SwissCube…

The Swiss Space Adventure!

Muriel Noca
Maurice Borgeaud
Ted Choueiri
Yann Voumard

March 14, 2009

All started…

Mid-2005

How can we maximize the learning of the students?

Space Center

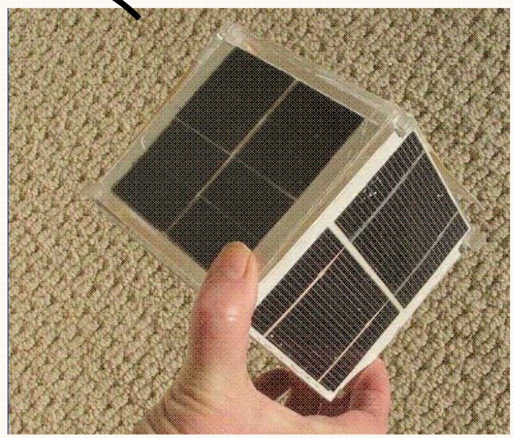
EPFL LMTS MICROSYSTEMS FOR SPACE TECHNOLOGY LABORATORY

Dr. Maurice Borgeaud
Directeur, Space Center

Prof. Herbert Shea
Professeur LMTS

All started…

Mid-2005



Space Center

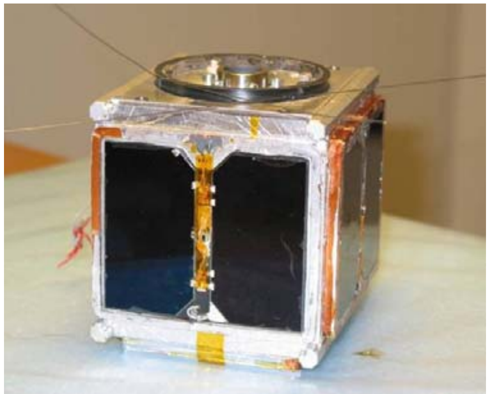
EPFL LMTS
MICROSYSTEMS FOR SPACE TECHNOLOGY LABORATORY

Dr. Maurice Borgeaud
Directeur, Space Center

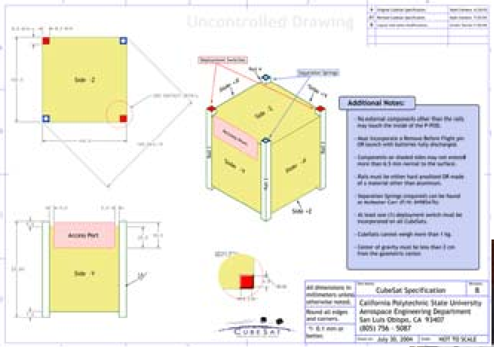
Prof. Herbert Shea
Professeur LMTS

CUBESATs

- Standard of pico-satellites
  - 1 kg, 10x10x10 cm3



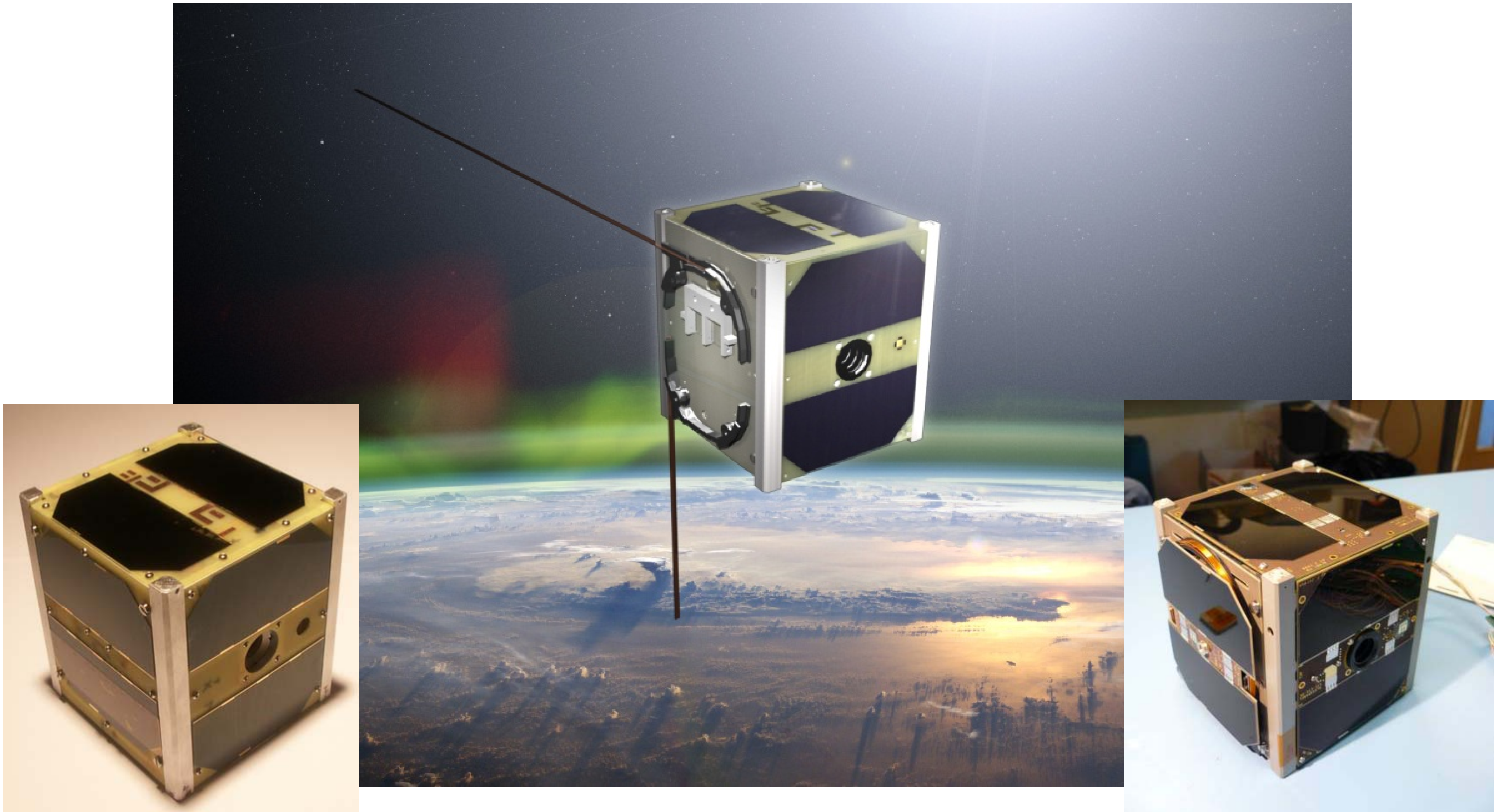
Aalborg University 1st cubesat



- ~ 80 universities in the world
- ~ 25 universities in Europe
- As of today:
  - 38 launched
  - 14 lost due to launch failure
  - 20 contact
  - 4 no contact

We will need 3 years to create SwissCube…

2006 – 2007 – 2008



A bit of history…

- Switzerland has been active in the space business for a while and participates in ESA's activities
- First experiment set up on the Moon by the crew of Apollo 11 was Swiss: analysis of solar winds, an experiment from the University of Bern

Photo NASA, Apollo 11

A bit of history…

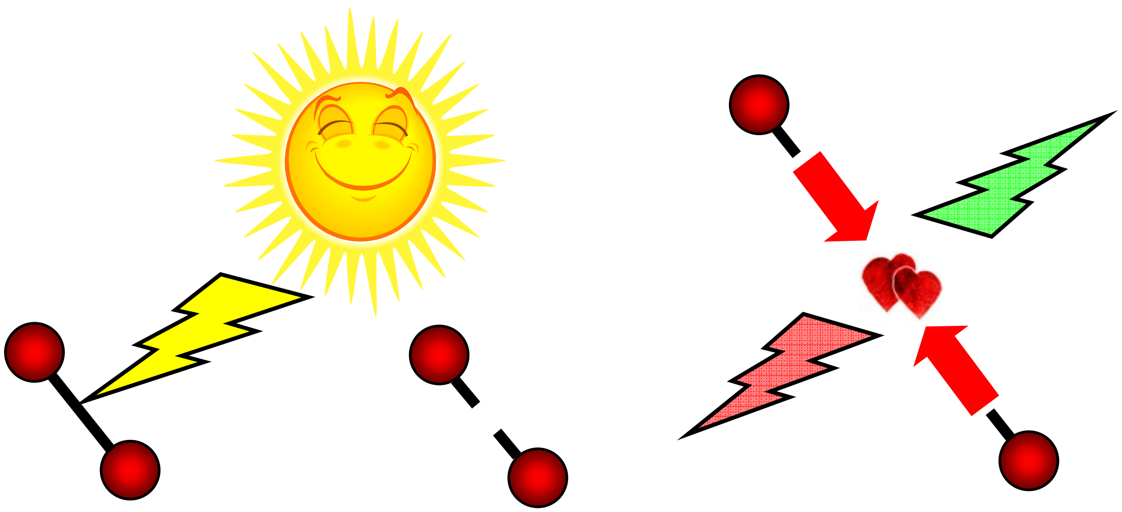
- Switzerland attempted to design and built a satellite with Austria in the early 90's, but initiative failed by lack of funding

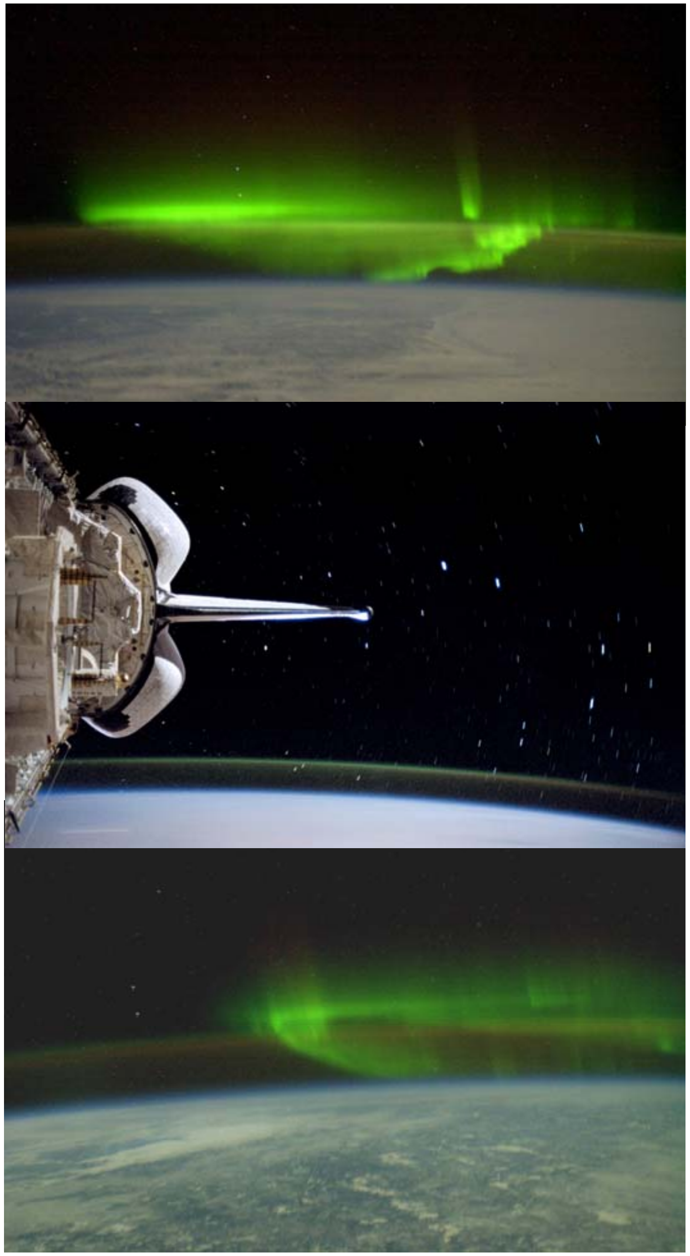
- SwissCube is the first entirely Swiss satellite, and all done by students

Scientific Mission

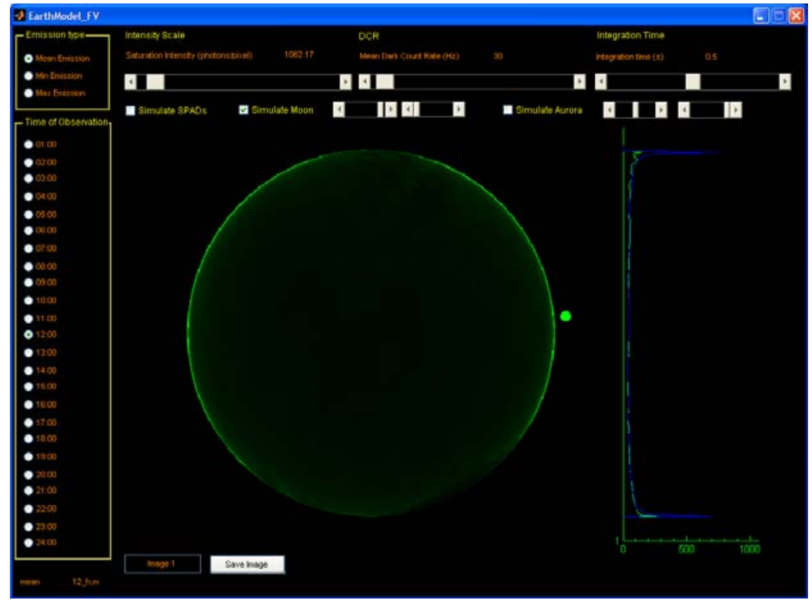
Measure atmospheric airglow

- Atmospheric layer at ~100 km
- Light due to recombination of Oxygen atoms
- Emissions mostly in the green (550 nm) and near infra-red (762 nm)





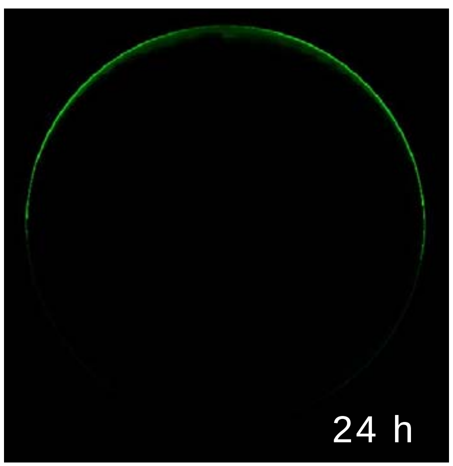
Scientific Mission

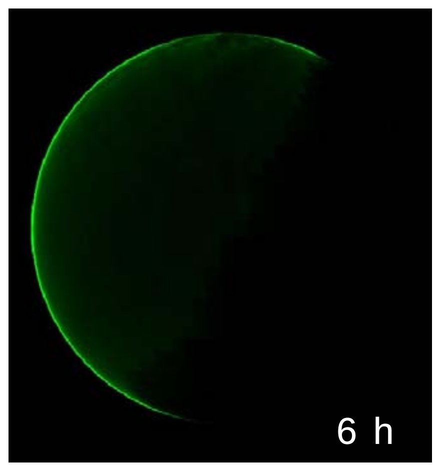


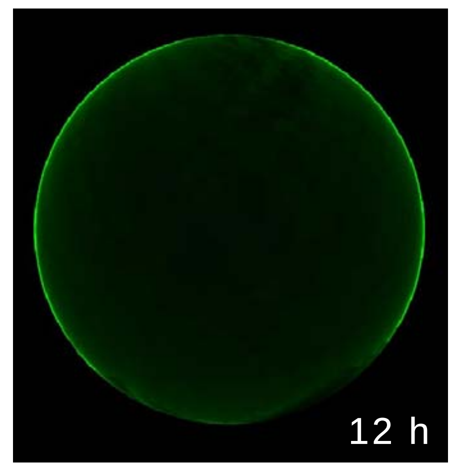
Measure airglow to :

- Validate an airglow model that predicts intensity as a function of

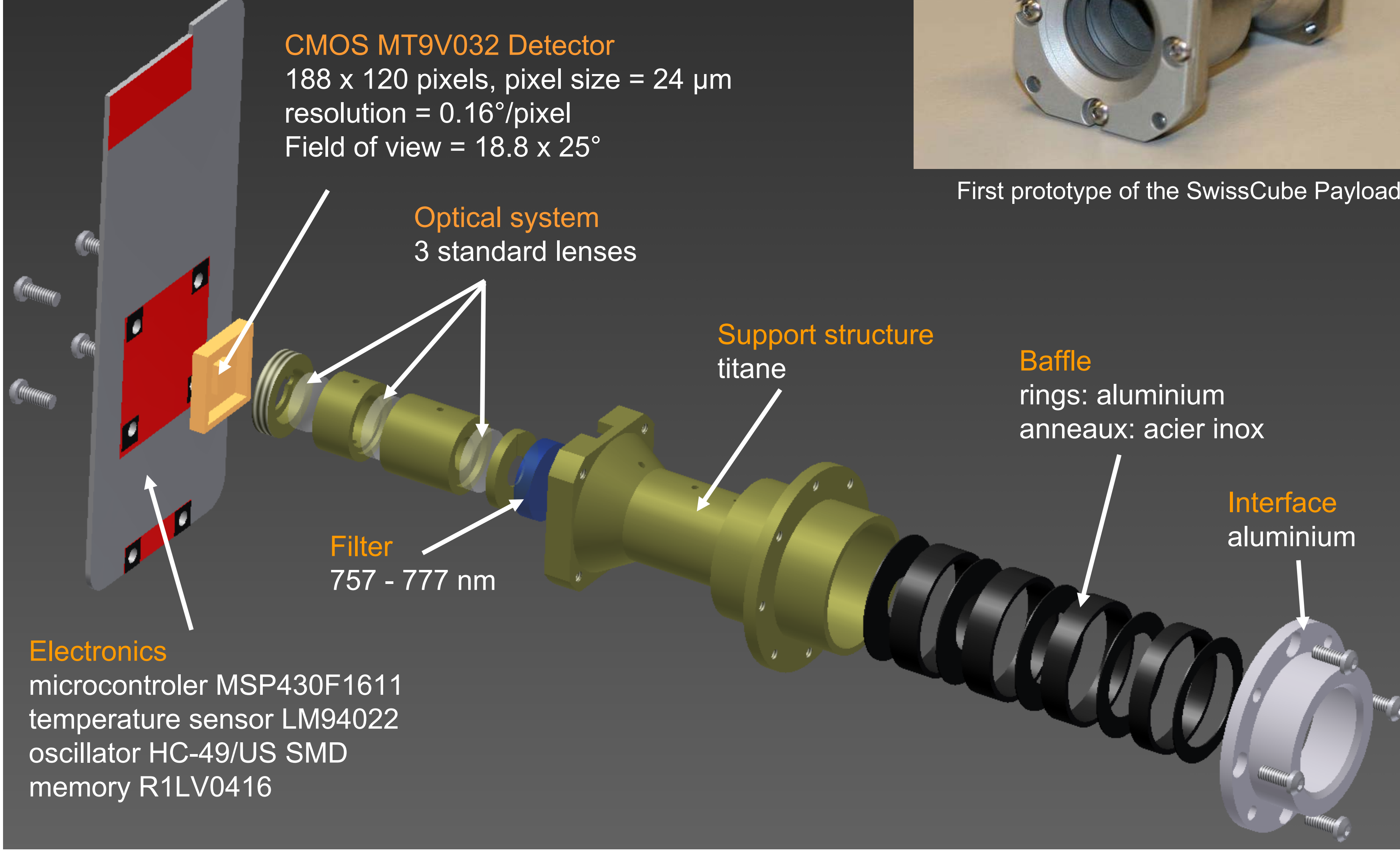
  → latitude
  → altitude
  → solar local time







Payload (Telescope)



First prototype of the SwissCube Payload

The launch options

Launch Options as of today:

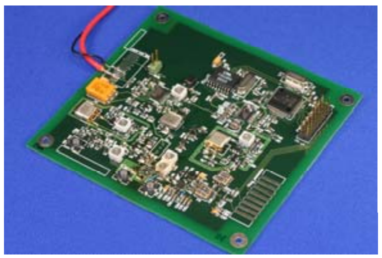
1. Indian PSLV
   - Launch opportunity planned for spring 2009
   - Orbit: sun-synchronous 720 km

2. ESA-VEGA Maiden Flight
   - Launch date November 09+
   - Orbit: 350 x 1450 km, 71^{o} inclination
   - Decision to fly on VEGA still pending

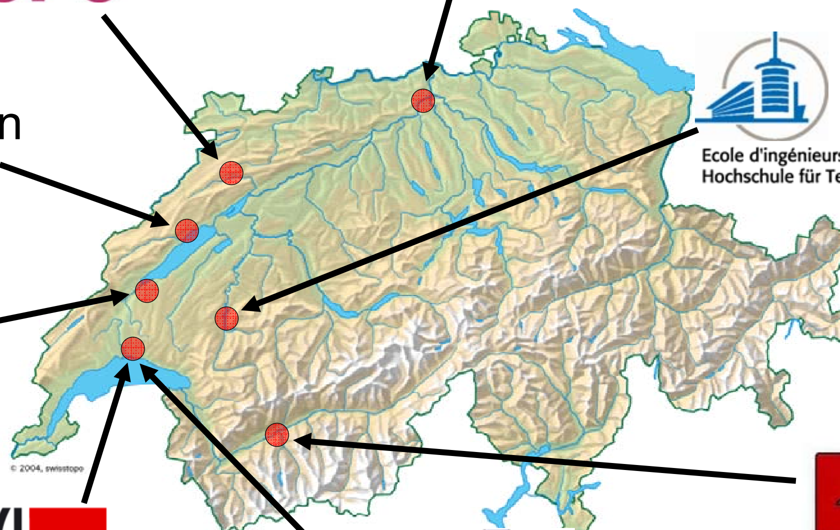
Project Partners

Flight and Ground Software
haute école neuchâtel berne jura arc

Science Mission
n|w Fachhochschule Nordwestschweiz

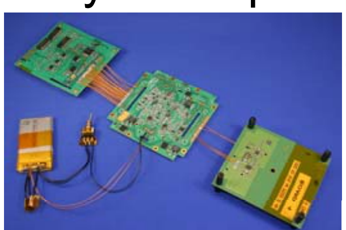


Système de communication
Université de Neuchâtel unine



Ground Station Beacon System
Ecole d'ingénieurs et d'architectes de Fribourg
Hochschule für Technik und Architektur Freiburg

Electrical Power and Payload Optics
heig-vd
Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud



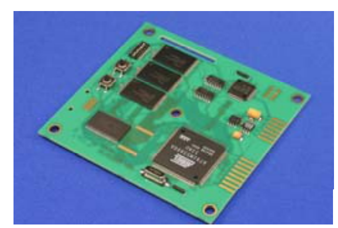
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

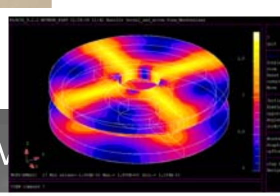
Mechanical systems
System Integration

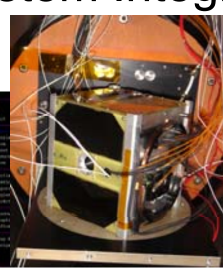
RADIOAMATEUR Vaudois HB9MM

HEVs

On-board Computer

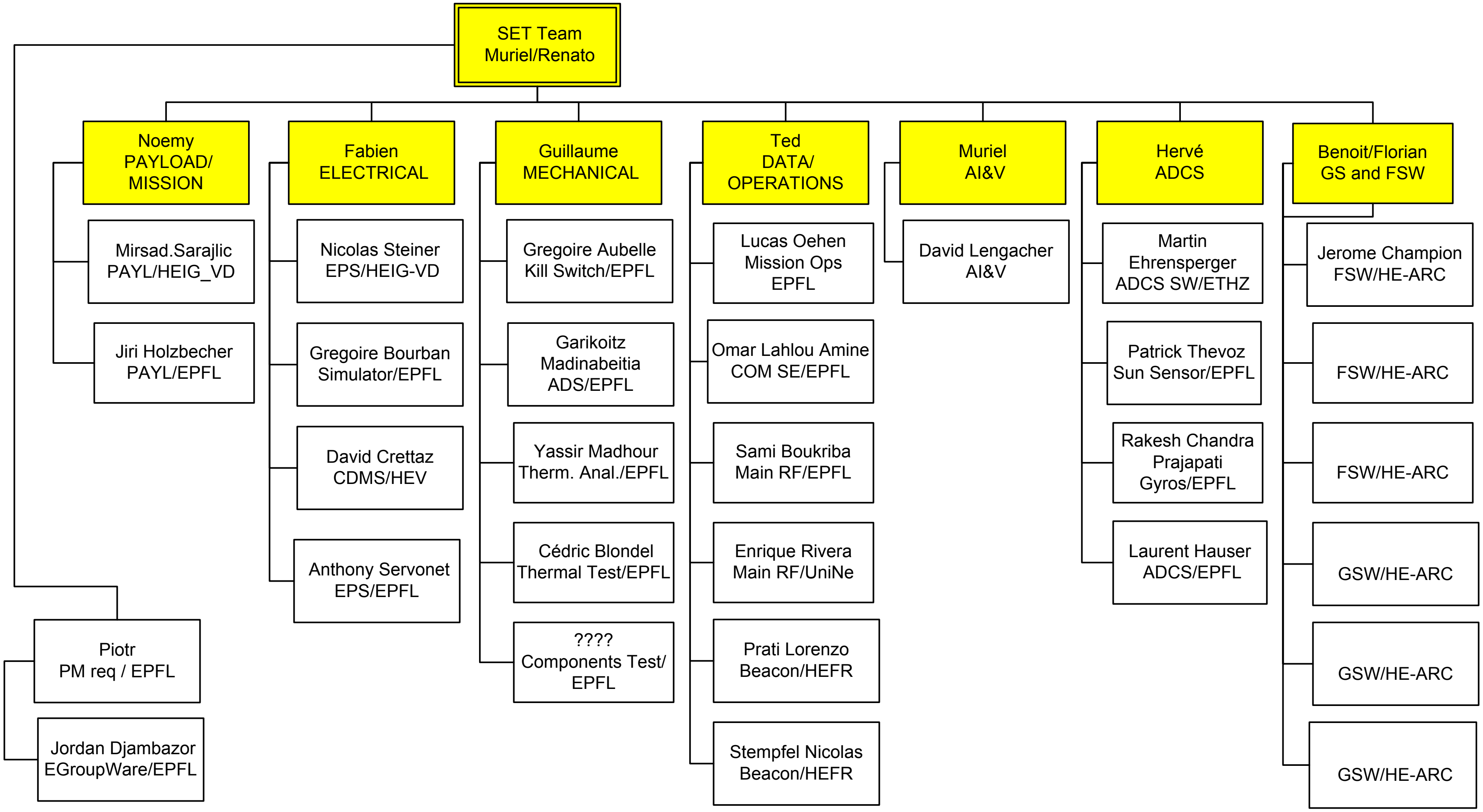






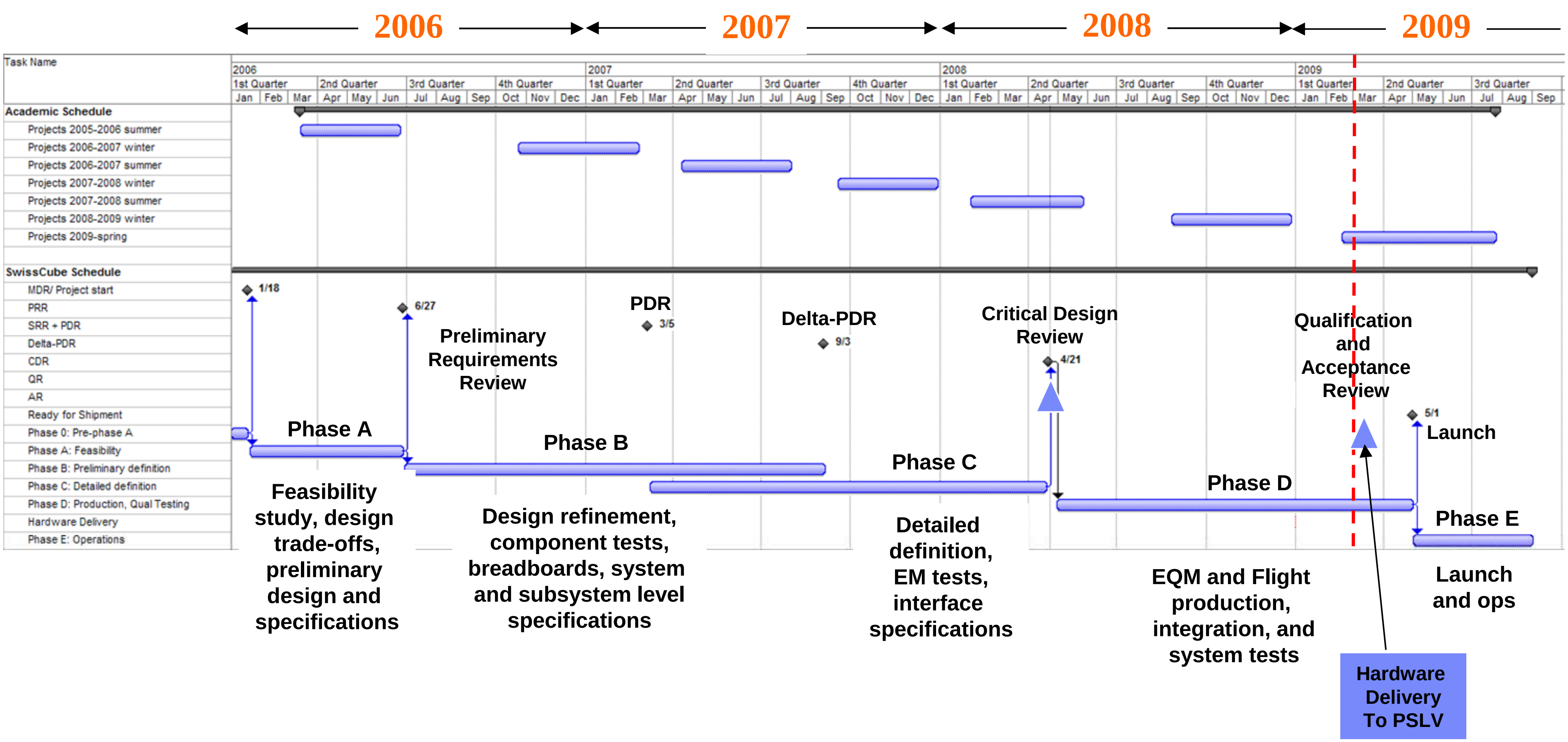
Hes·so Haute Ecole Spécialisée de Suisse occidentale
Université de Neuchâtel unine

Winter Semester 2007-8 Team (example)

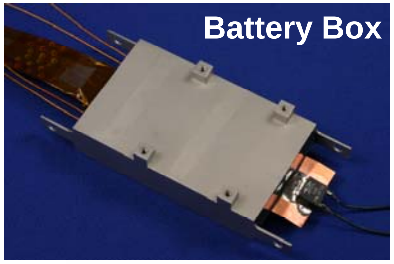


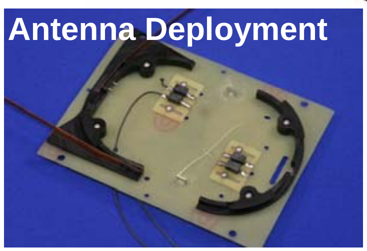
- ~ 30 students, spread under the responsibility of core system engineering team
- Most of the system engineering team expected to stay up to launch

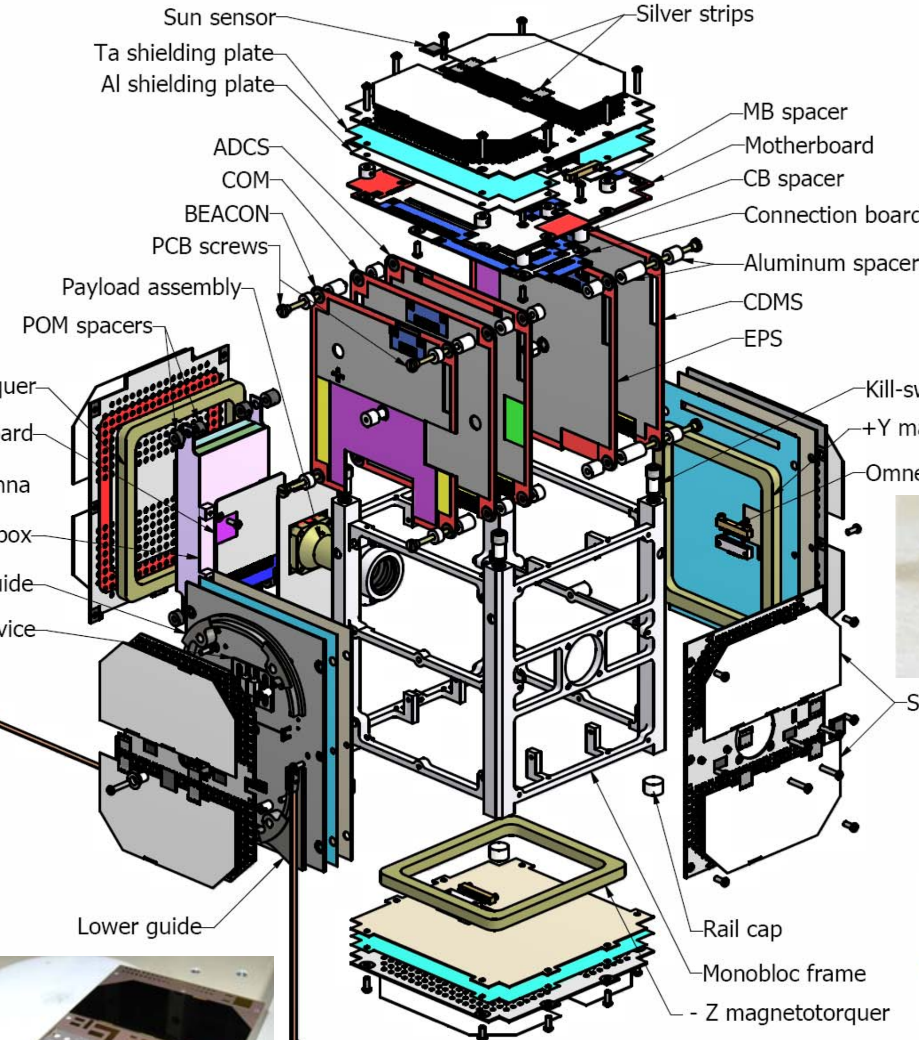
Where are we at?

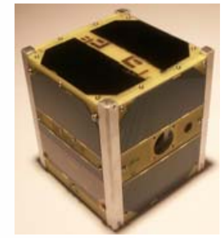


Flight System

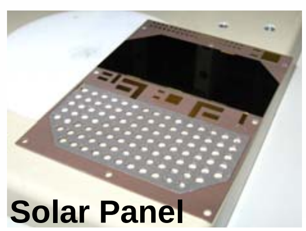






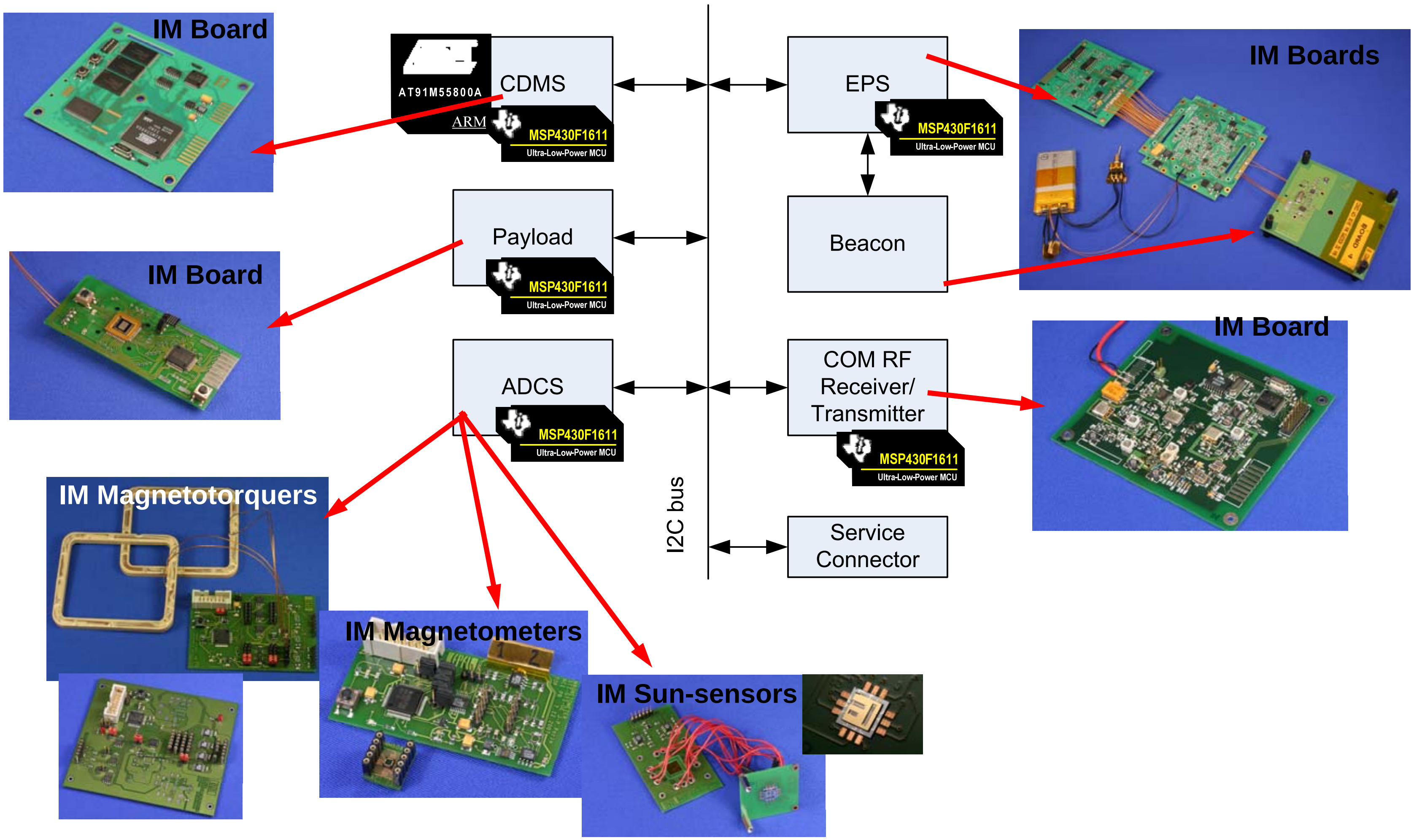


STM Model



EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE | Hes·so Haute Ecole Spécialisée de Suisse occidentale | Université de Neuchâtel unine

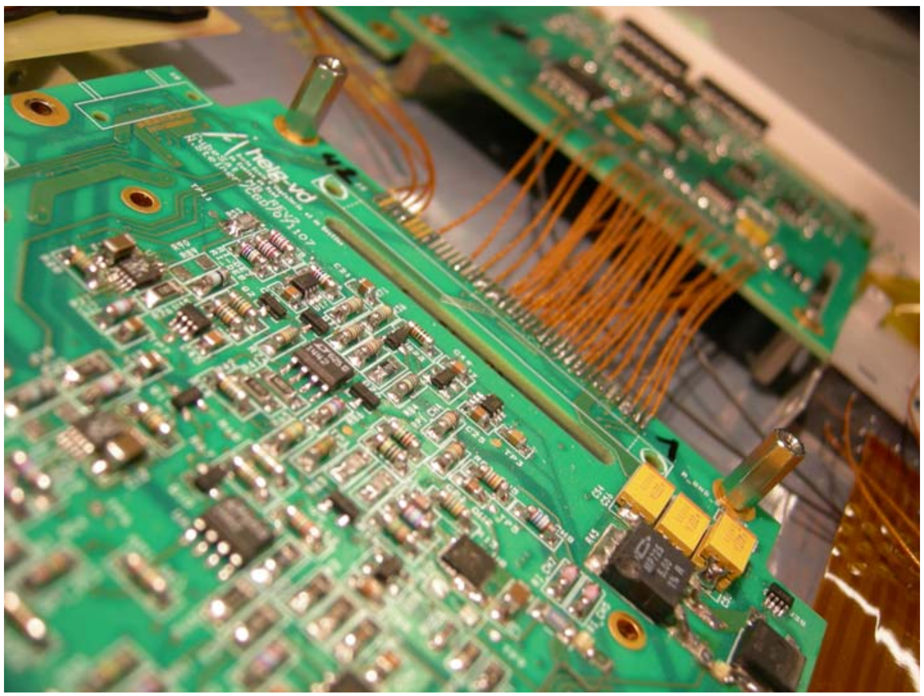
High Level Architecture

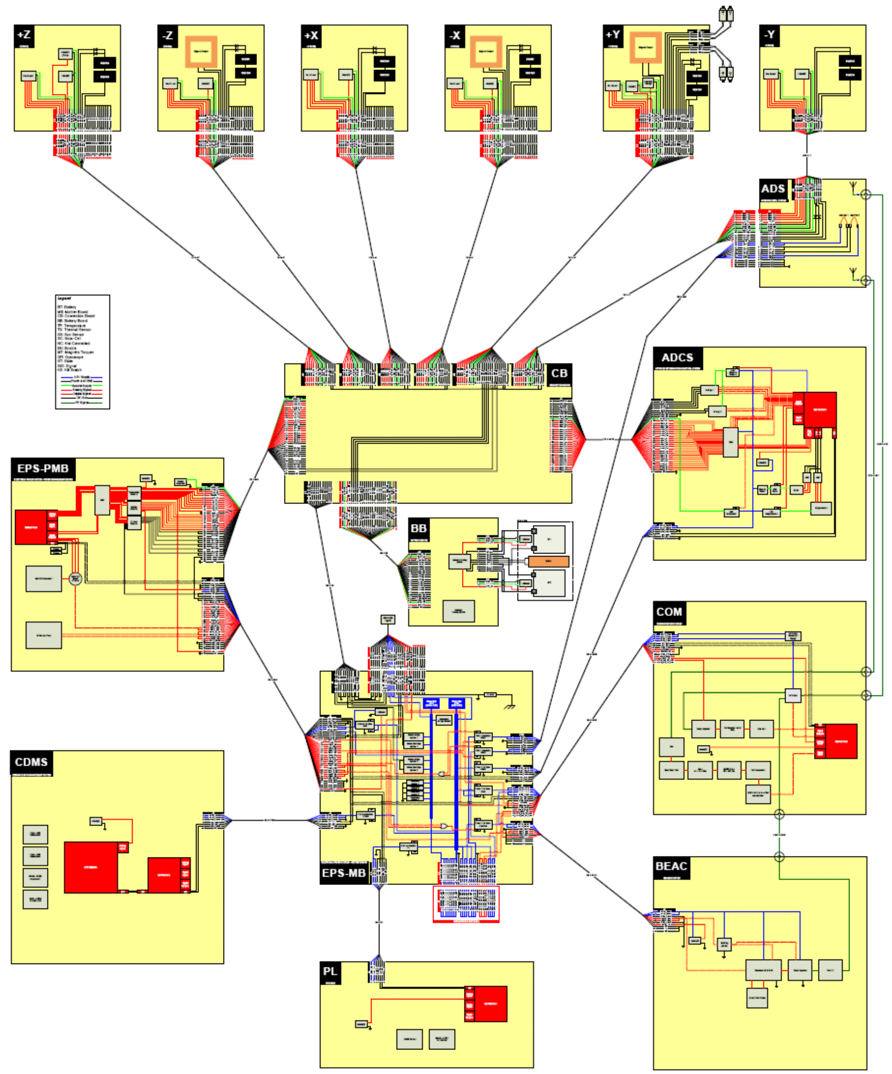


EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
Hes·so Haute Ecole Spécialisée de Suisse occidentale
Université de Neuchâtel unine

Electronic system composed of…

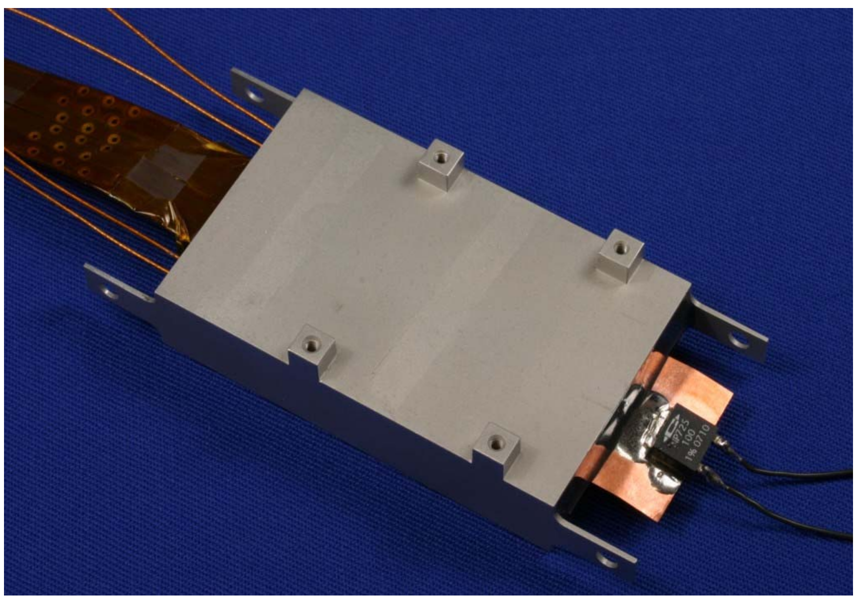
- 7 subsystems
  - Spread over 16 electronic boards
  - 357 wires, more than 700 solders
  - About 1000 components



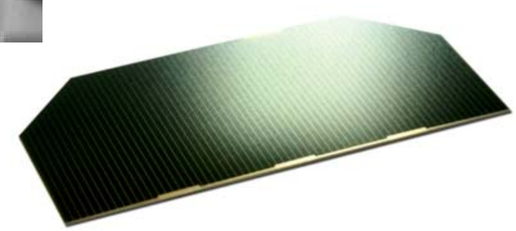


An Energy Management Challenge !

- Mean power production : 1.5 Watt
- Power produced via
  - 12 high efficiency solar cells
- Energy storage
  - 2 Lithium-Polymer batteries of 1.2 Ah
  - Internal heating to keep batteries warm

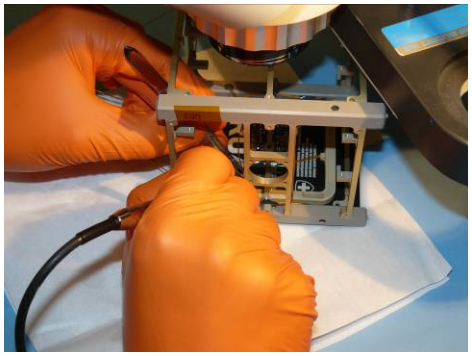


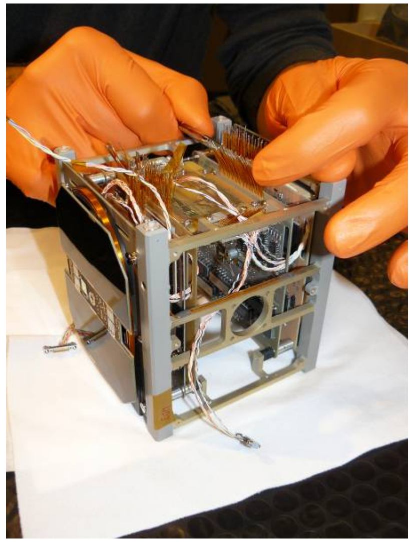
<u>Mass</u> : 4 grammes
<u>Efficiency</u> : 27 %
<u>Price</u>: CHF 650.-

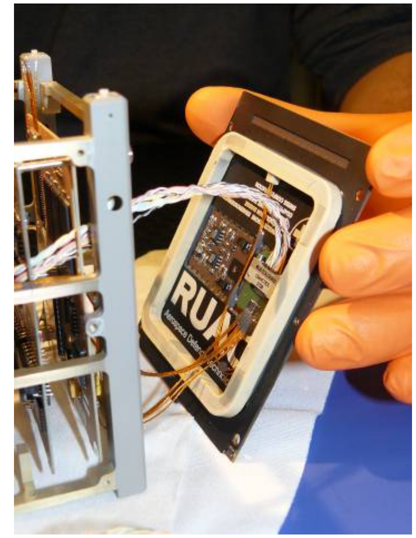


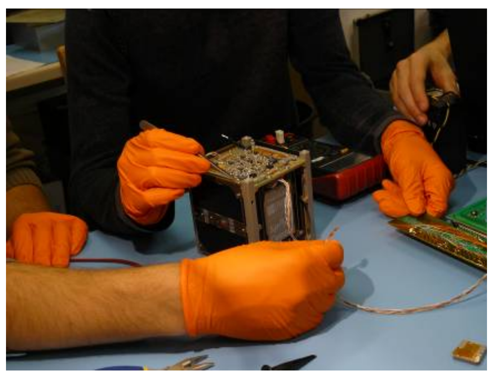
<u>Operating temperature</u>: -50 à +70 °C

Integration of the Engineering Qualification Model (EQM)

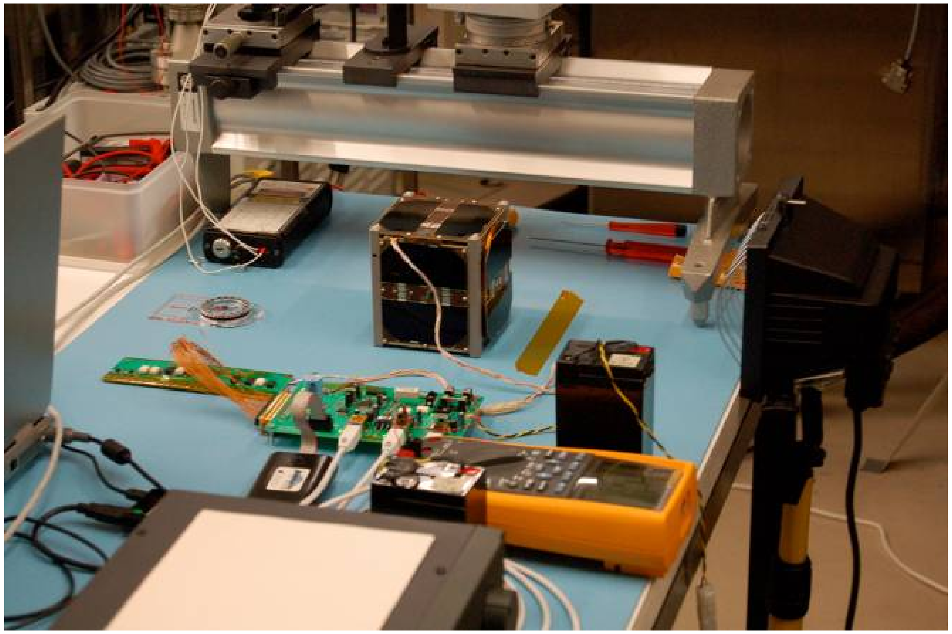


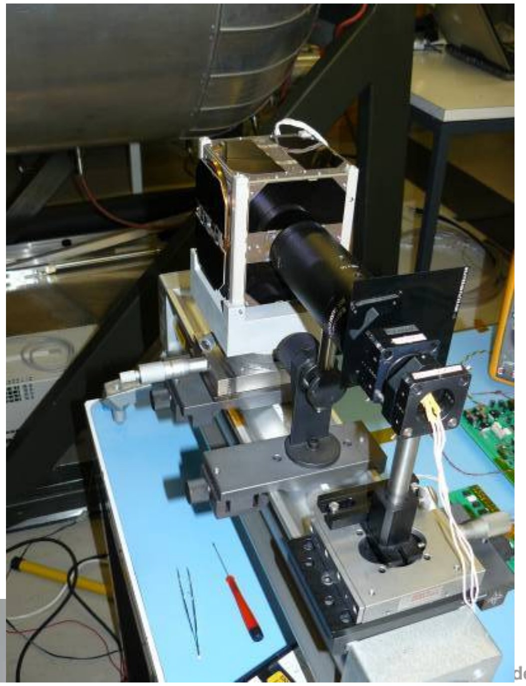






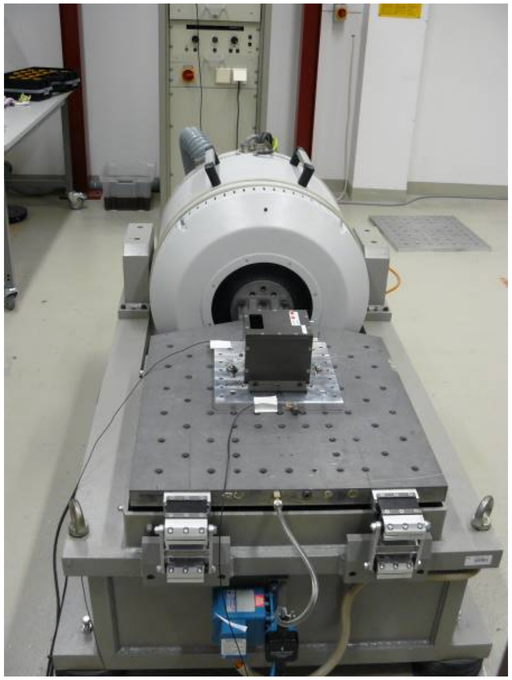
Test Set-Up





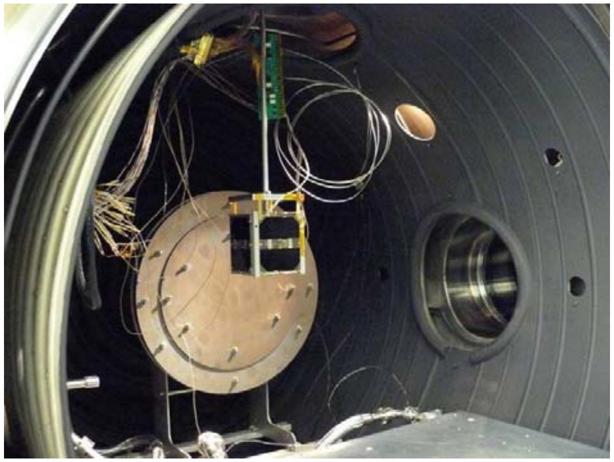
Qualification Testing of the EQM: Sine, Random and Pyroshock

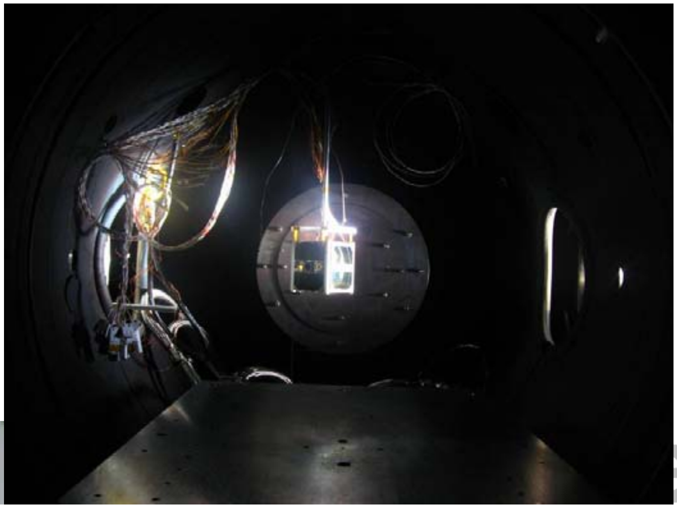
- Tests done at DLR/Astro-Feinwerktechnik in Berlin over 3 days (financed by RUAG-Aerospace)
- Qualified for PSLV-ISIS levels
- All subsystems survived, no defects, no major problem
- Pyroshock: hard time with the calibration of the test facility



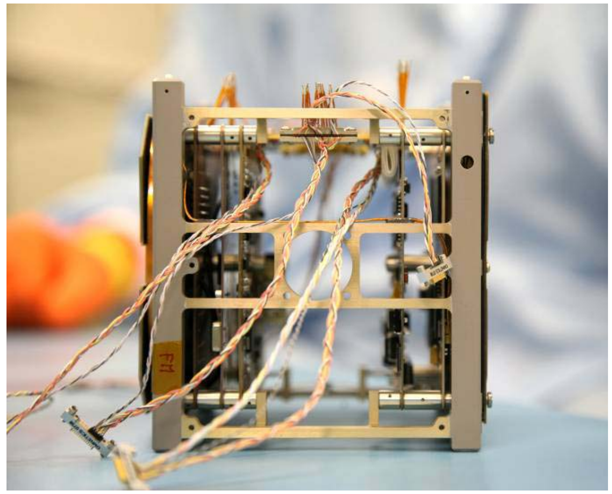
Qualification Testing of the EQM: TVC

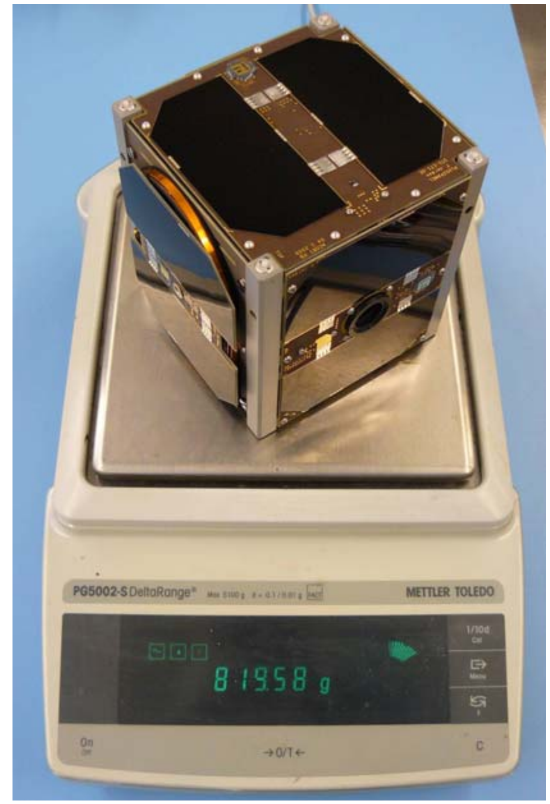
- Done at the University of Bern over 3 weeks
- Sun simulator + rotating device to simulate best environment
- 8 cycles, ~5-20 deg. K qualification margin
- Several problems occurred
  - All of them resolved within 1-2 days
  - Could resume testing quite fast, but still long test process
- Time and people management

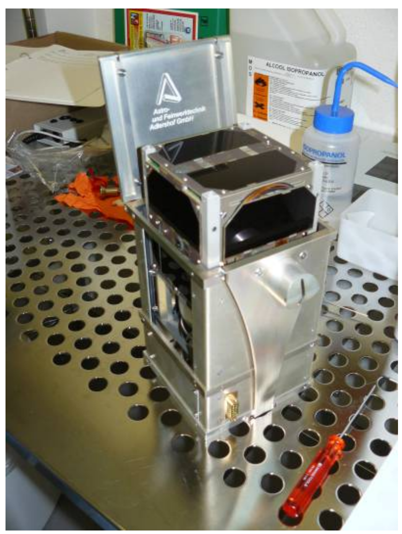




Integration of SwissCube FM

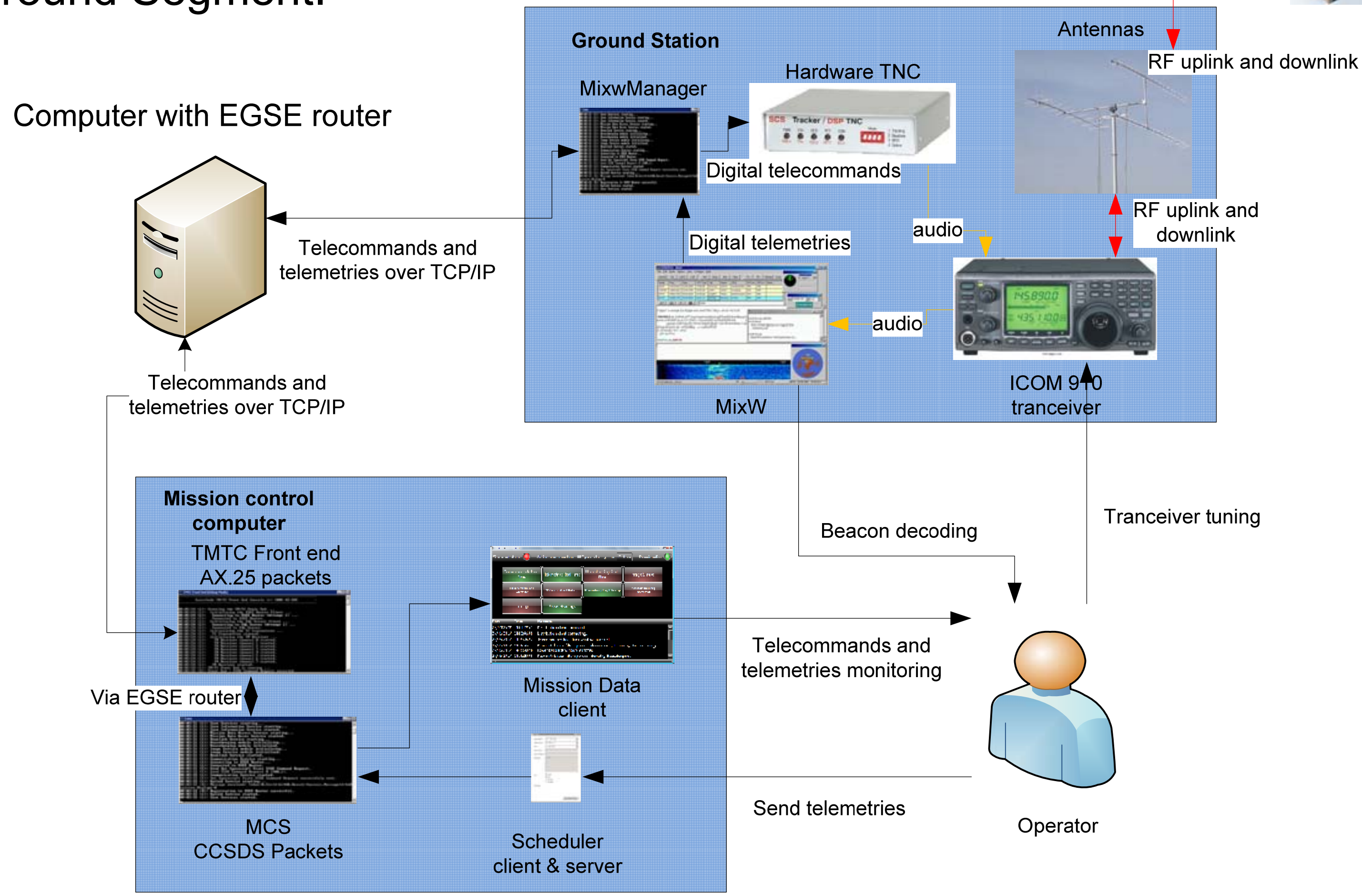




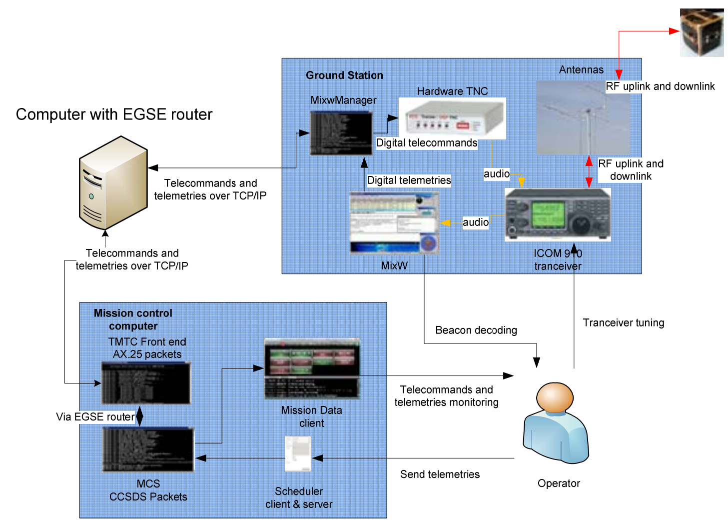


Overview of the telecom system ¼ - Overview

- The system is composed of two main parts: the Swisscube spacecraft and the Ground Segment.



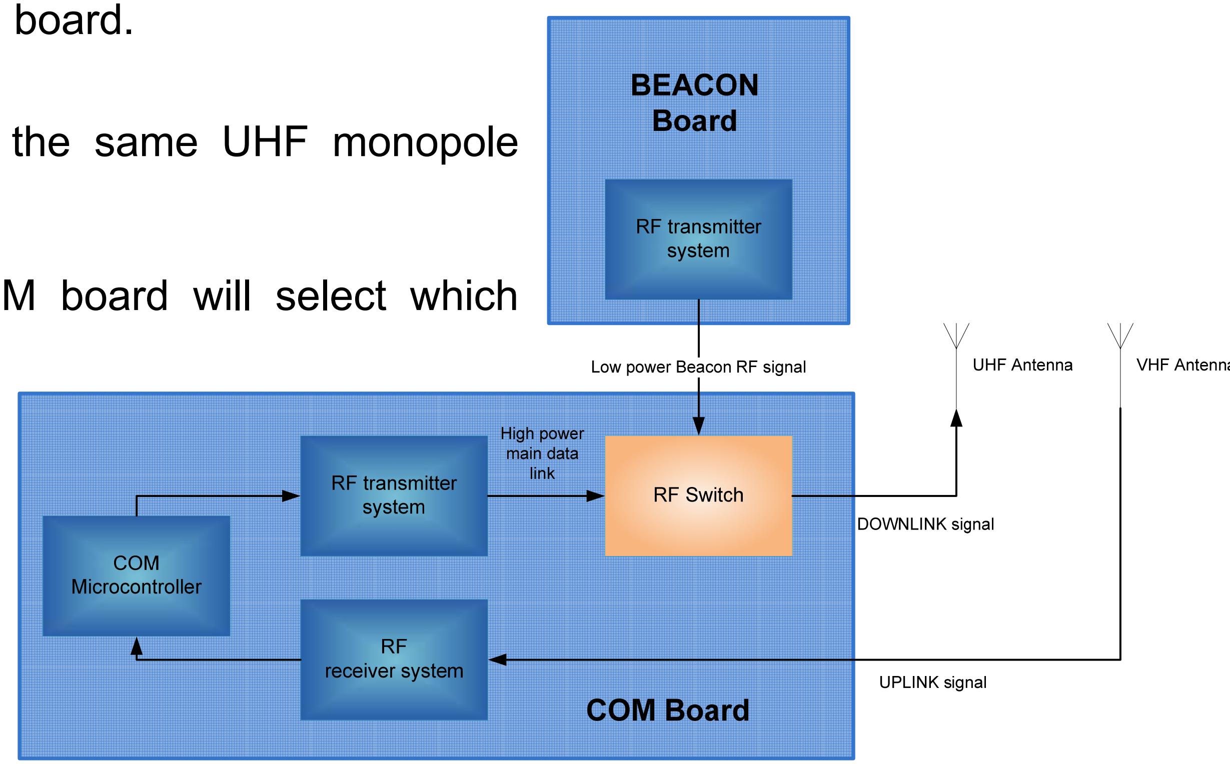
Overview of the telecom system 2/4 - Ground Segment



- The mission operators interact with the Mission Data Client and the Planning Tool.
- These two blocks allow for the visualisation of the telemetry received from the satellite and the planning of scenarios that will be played out during the communication windows.
- The Mission Control System manages the CCSDS PUS packet format. It encapsulates telecommands in CCSDS PUS packets and decapsulates the telemetry. It communicates with the TMTC Front End through the EGSE router.
- The TMTC Front End manages the AX.25 protocol, and encapsulates telecommands and decapsulates telemetry into AX.25 transfer frames. These frames are sent to and received from the Ground Station(s) through the EGSE Router.

Overview of the telecom system 3/4 - RF links

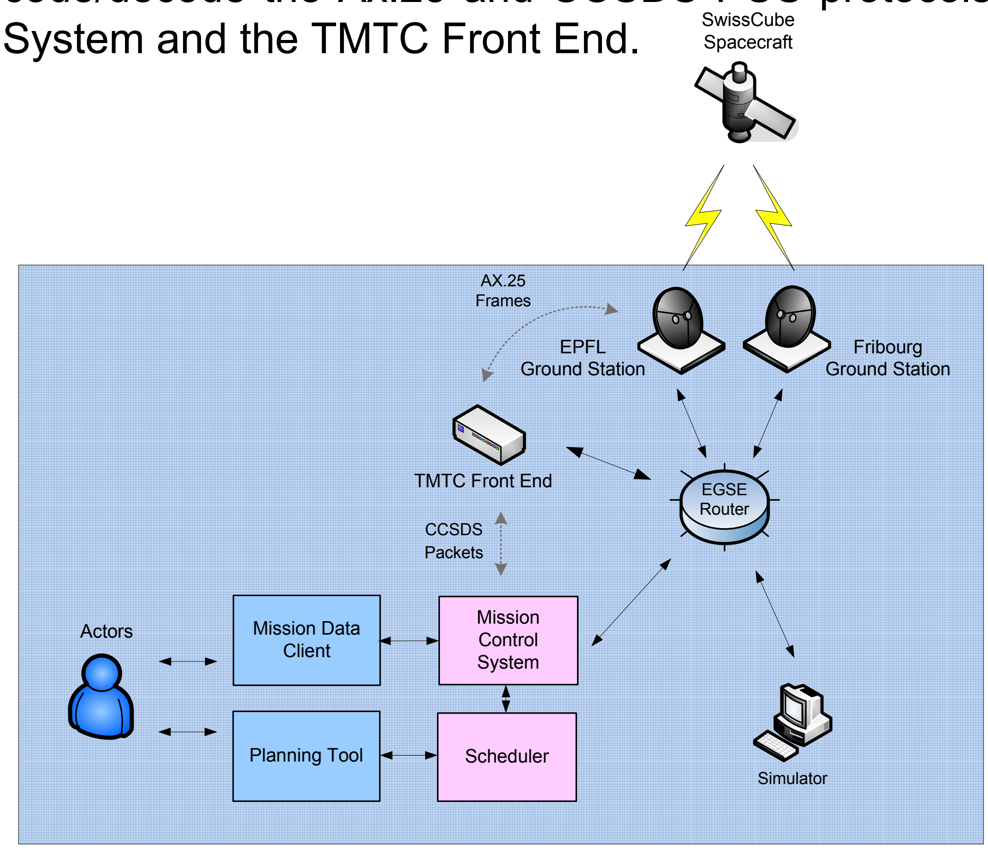
- The Swisscube satellite has two main communication links.
- First link: main data RF link. High power and high data rate RF downlink (1W at 1200 bps) and uplink (20W-50W at 1200 bps). This RF link is handled by the COM board.
- Second link: Low power (120 mW) beacon signal. This signal is generated by the EPS board and amplified by the Beacon board.
- Both downlink signals use the same UHF monopole antenna.
- The RF switch on the COM board will select which signal will be transmitted.



Overview of the telecom system 4/4 - Ground Stations

- The Swisscube will communicate with two Ground Stations in Switzerland. One is in Fribourg at the EIA-Fr Engineering school, and the second one is in Lausanne at EPFL.

- The Ground Stations only handle the RF links, i.e. it modulates and/or demodulates the data, but does not encode/decode the Ax.25 and CCSDS PUS protocols. This is handled by the Mission Control System and the TMTC Front End.



RF interfaces between the Swisscube and the Ground Stations. Assumptions and status.

- It was assumed that the satellite follows the following orbit:
  - Circular sun synchronous orbit with 720km radius,
  - 98.61° inclination,
  - argument of Perigee 180 degree,
  - R.A.A.N 7.13 decrees.

- The frequencies have been assigned by the IARU and the international notification process was achieved by the ITU.

- The Swisscube satellite has been assigned a radioamateur callsign: HB9EG/1.

RF interfaces between the Swisscube and the Ground Stations. Main data uplink.

Main data uplink specifications	
Frequency	145.XXX MHz
Admissible frequency deviation	4 kHz (i.e. ± 2kHz)
Data rate	1200 bits/s
Modulation	AFSK over FM
Mark frequency (binary 1)	2200 Hz
Space frequency (binary 0)	1200 Hz
Bandwidth	14.3 KHz

RF interfaces between the Swisscube and the Ground Stations. Main data downlink.

Main data downlink specifications	
Frequency	437.505 MHz
Admissible frequency deviation	4 kHz (i.e. ± 2kHz)
Data rate	1200 bits/s
Modulation	FSK
Frequency deviation	500 Hz
Bandwidth	2.920 kHz
Isotropic Signal Level at GS	-161.8 dBW at EPFL -159.1 dBW at HES-SO Fribourg

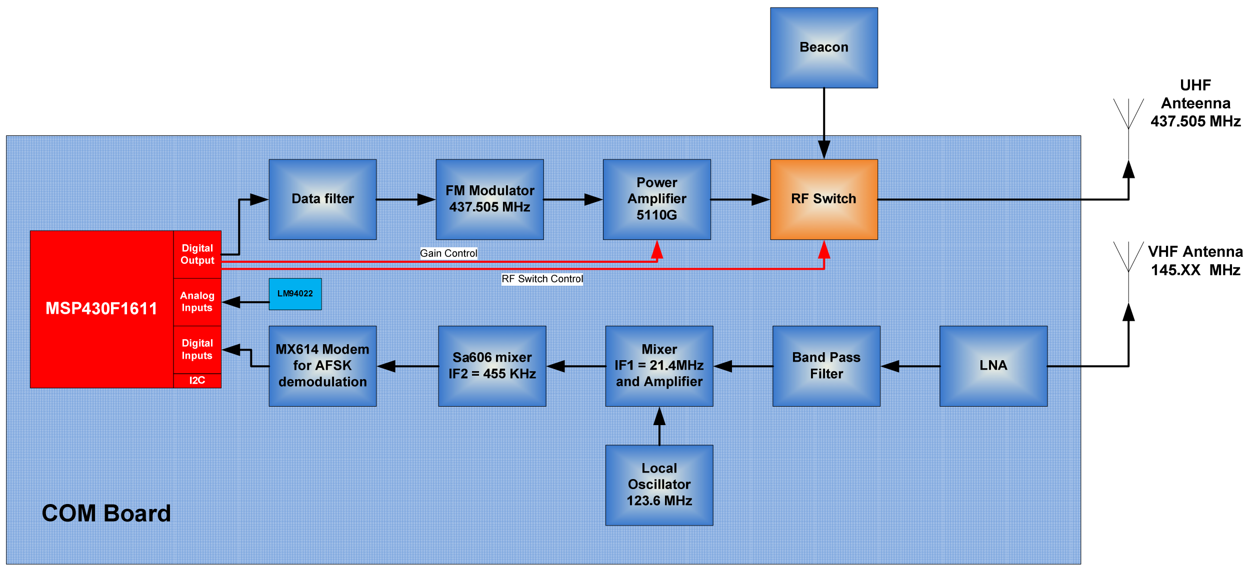
- The signal must be received as an FSK signal using SSB. It can then be demodulated by a TNC.

RF interfaces between the Swisscube and the Ground Stations. Beacon downlink.

Beacon downlink specifications	
Frequency	437.505 MHz
Admissible frequency deviation	4 kHz (i.e. ± 2kHz)
Data rate	14 bits/s
Modulation	ASK/OOK CW
Bandwidth	22.4 Hz (1.6*data rate)
Isotropic Signal Level at GS	-171.8 dBW

Part	Correct example
0	HB9EG/1
1	1 0 3
2	2 310 316
3	3 001010 45

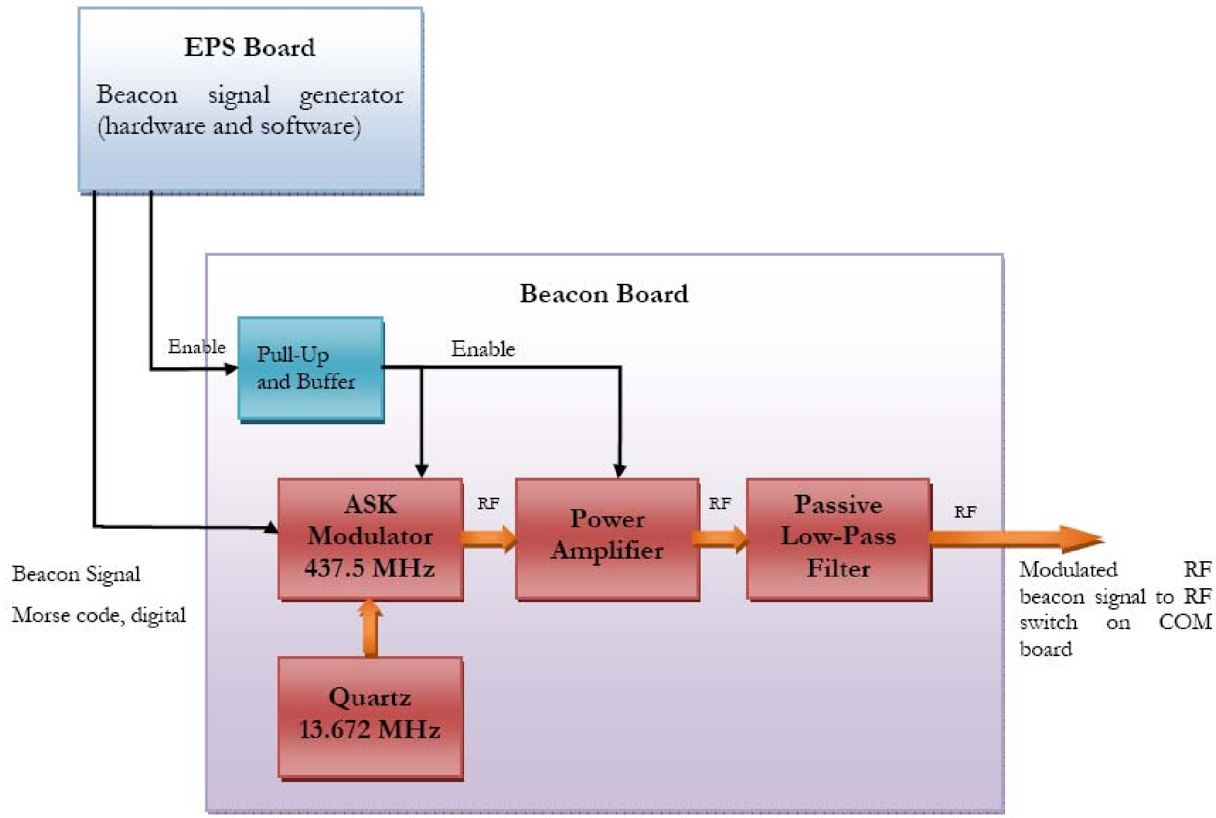
Block diagram of the COM board.



- The COM board manages the uplink and downlink signals. As such, it can demodulate the AFSK uplink signal, modulate the FSK downlink signal and can encapsulate and decapsulate AX.25 frames.
- The microcontroller MSP430 handles the AX.25 protocol and controls the transmitter and the receiver. The microcontroller also reads the temperature sensor that is on the Beacon board.

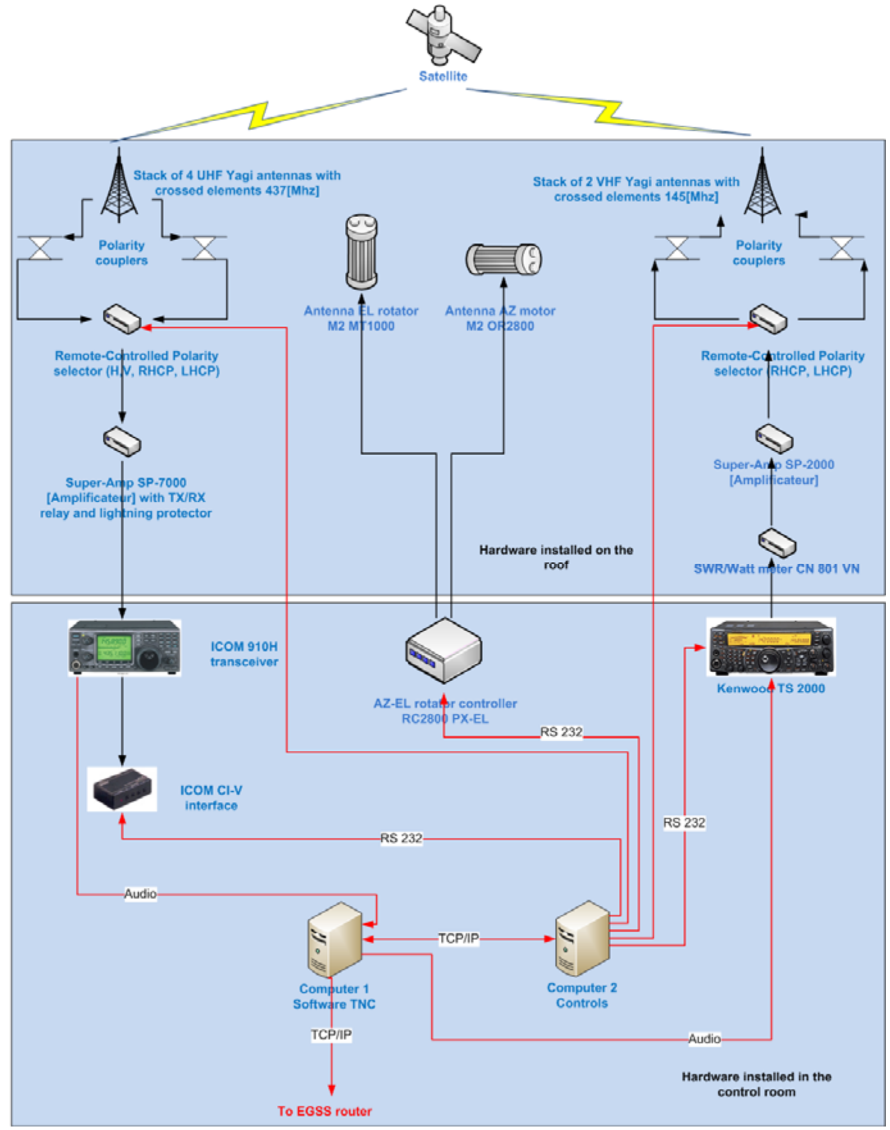
Block diagram of the Beacon board.

- The beacon board receives the beacon signal generated by the EPS board and modulates this signal in Morse code (ASK/OOK).
- It then amplifies and transmits the beacon signal to the RF switch on the COM board.



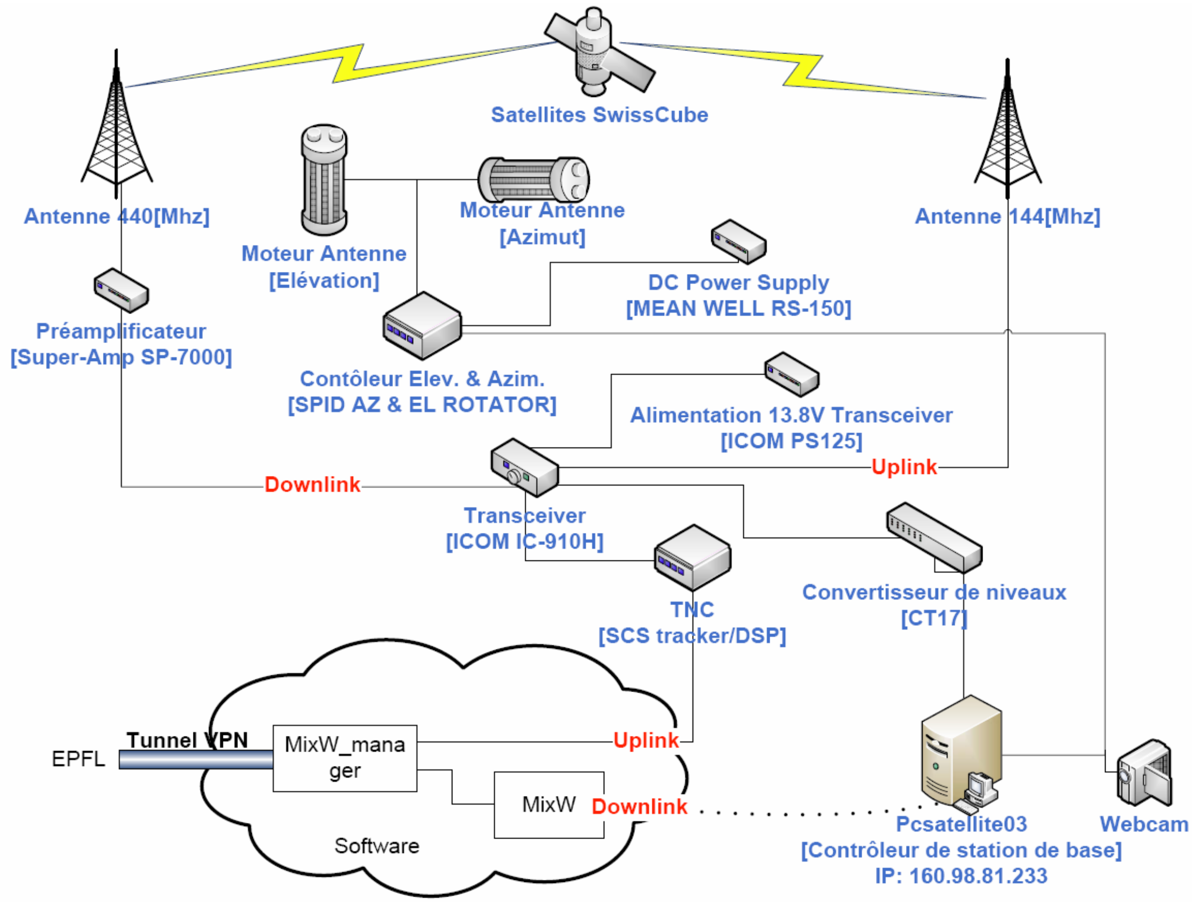
Block diagram of the EPFL ground station.

- There are 2 transceivers. One Kenwood TS-2000 for the uplink and one ICOM IC-910 for the downlink.
- There are several reasons for having two transceivers:
  - Experience has shown that the ICOM 910 receiver has better performances than the Kenwood TS-2000 receiver.
  - Both transceivers handle duplex communications. As such, one transceiver can handle all the communications with the satellite if the other transceiver fails.
  - Interfacing the transceivers in simplex mode with the computer and the TNC (be it software or hardware) is simpler than in duplex mode.

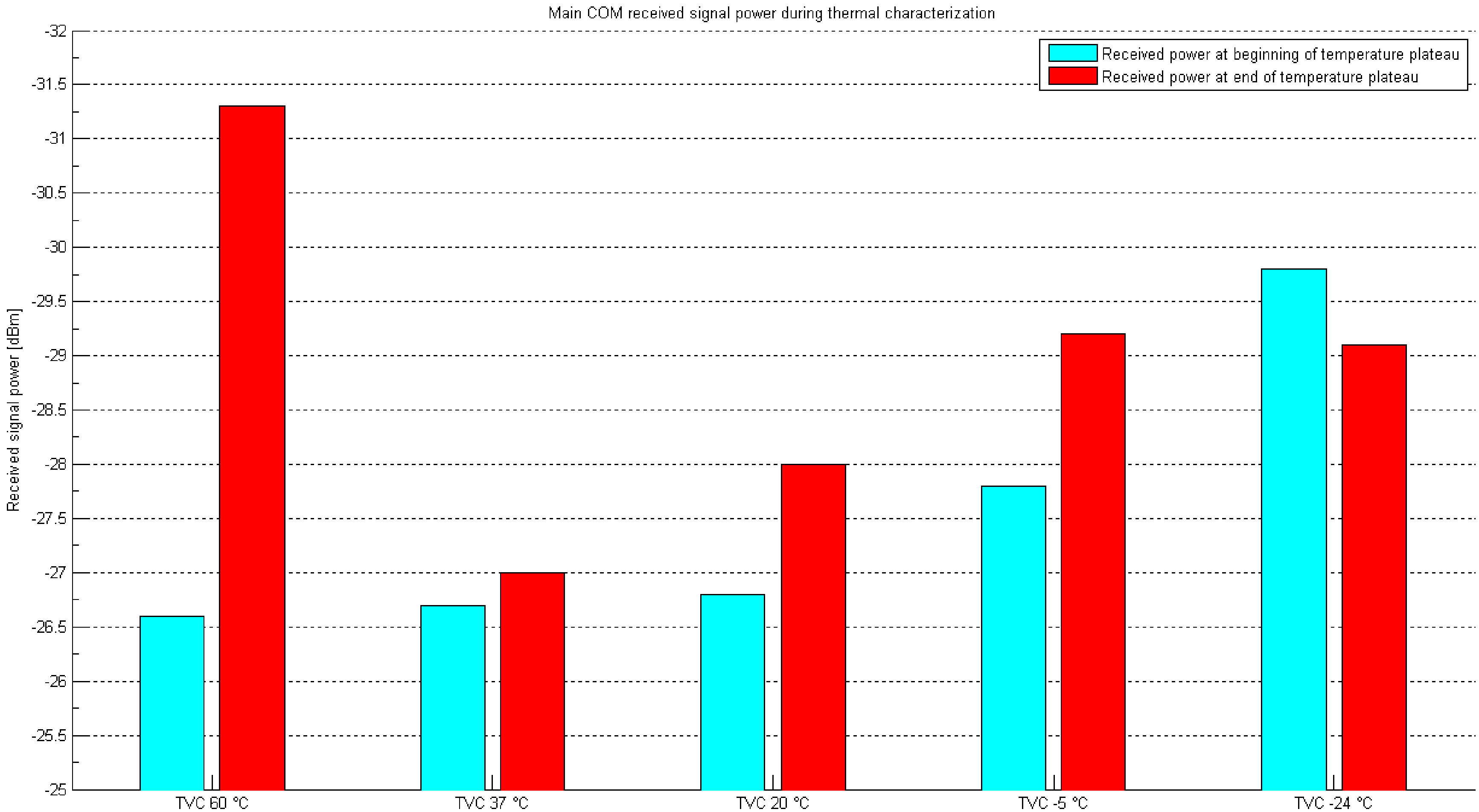


Block diagram of the EIA-Fr ground station.

- The HES-SO Fribourg ground station is fully operational.
- Some work still has to be done on the interface between the HES-SO Fribourg ground station and the EGSE router and the ground segment.

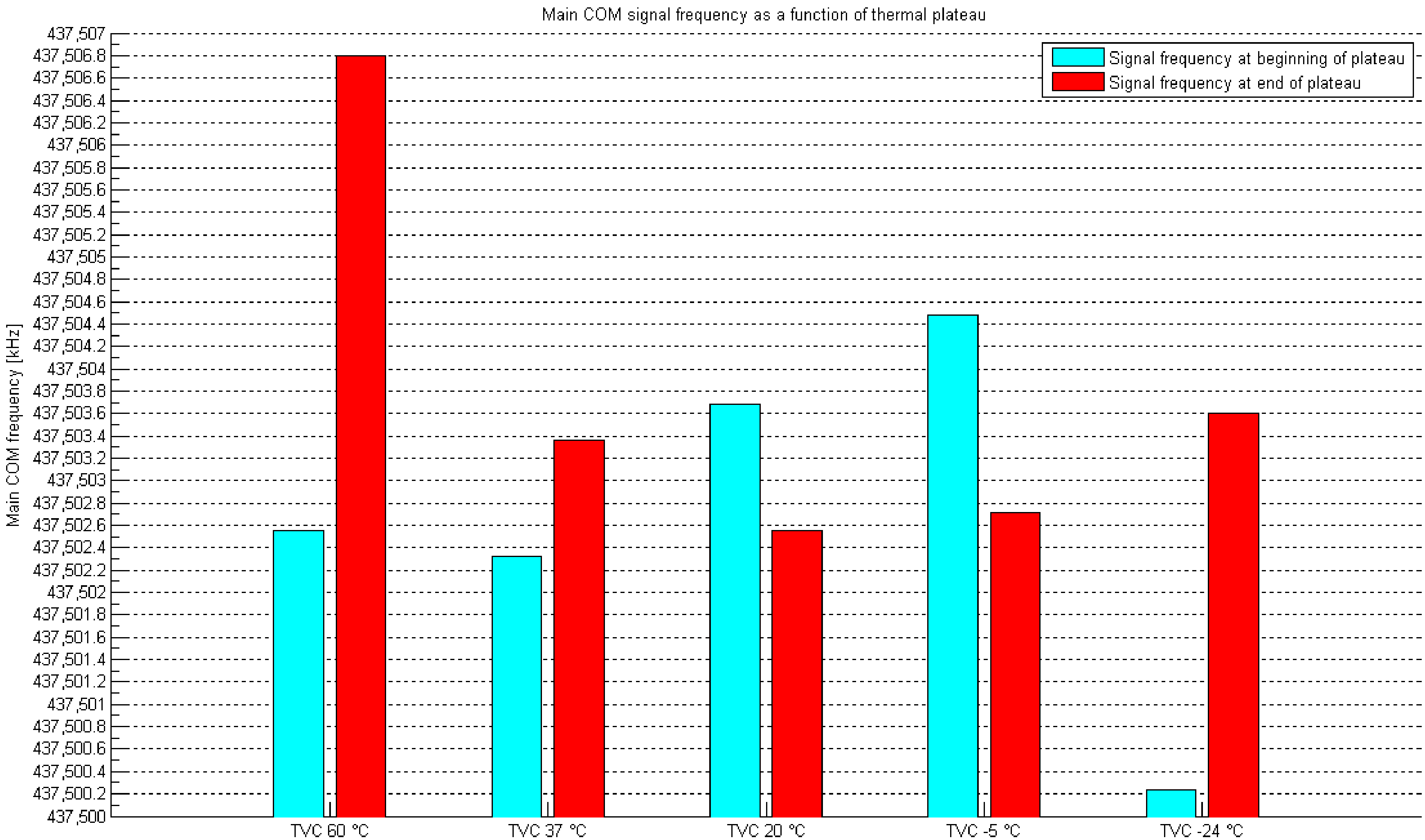


Thermal characterization of the COM board



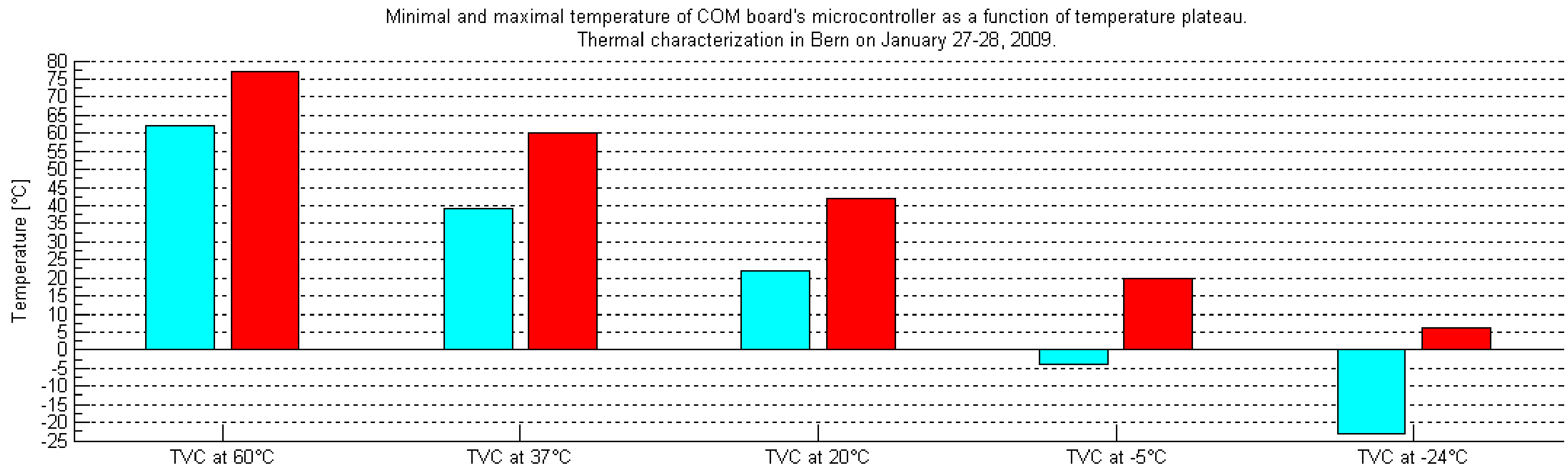
- The values are not that important as they give the received signal's power. However, their variation is.
- The greatest variation is 4.7 dB. This is due to the overheating of the COM's PA. When the environment is already at 60°C, the PA goes to 96°C and regulates itself to reduce the output signal's power.

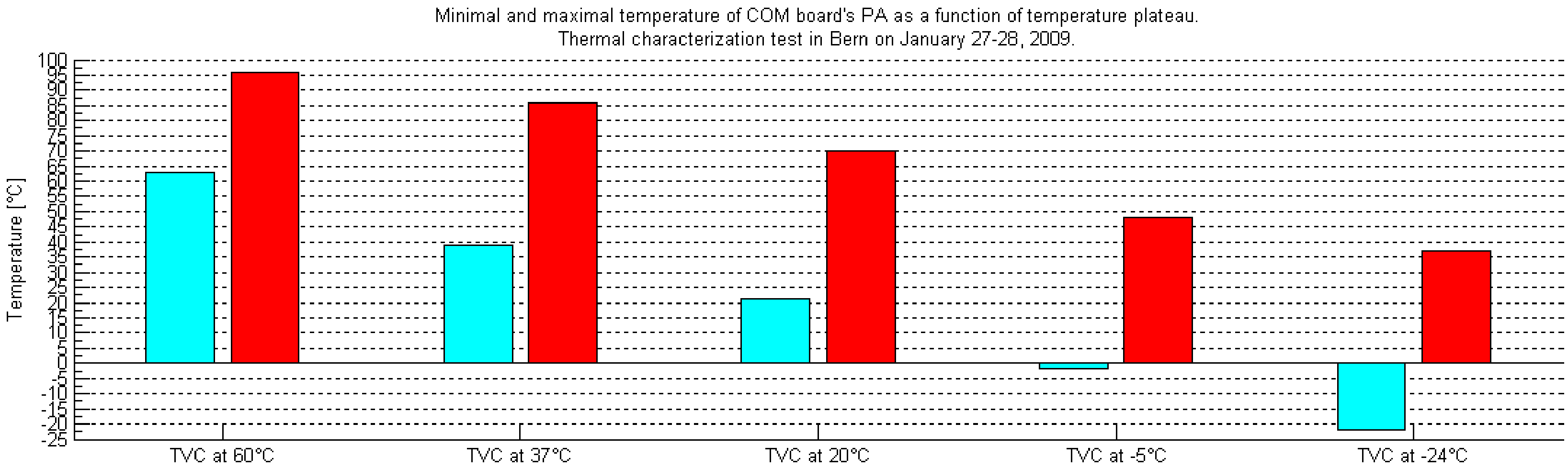
Thermal characterization of the COM board



- The highest frequency deviation during a plateau is 4.24 kHz. This satisfies the 4 kHz frequency deviation requirement.

Thermal characterization of the COM board





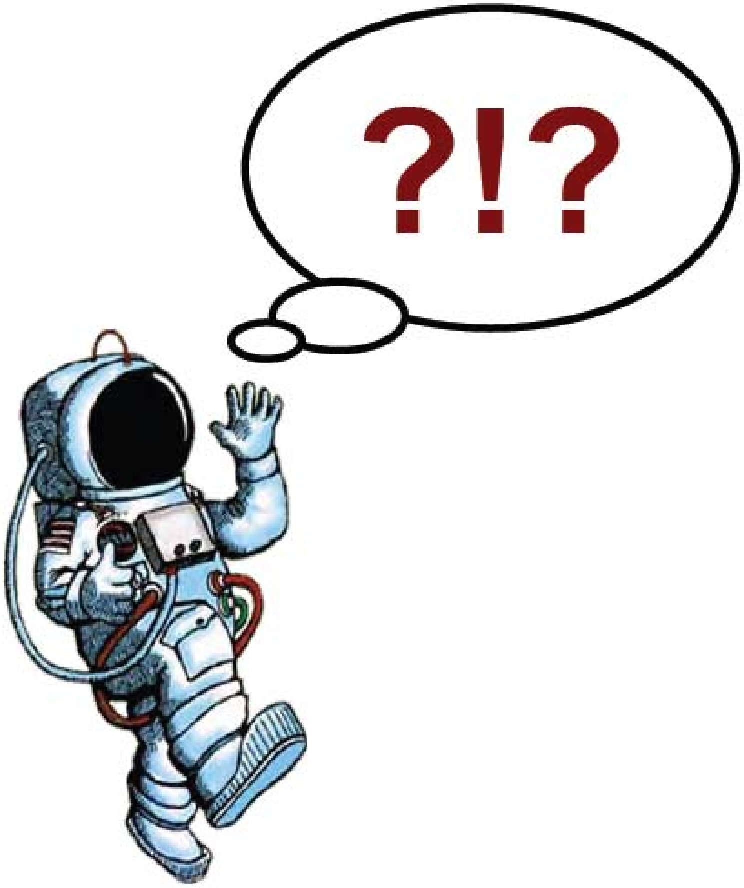
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
Hes·so Haute Ecole Spécialisée de Suisse occidentale
Université de Neuchâtel

Conclusion

- SiwssCube is a fascinating project for students
  - Provides an opportunity to try out and be creative
  - Requires development of a large span of expertise
  - Promotes and strenghten contacts and collaboration with industry
  - Provides an opportunity to participate in international workshops
  - Work within a dynamic team

- Very enthousiastic about the upcoming events…

Questions



More info on: swisscube.epfl.ch or space@epfl.ch