ALL)

11-03-2009 21:03:04 (r29/EVENTS_ALL)

11-03-2009 21:03:06 (r29/EVENTS_ALL)

11-03-2009 21:03:22 (r29/EVENTS_ALL)

11-03-2009 21:03:24 (r29/EVENTS_ALL)

11-03-2009 21:03:27 (r29/EVENTS_ALL)

11-03-2009 21:03:28 (r29/EVENTS_ALL)

11-03-2009 21:03:34 (r27/ZUPLOAD_REPLAY)

11-03-2009 21:03:38 (r17/ZUPLOAD)

11-03-2009 21:04:19 (r17/ZUPLOAD)

11-03-2009 21:04:20 (r17/ZUPLOAD)

11-03-2009 21:04:22 (r17/ZUPLOAD)

11-03-2009 21:04:47 (r04/BTAB)

Boot table

Last updated: xx-xx-xxxx xx:xx:xx

	Id	Ok	Address	Size	Boots
	PR		0x48000000		0
	01	n	0x48000000	0x00000000	0

Received ZUPLOAD reply

Status of current software receive:

Checksum: 0x55AA55AA

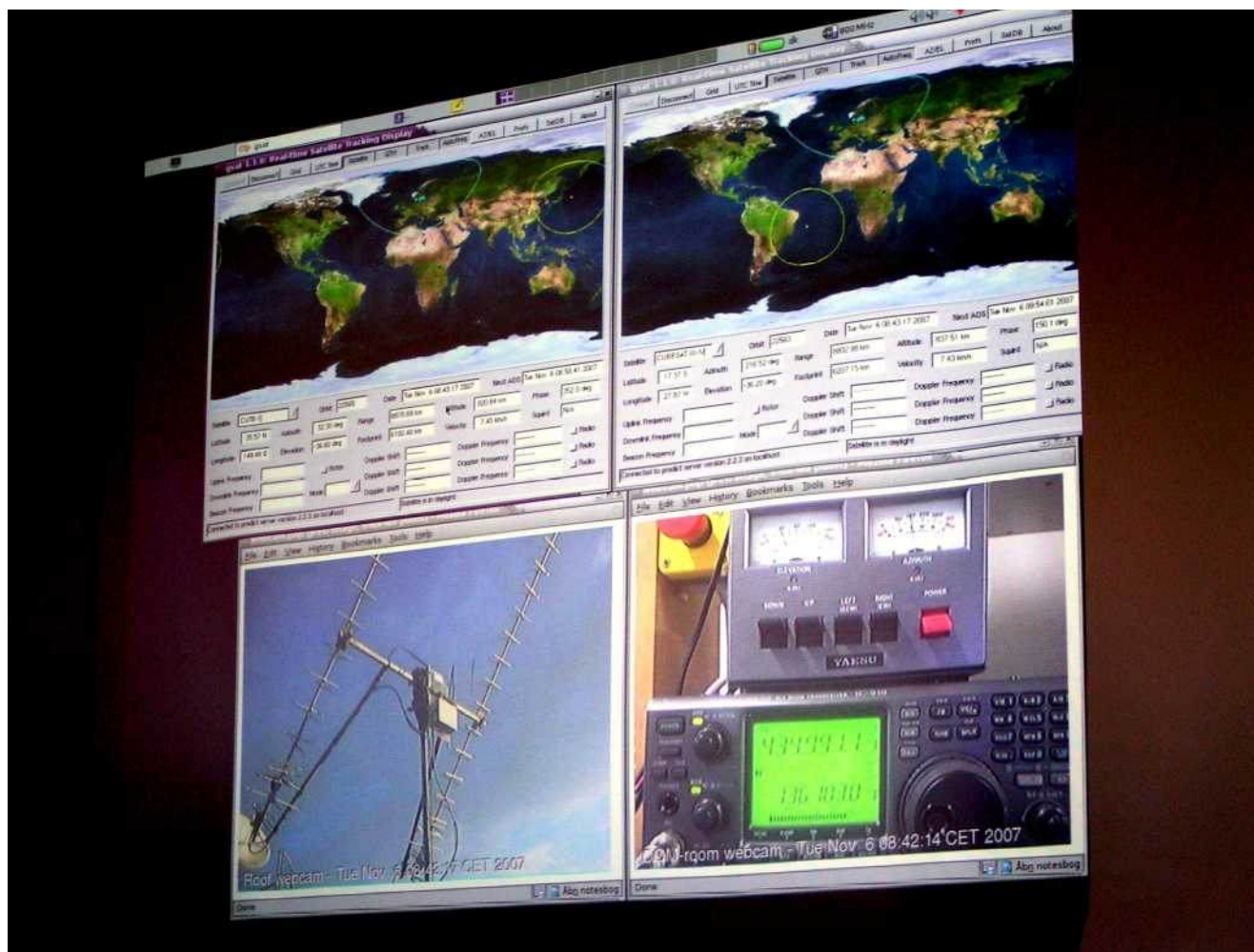
Total packets: 1

*** Software uploaded correctly to FLASH

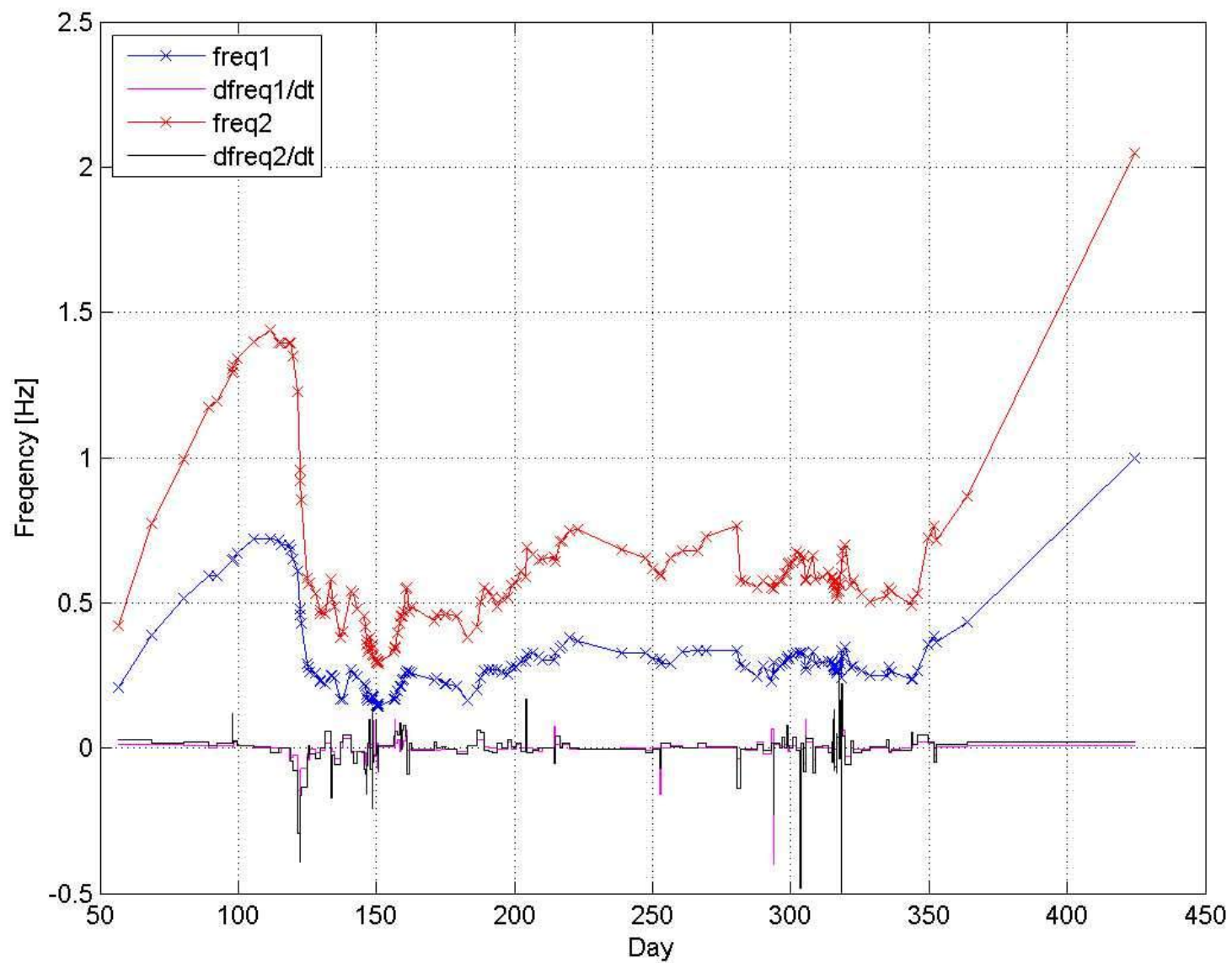
19/32

in between II – GENSO Global Educational Network for Satellite Operations

- Start 2006
- AAU participated and hosted first real demo

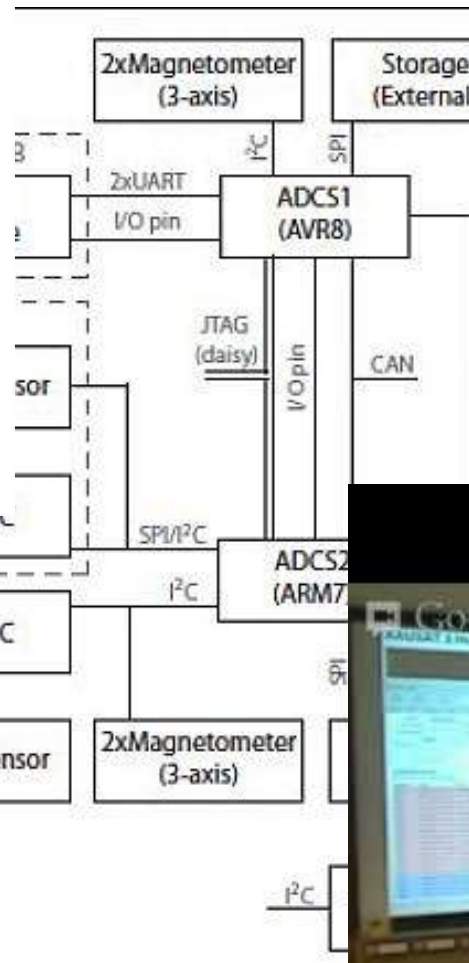


AAUSAT-II TUMBLING



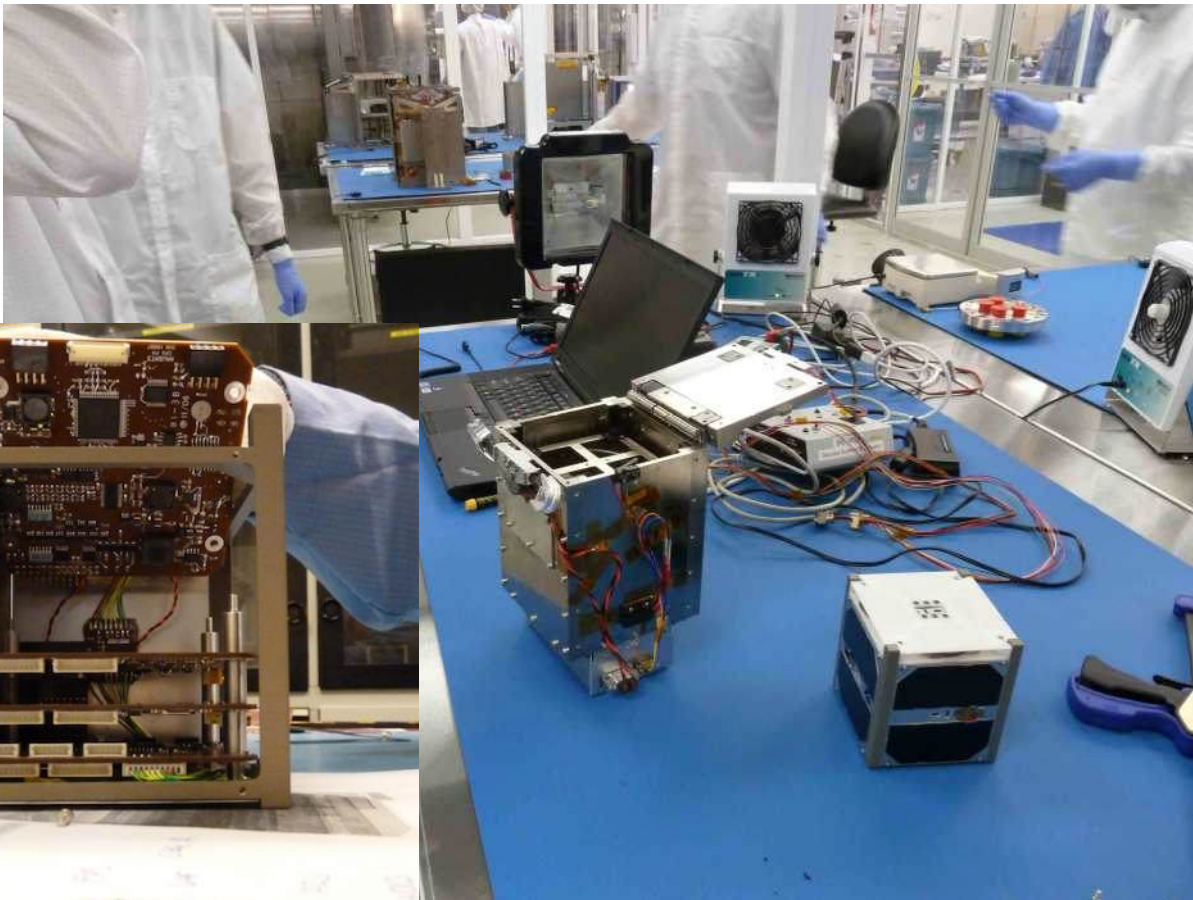


Big Science - Small Satellites does it fit together ?



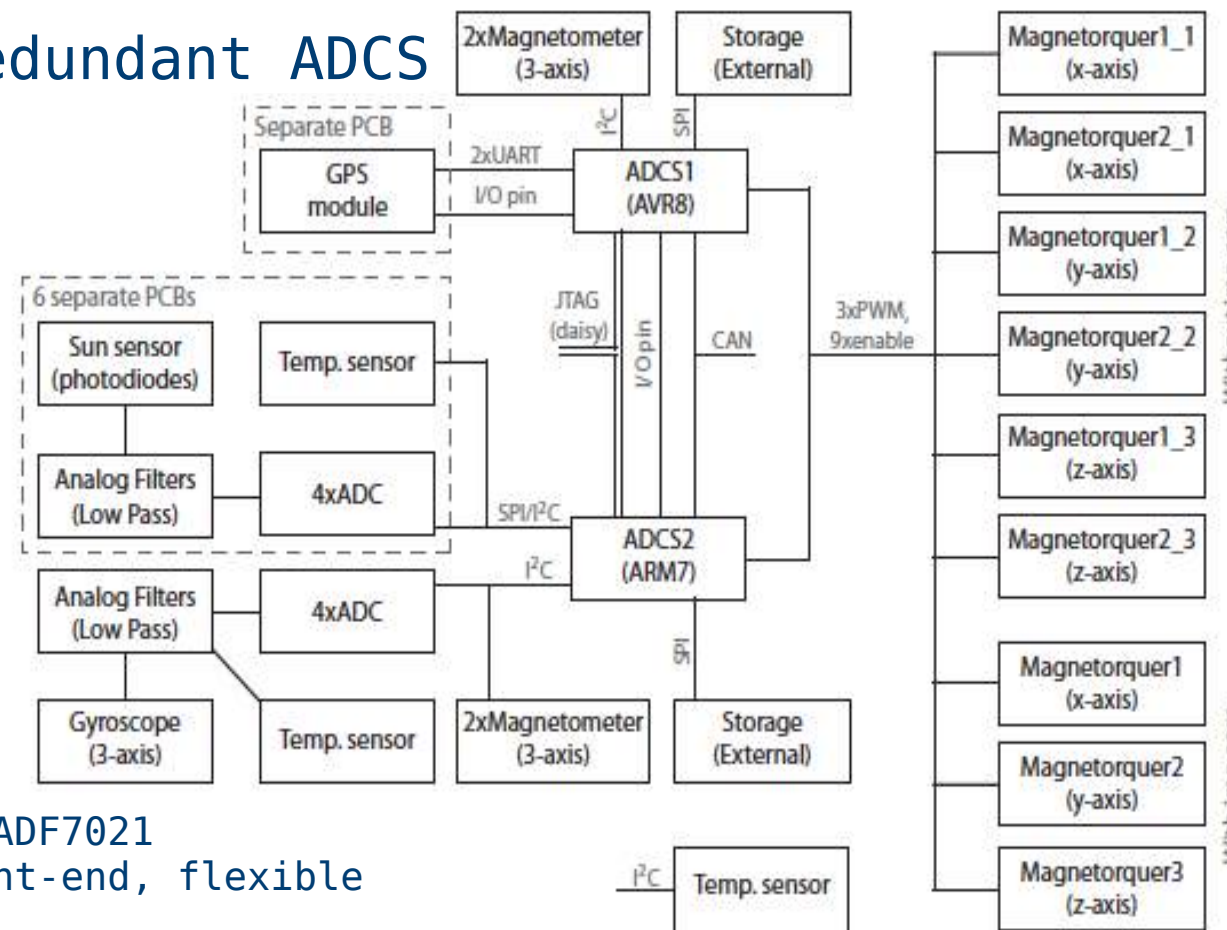
Assembly and launch(A3)

- Launched from Sriharikota, India with PSLV-C20
- Launched on Feb. 25th 2013





Redundant ADCS



- Two receivers:
- Antenna
- 162 MHz $\lambda/4$ -dipole
- +15 dB LNA
- Splitter
- Traditional
 - Receiver: Analog Devices ADF7021
 - Advantage: Integrated front-end, flexible
- SDR based
 - Receiver: Analog Devices ADF7020
 - Advantage: I/Q at 200kHz IF, integrated front-end, flexible
 - ADC: Analog Devices AD7262, 1 MSPS
 - DSP: Analog Devices Blackfin BF537

FIRST PASS – MISSION COMPLETED :-)

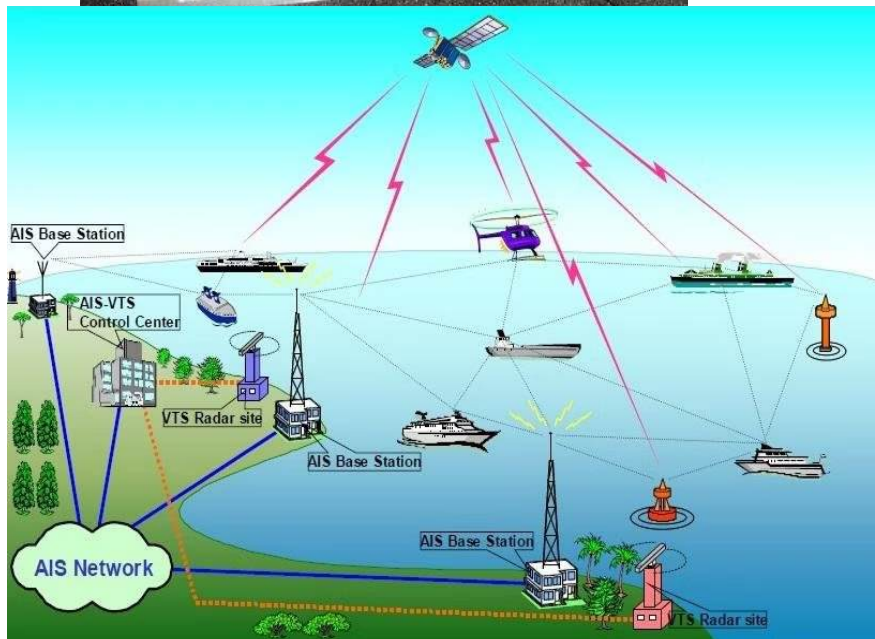
Beacon	Debug	LOG	ADCS1	ADCS2	AIS1	AIS2	COM	EPS	FP	AIS-MAP																																																																																																							
EPS		COM		AIS1		AIS2		ADCS1		ADCS2		Next beacon 0:07:33		Request 1		☒ Show newest																																																																																																	
EPS <table border="1"> <tr> <td>Bootcount</td> <td>2</td> <td>PORF</td> <td>Uptime</td> <td>2:56:28</td> </tr> <tr> <td>Time</td> <td colspan="3">2013-02-25 16:48:33</td> <td>Battery Vol.</td> <td>7800</td> </tr> <tr> <td>Cell balance</td> <td colspan="3">-104.0</td> <td>Battery Cur.</td> <td>150</td> </tr> <tr> <td>PV power</td> <td>100</td> <td>3.3V</td> <td>3260</td> <td>EPS temp</td> <td>24</td> <td>PA temp</td> <td>24</td> </tr> <tr> <td colspan="8">Subsystems ON/OFF/PING</td> </tr> <tr> <td>I2C</td> <td colspan="3"></td> <td>AIS2 5V</td> <td colspan="3"></td> </tr> <tr> <td>AIS1</td> <td colspan="3"></td> <td>LOG</td> <td colspan="3"></td> </tr> <tr> <td>DEPLOY1</td> <td colspan="3"></td> <td>ADCS2</td> <td colspan="3"></td> </tr> <tr> <td>AIS2 3.3V</td> <td colspan="3"></td> <td>Magnetorq</td> <td colspan="3"></td> </tr> <tr> <td>COM</td> <td colspan="3"></td> <td>ADCS1</td> <td colspan="3"></td> </tr> <tr> <td>DEPLOY2</td> <td colspan="3"></td> <td>UHF PA</td> <td colspan="3"></td> </tr> </table> COM <table border="1"> <tr> <td>Bootcount</td> <td>2</td> <td>PORF</td> <td>RSSI</td> <td>-92</td> </tr> <tr> <td>Packets RX</td> <td>20</td> <td>Packets TX</td> <td>182</td> <td></td> </tr> <tr> <td>Bit cor.</td> <td>2</td> <td>Byte cor.</td> <td>0</td> <td></td> </tr> </table>																		Bootcount	2	PORF	Uptime	2:56:28	Time	2013-02-25 16:48:33			Battery Vol.	7800	Cell balance	-104.0			Battery Cur.	150	PV power	100	3.3V	3260	EPS temp	24	PA temp	24	Subsystems ON/OFF/PING								I2C				AIS2 5V				AIS1				LOG				DEPLOY1				ADCS2				AIS2 3.3V				Magnetorq				COM				ADCS1				DEPLOY2				UHF PA				Bootcount	2	PORF	RSSI	-92	Packets RX	20	Packets TX	182		Bit cor.	2	Byte cor.	0	
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TEST @ Esrange

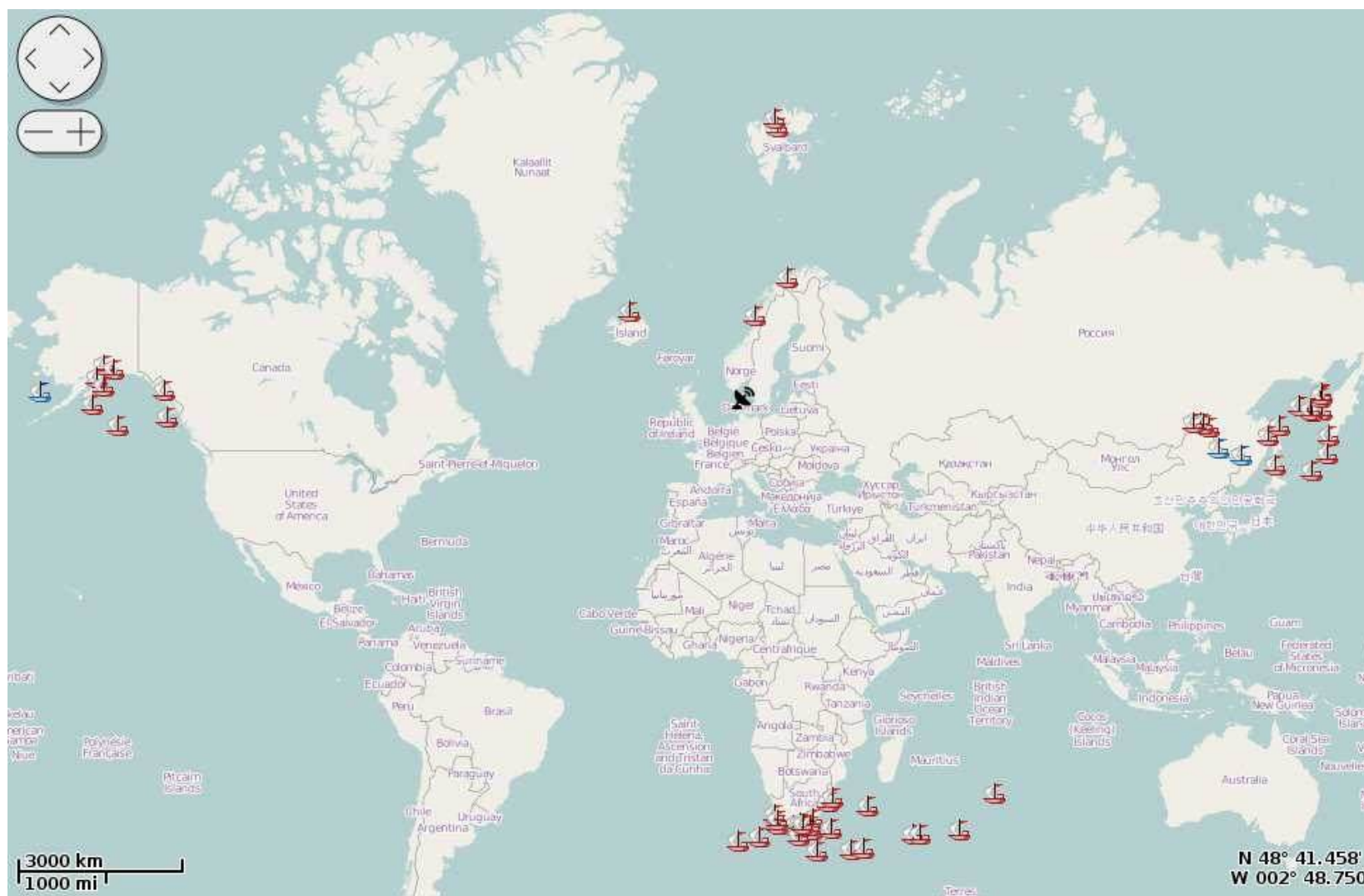


NAVIS
North Atlantic Vessel Identification System

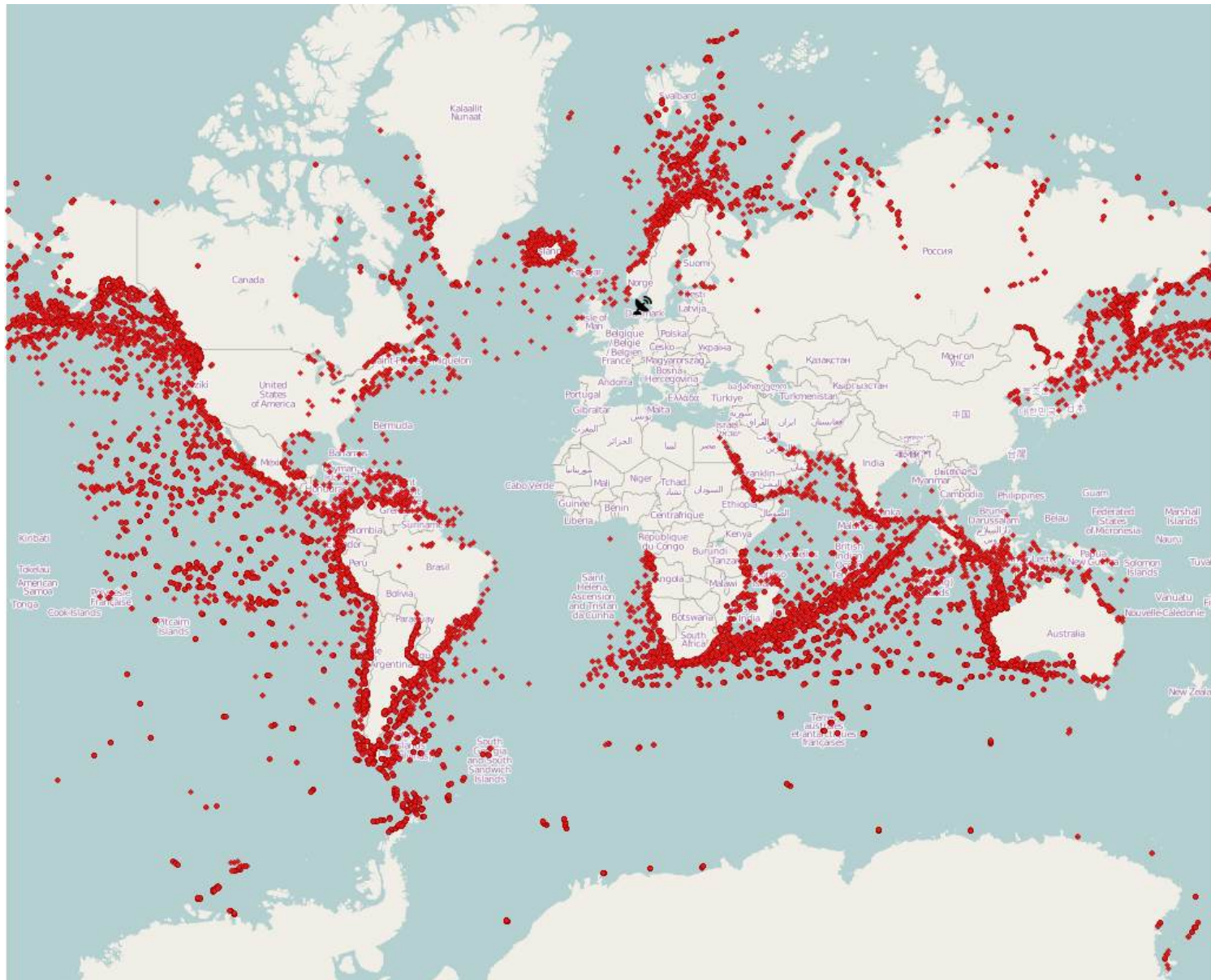


Results

- First results – the second pass over the Aalborg Ground Station

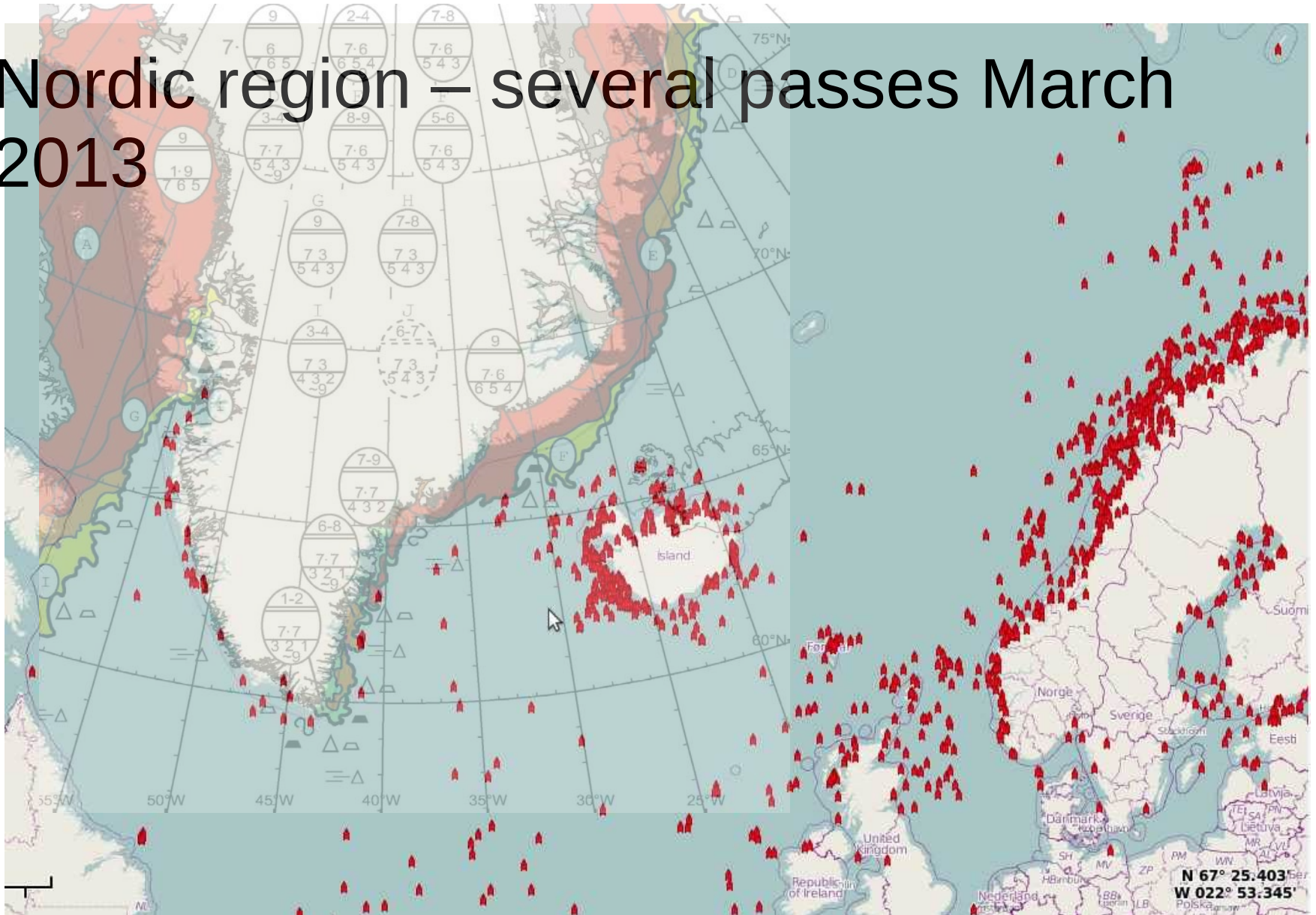


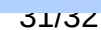
2014 13th February - 45000 messages downloaded



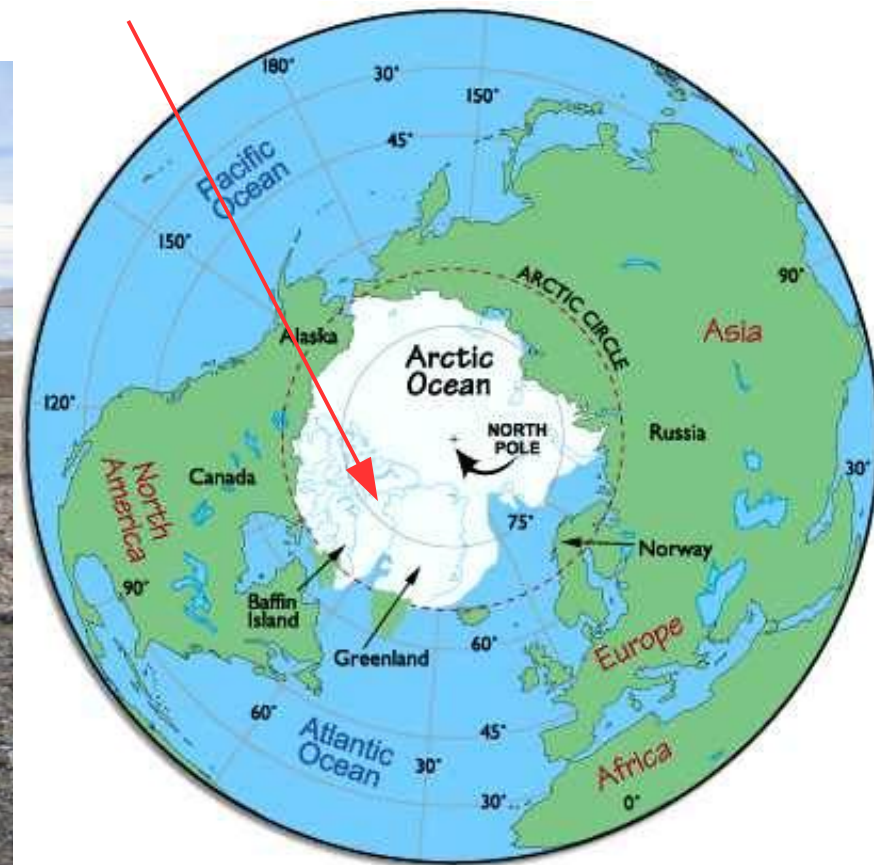
Results

- Nordic region – several passes March 2013





- AAU @ Thule
- Thanks to local DMI representative



AAUSAT4 AAUSAT5

- AAUSAT4 - launch 22 April 2016. + 1 year delayed

FLY YOUR SATELLITE! CUBESAT TEAMS

In June 2013, six teams were selected to participate in the Fly Your Satellite! programme. The satellites carry different payloads selected by the university teams, with a variety of mission objectives, as outlined below.

AAUSAT4



Aalborg University, Denmark

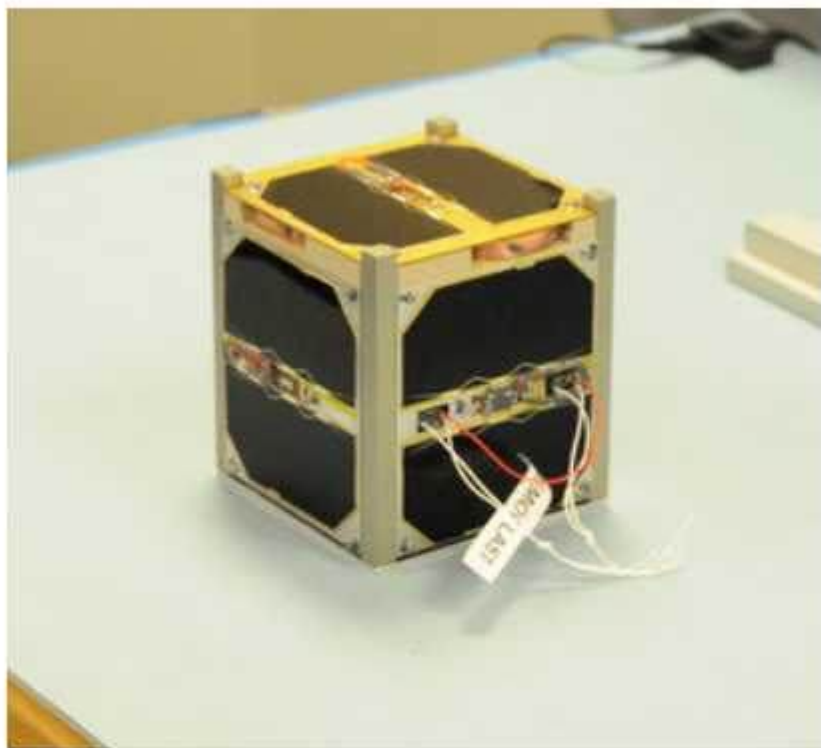
Mission objectives

Testing of an Automatic Identification System (AIS) receiver and of student-developed ground station software

Technology demonstration of an active 3-axis attitude determination and control system

AAUSAT4 AAUSAT5

ANDREAS MOGENSEN PRESENTS THE AAUSAT5 MISSION FROM THE ISS



AAUSAT5 CubeSat

11 September 2015 From the International Space Station, ESA's Danish astronaut Andreas Mogensen is introducing the CubeSat AAUSAT5, which has been designed and built by students of Aalborg University in Denmark, with the support of ESA. During its mission, the satellite is designed to test student-built receivers for signals released by sea vessels hosting an Automated Identification System, using a new communication protocol that has been designed by the students.

The opportunity to launch AAUSAT5 from the ISS emerged in conjunction with the planned short-duration mission of Andreas Mogensen. The cube satellite was launched to the ISS on 19 August 2015, for a later deployment into space.

Due to the complexity of operations to be carried out on station by the astronauts, as well as the demanding schedule throughout the docking and undocking of spacecraft to/from the ISS, the originally scheduled CubeSat deployment has been re-scheduled to after Andreas' return to Earth.

AAUSAT5 leaving ISS



AAUSAT5 – ISS launch

- **Ok launch from ISS**
- **Problematic operations – very weak radio link**
- **Uplink from Aalborg (+400W)**
- **Downlink via Germany (Mike Rupprecht – DK3WN)**
- **Contact whole mission**
- **AIS did not receive anything**
- **Onboard conditions was very fine acc to telemetry**
- **hm**
- **???**

Spinn Off



- **Gamle AAUSAT studerende har startet 3 lokale rumskibsfabrikker**
 - **Gomspace**
 - **Space Inventor**
 - **Satlab**
- **2025: tilsammen 300-320 ansatte**
- **Set værre**

CANSAT – also for fun



Danish Cansat Competition 2016



A very low “orbit” CAN SATellite



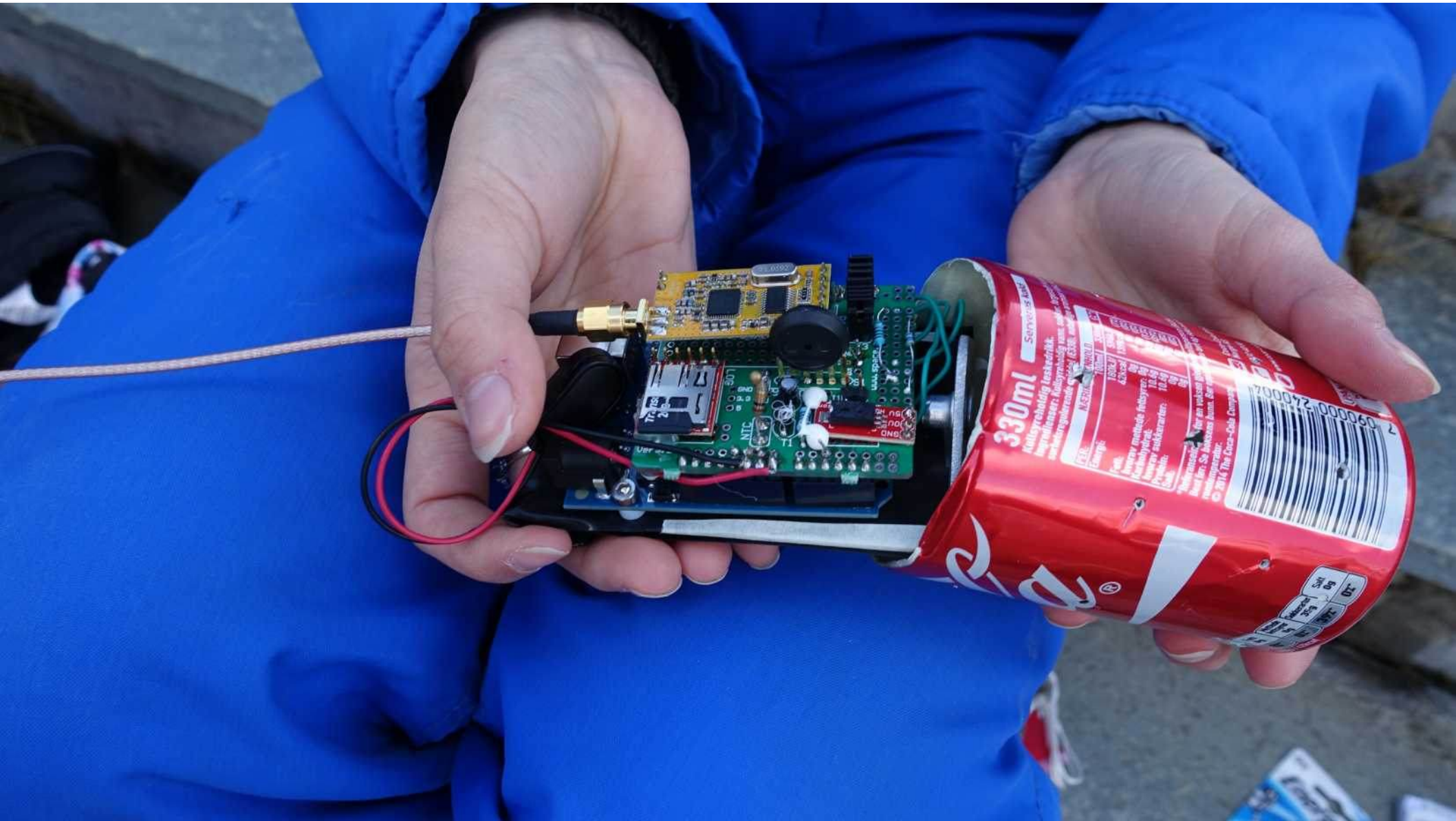


WHAT NOW ? :-)

- CANSAT in detail
- Arduino computer
 - 16 MHz, 2 kByte RAM,
 - primitiv
 - robust
- radio system til komm
- SDkort til at gemme data
- IMU (Inertial Measuring Unit)
 - 3 akser acceleration
 - 3 akser rotation
 - 3 akser magnetfelt
 - lufttryk
 - temperature
- Dit bidrag
 - GPS
 - luftsensor kvalitet
 - lys sammensætning
 - kamera
 - ...

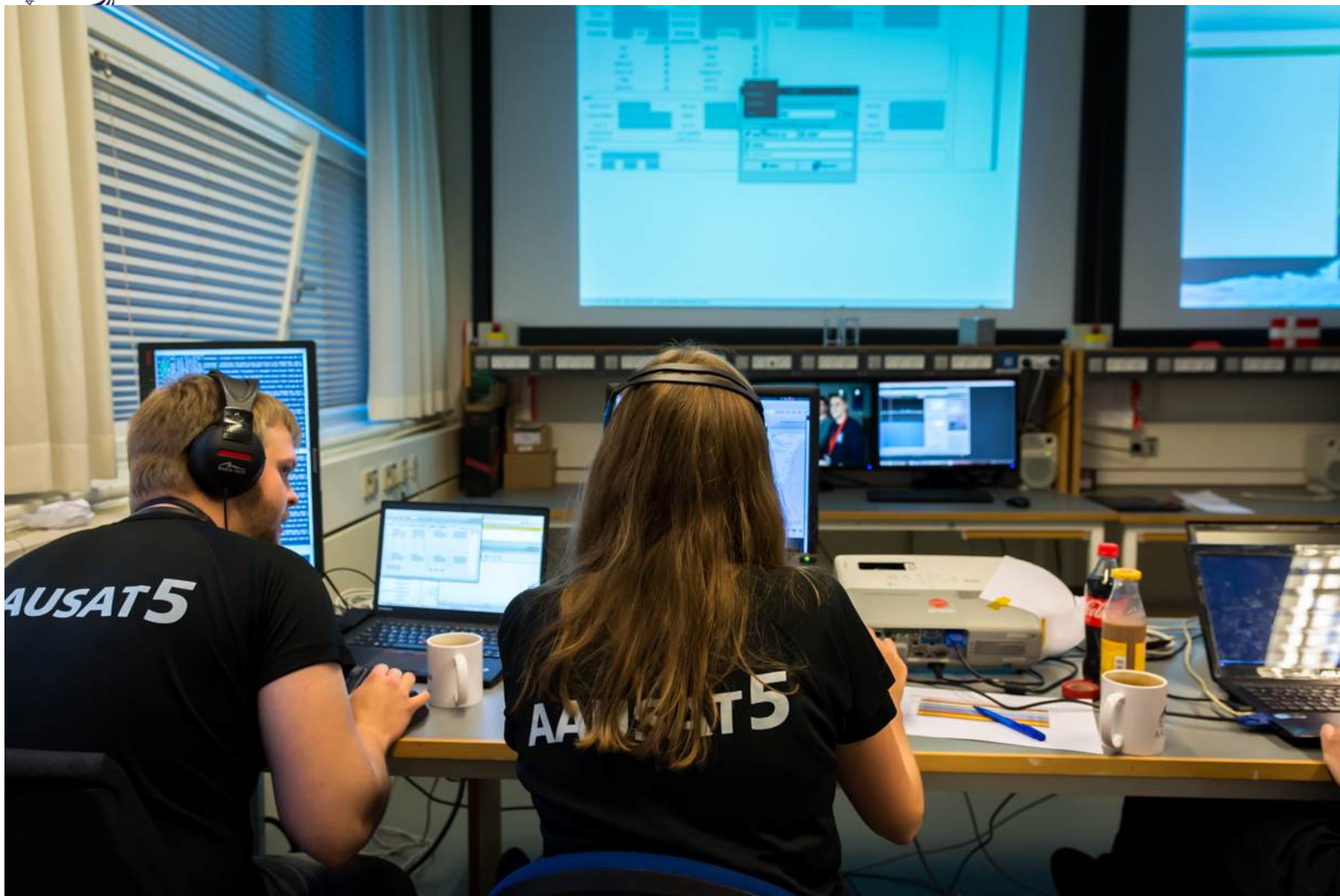


A Coke – I Hope ;-)



skywatch :-)





efter fyraften – Lofoten(nord Norge)





IDAG

<https://jensd.dk/doc/aaucansat/>

<https://satlab.aau.dk/stem/jensd/doc/cansat/scienceday25.html>

<https://satlab.aau.dk/stem/jensd/doc/sensors/imushield/>