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EPFL CubeSats and future missions

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Workshop Paris Diderot
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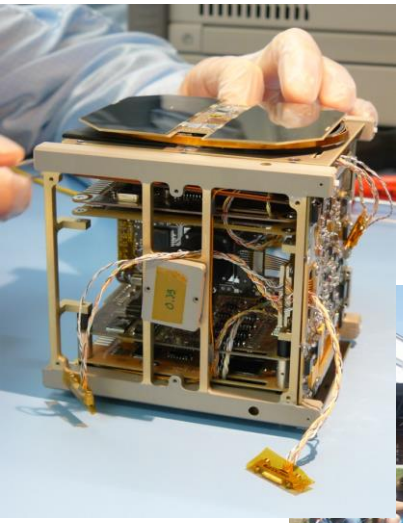
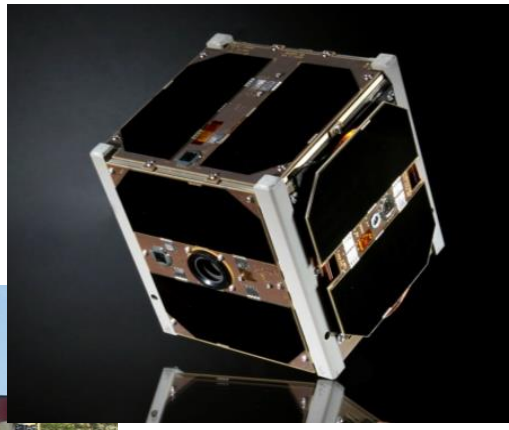
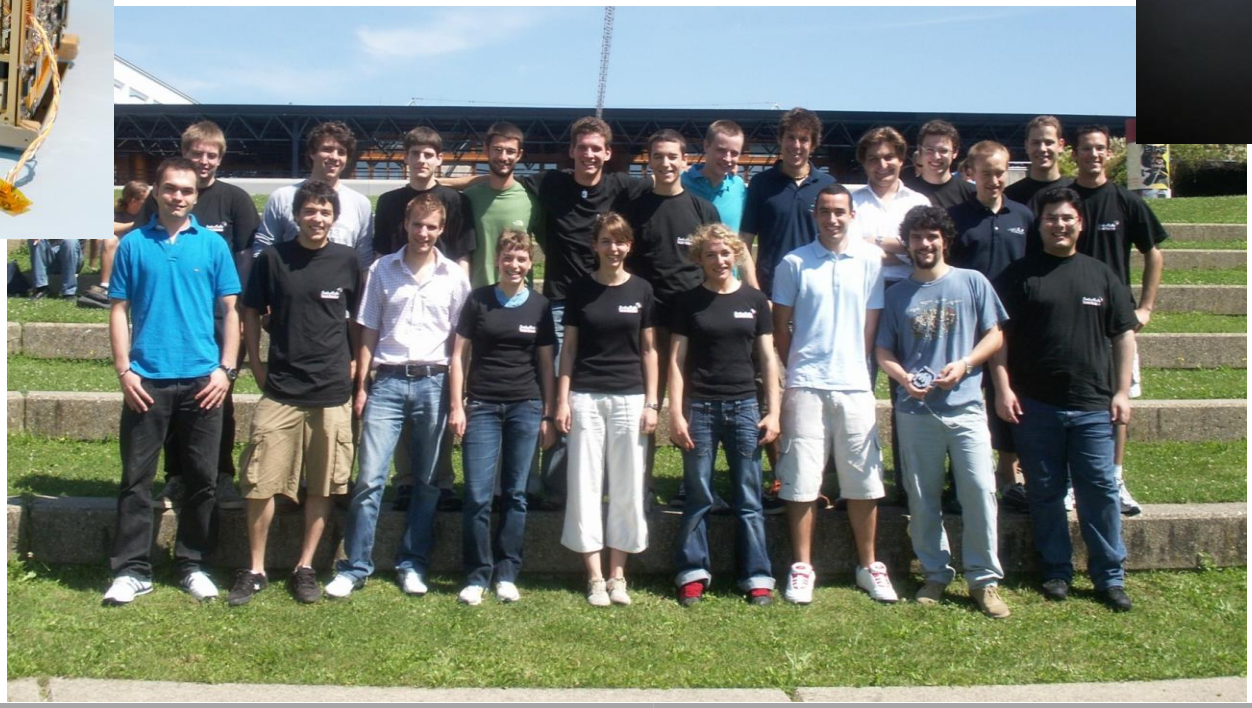
6 years ago (Sept 23, 2009), EPFL and partners

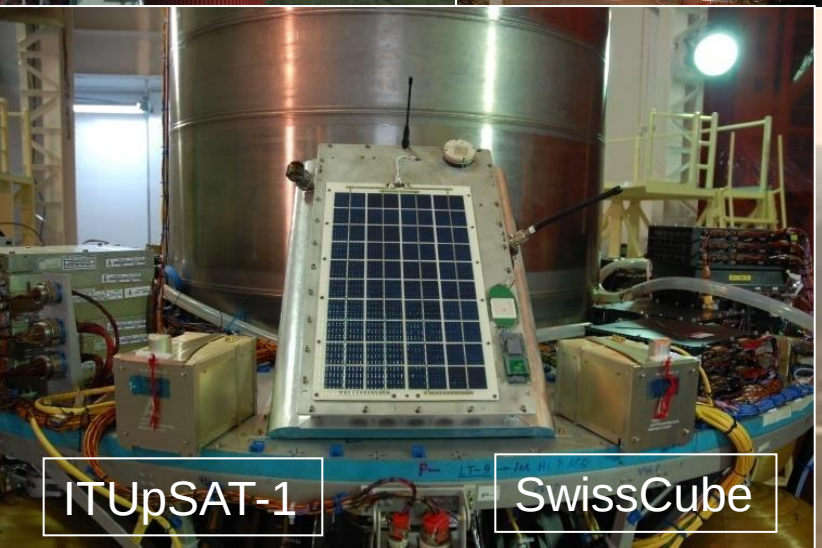
launched the first Swiss student satellite… SwissCube…







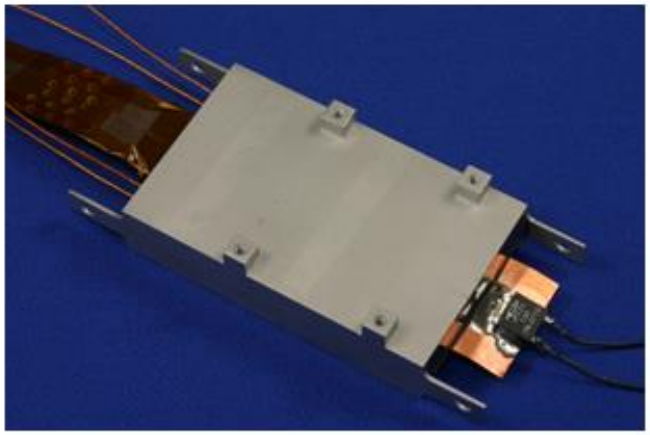
SwissCube launch at 720 km altitude, 23-09-09



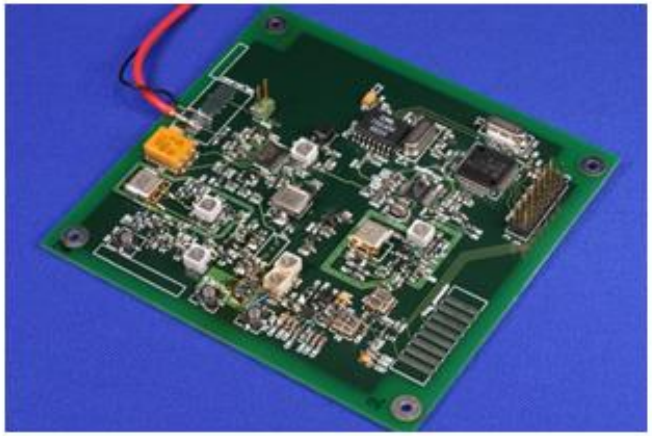
SwissCube keys to success…

- # 1: a good SE team and continuity
- # 2: Clear and prioritized list of mission objectives
- # 3: Plan for regular reviews with CubeSat, industry and ESA/CNES experts
- # 4: Descoping is OK, carry back-up options
- # 5: KISS but “clean” design
- # 6: Testing, testing, testing…

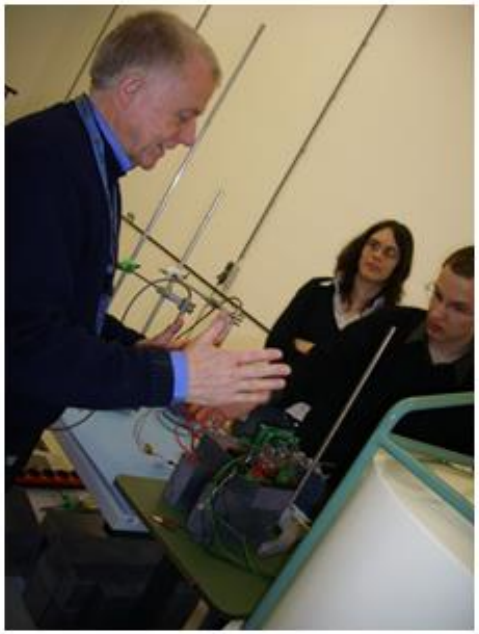
Phase C tests



Test of the battery thermal regulator

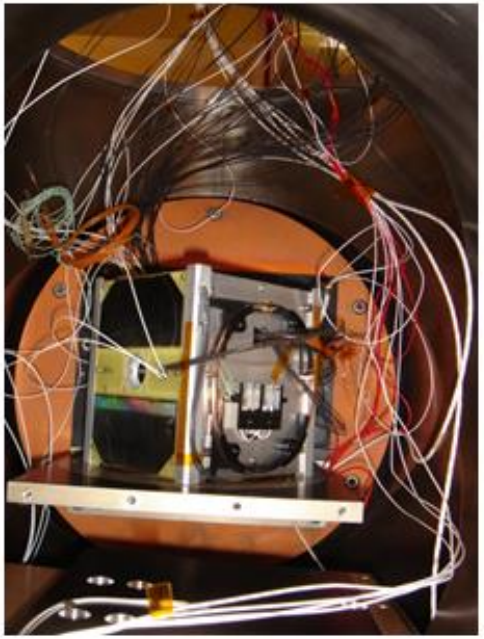


Verification of RF COM board performances and thermal behavior at the Power Amplifier

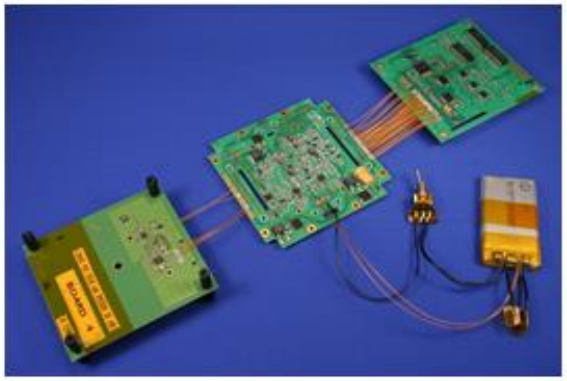


Radiation testing of MSP 430, ATMEL ARM 7, CMOS detector, COM

Thermal verification of Structural Thermal Model

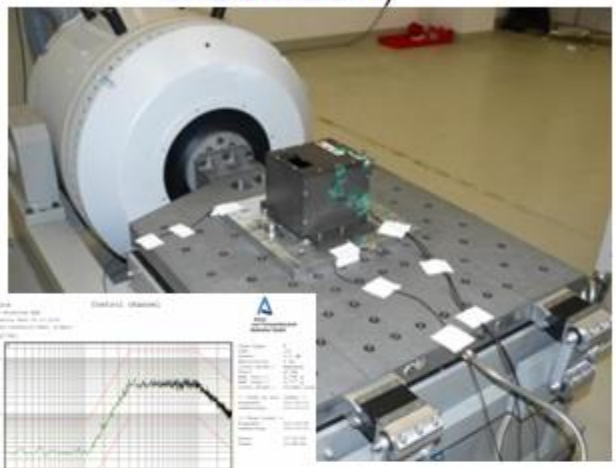


Communication and power system tests



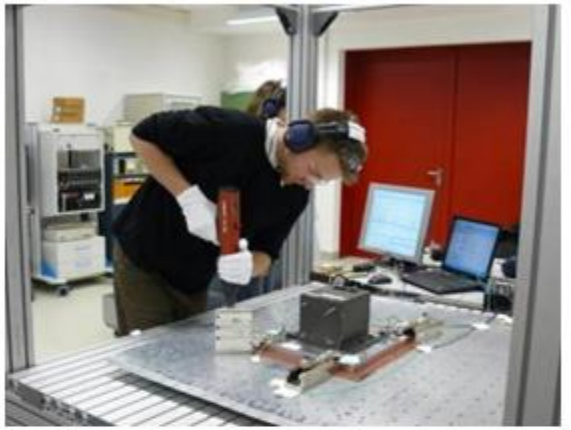
Phase D tests

Vibrations (*DLR / Astro Berlin and Uni Bern*)

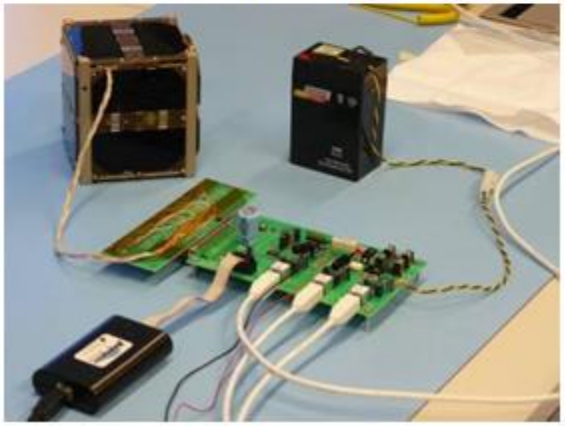


EMC Tests (*Montena EMC*)

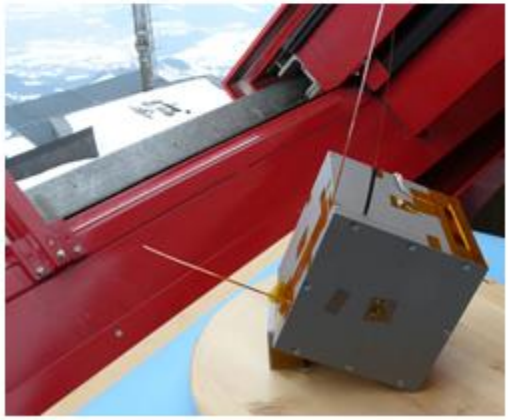
Pyro-shocks (*DLR / Astro Berlin*)



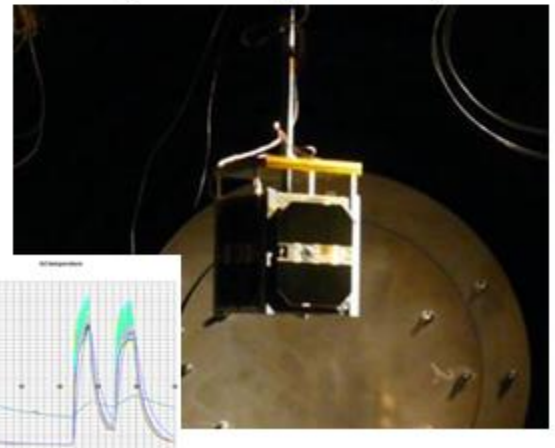
Functional and software tests

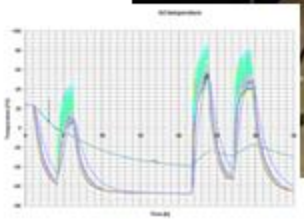


RF Sat-Ground Compatibility (*HES-Fr*)

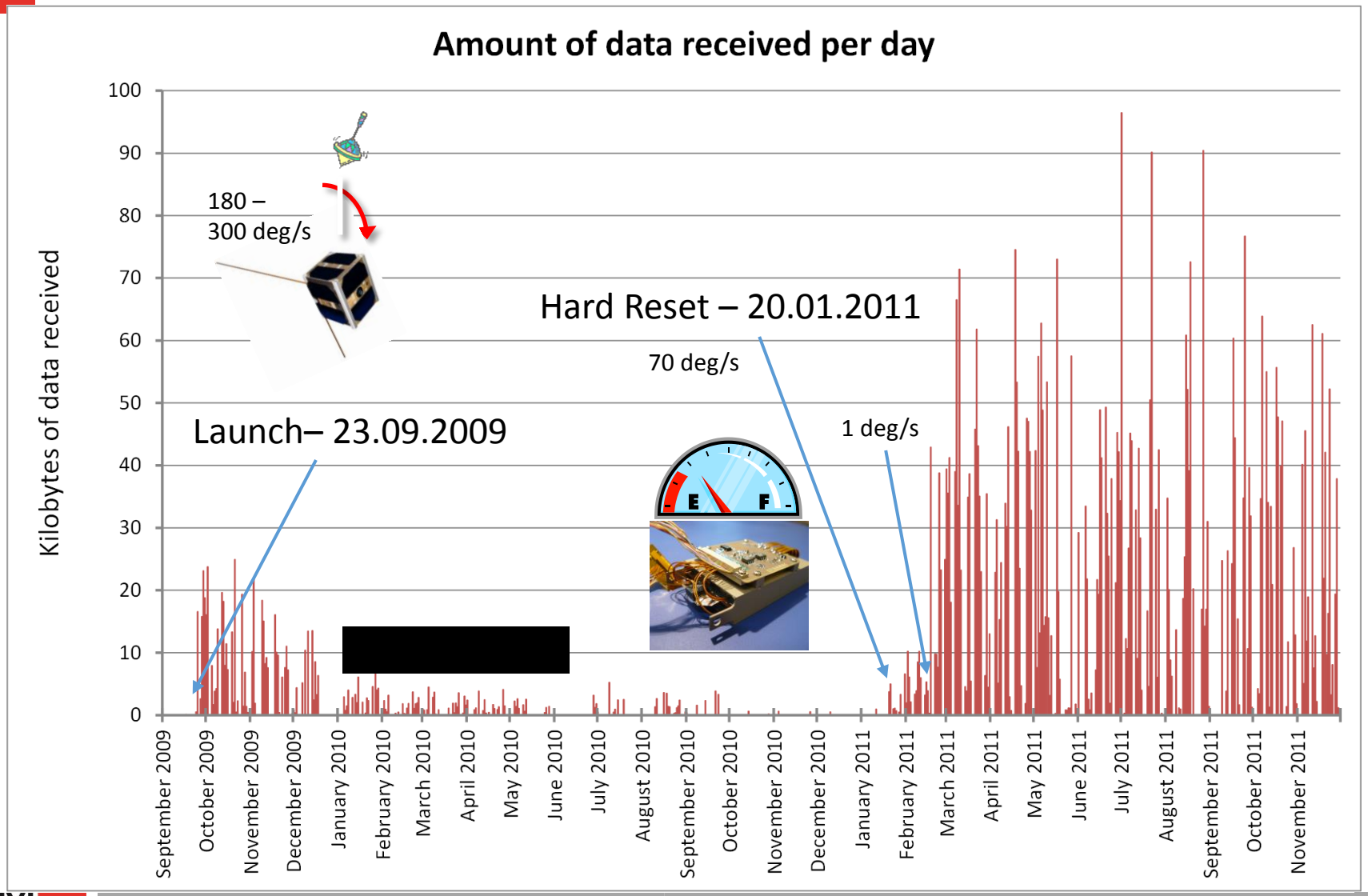


Thermal Vacuum Cycles (*University of Bern*)

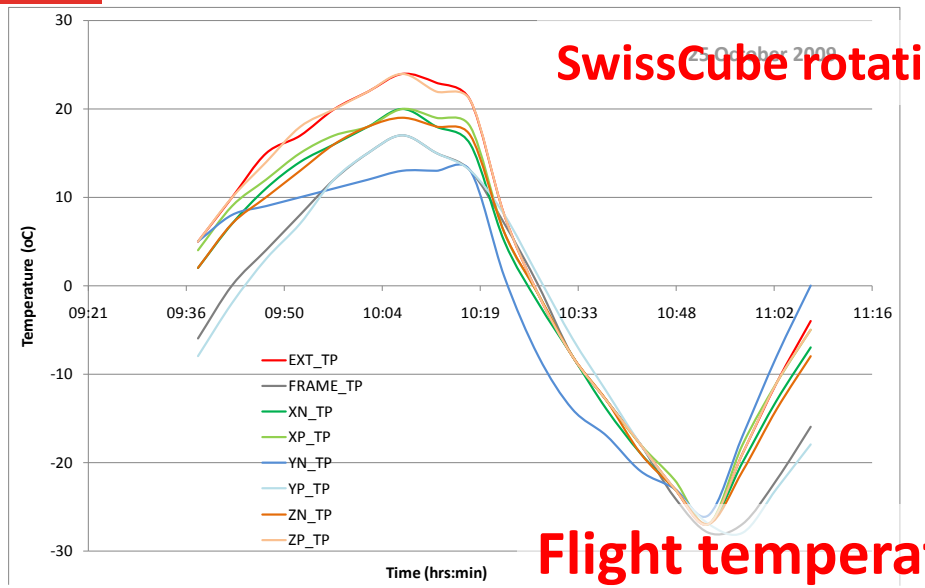




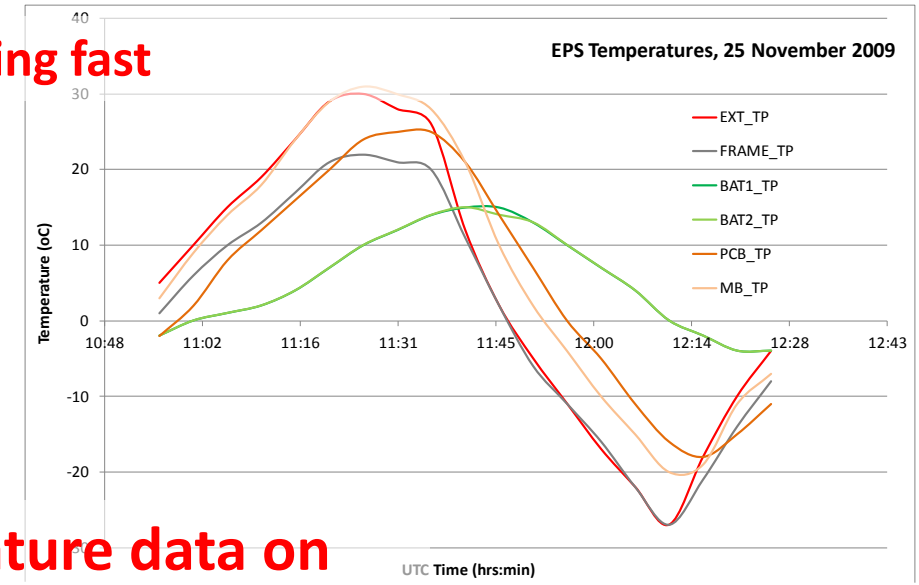
First 2 years of ops in 1 slide ☺



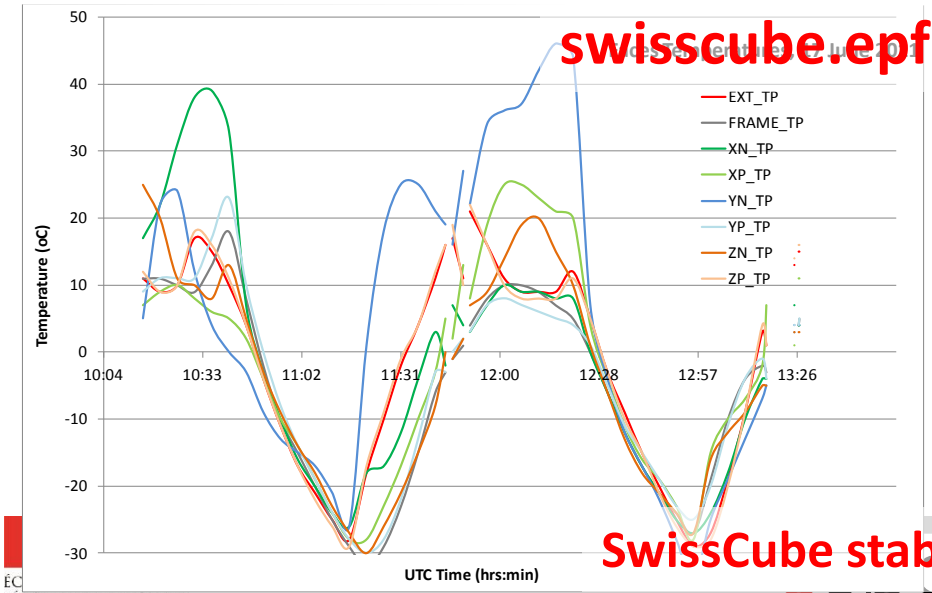
Example of flight data



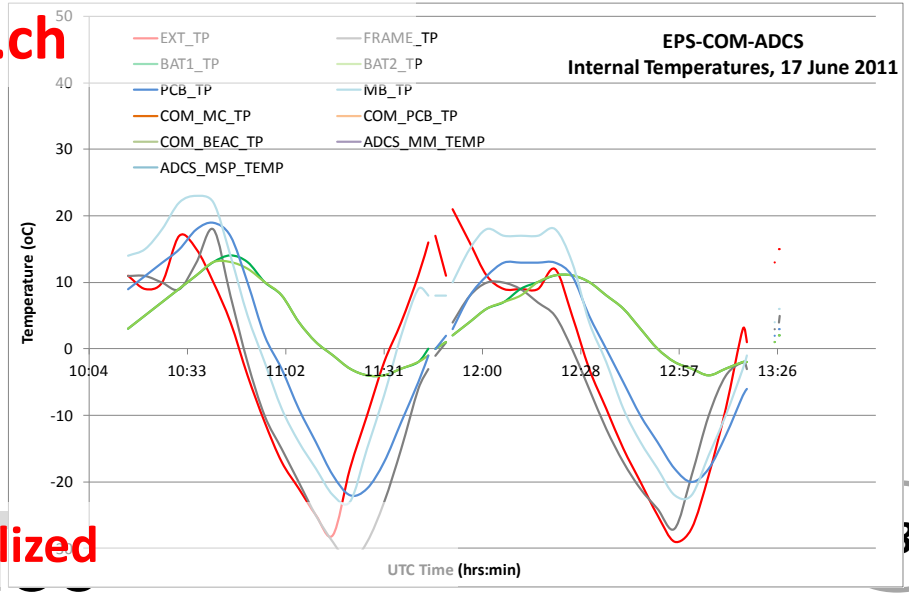
SwissCube rotating fast



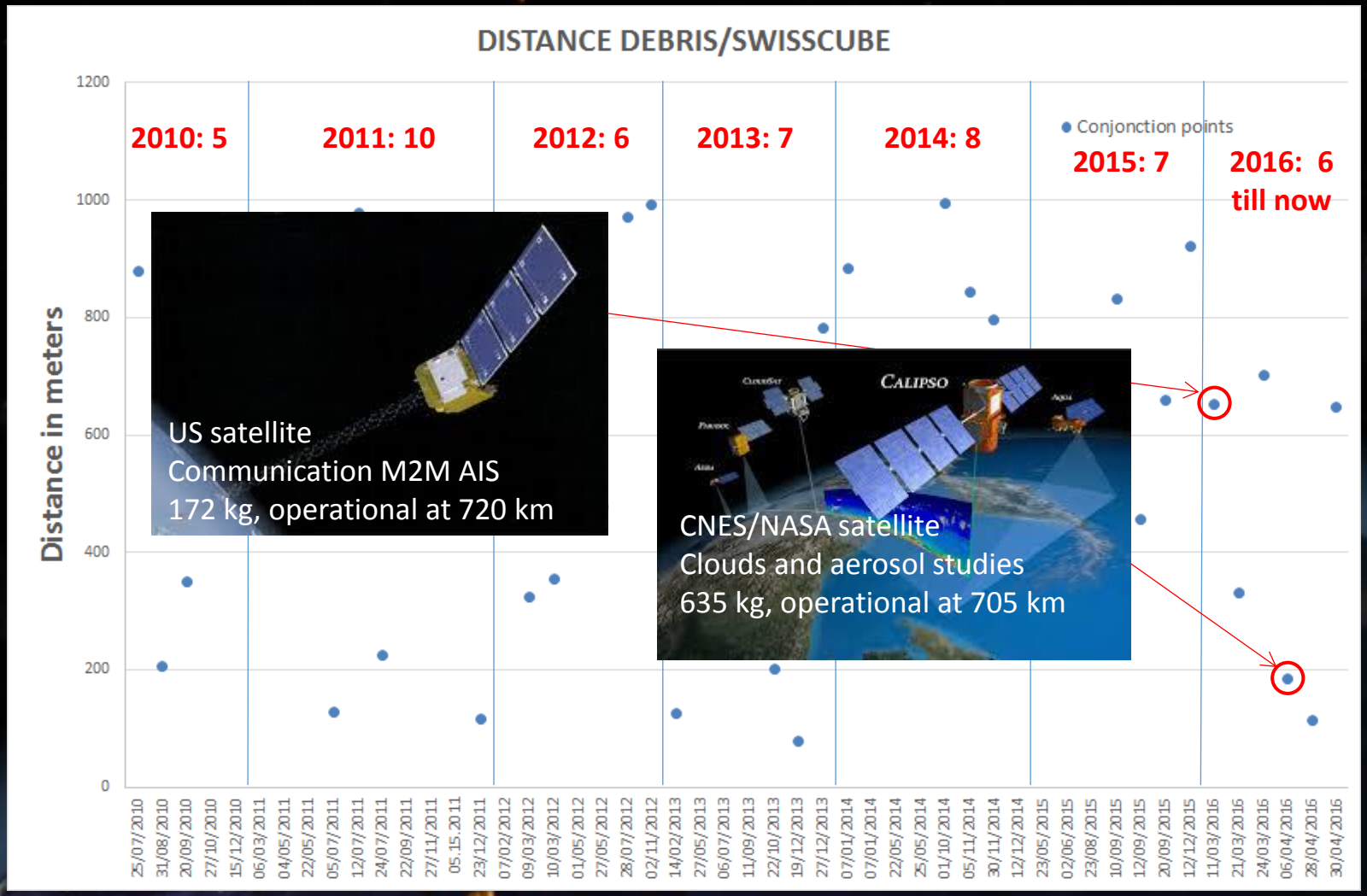
Flight temperature data on swisscube.epfl.ch



SwissCube stabilized



And this is what SwissCube saw since the first months



So what do you do?

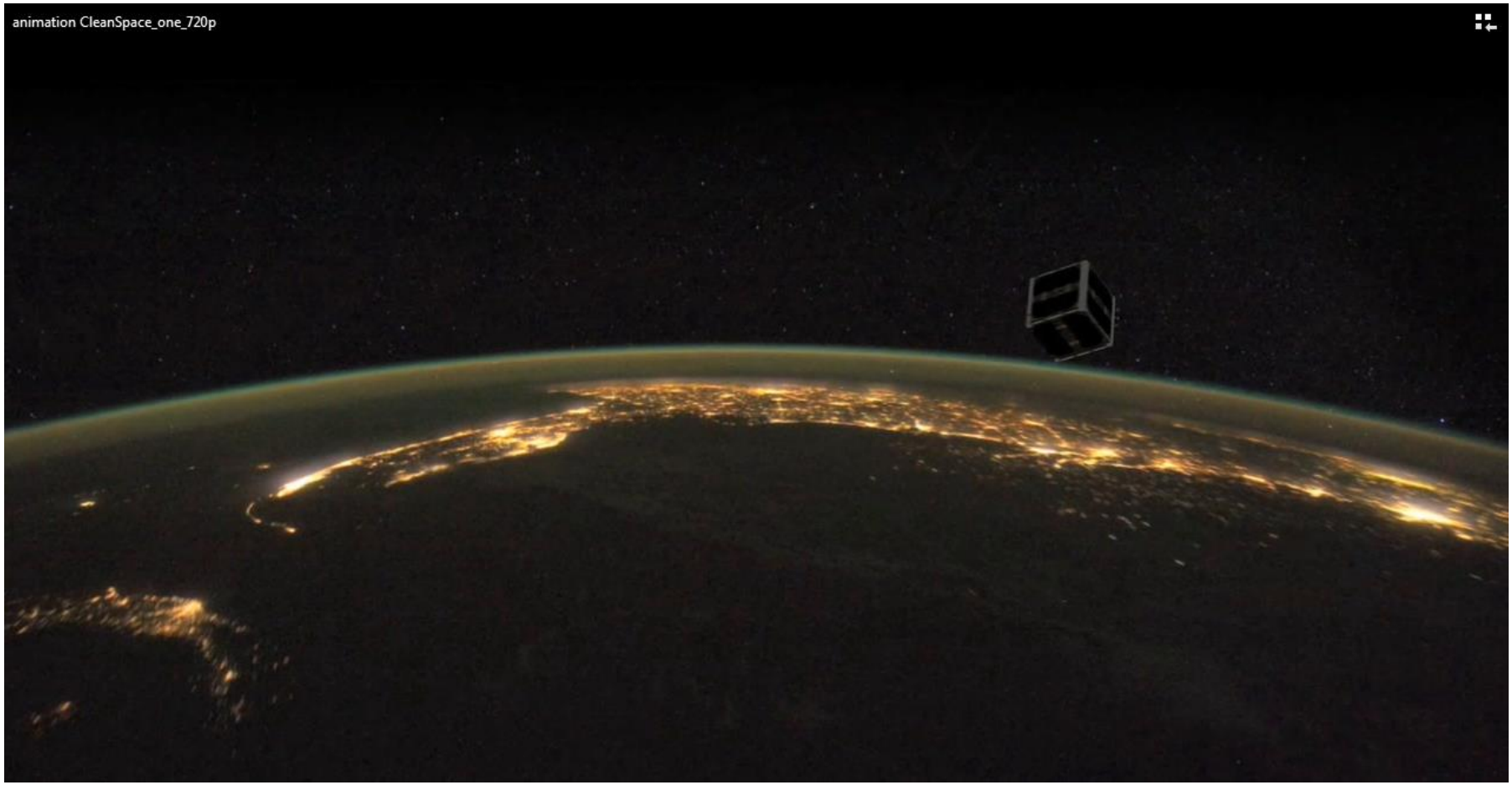
- EPFL decided to take responsibility and created a mission (CleanSpace One) to:

1. Increase the **awareness and responsibility** in regard to orbital debris problem in the world, and **educate aerospace students,**

2. Develop and test the technologies required for **a rendezvous with an uncooperative object in space**,

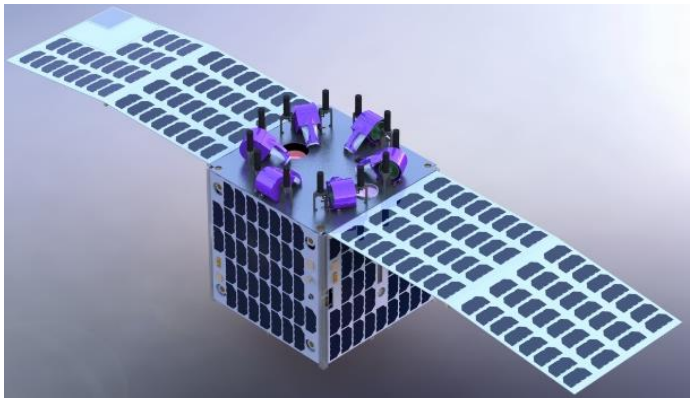
3. Bring **SwissCube** back!

CleanSpace One mission scenario



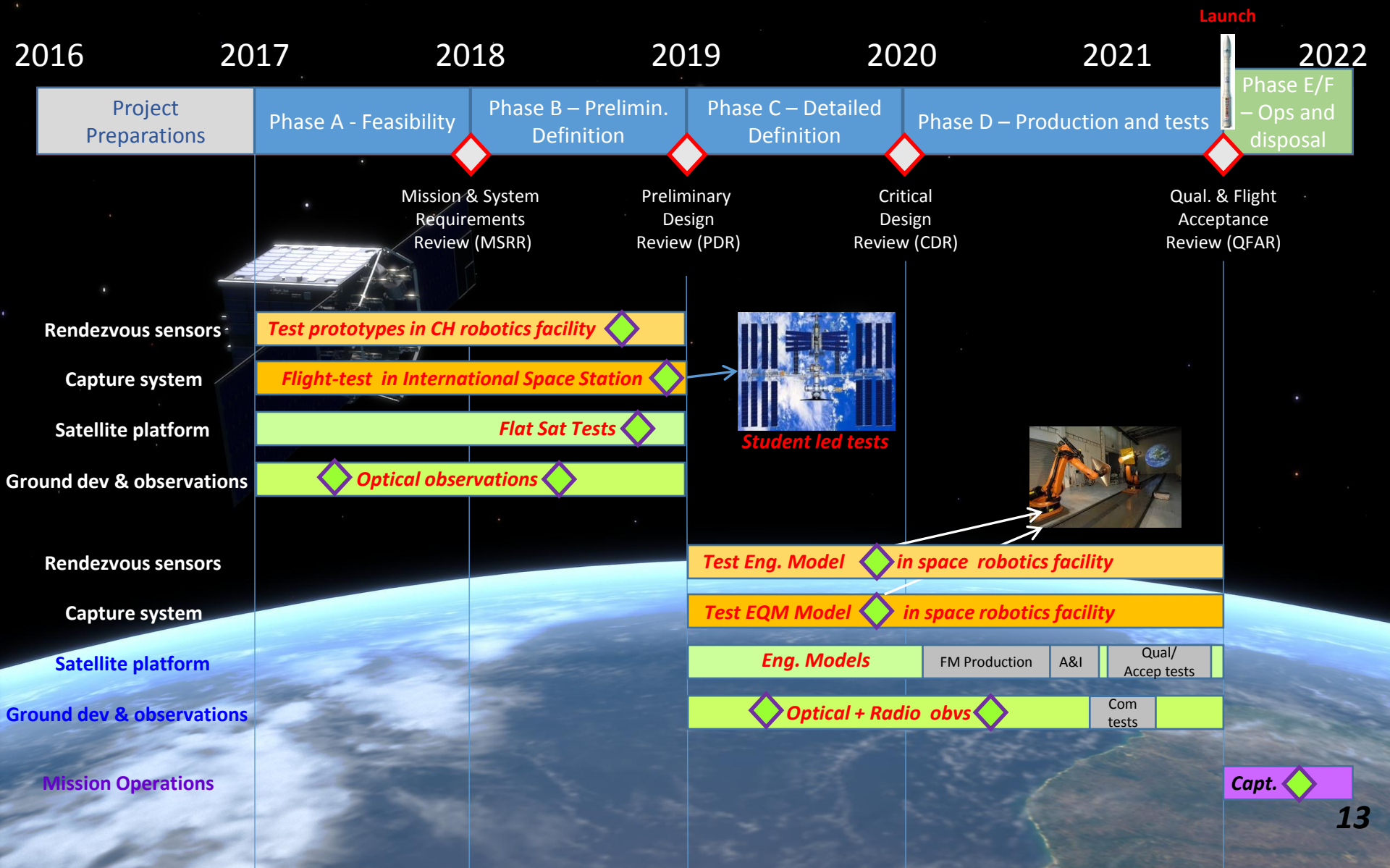
CleanSpace One microsatellite

- CleanSpace One microsat:
  - Based on a CubeSat and COTS technologies for the most part
  - Preliminary design done using CDF (but needs re-evaluation)
  - Expect ~50 kg dry mass, < 80 W

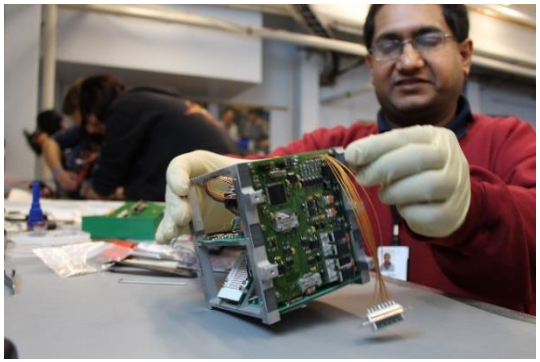


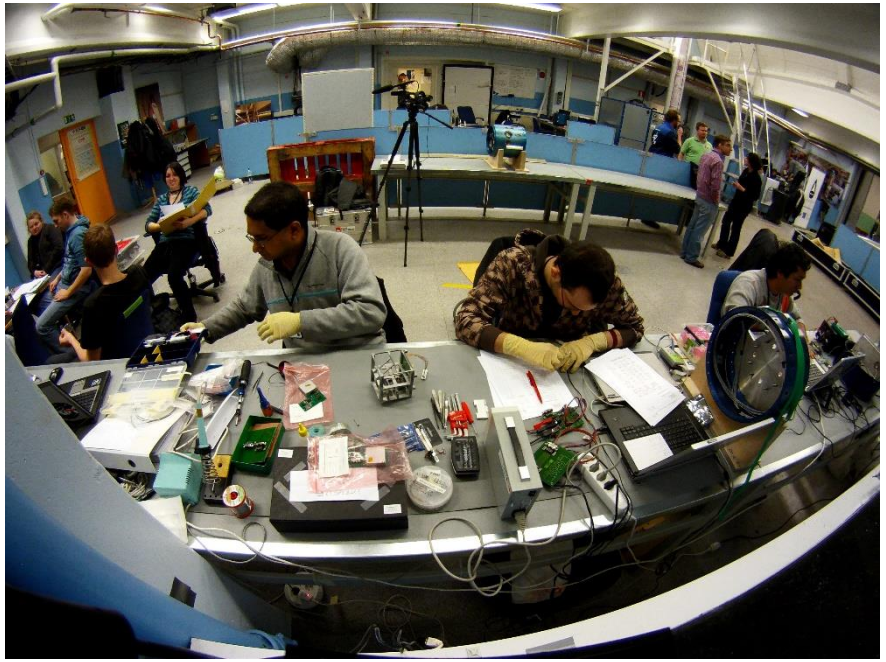
- Mix of professional and student participation
- Open to international cooperation

CSO project schedule



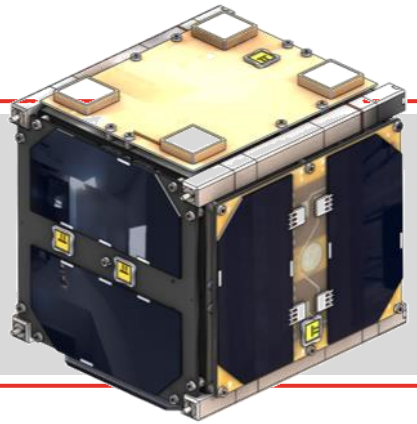
And in the meantime: Rexus GGES (2010 – 2012)

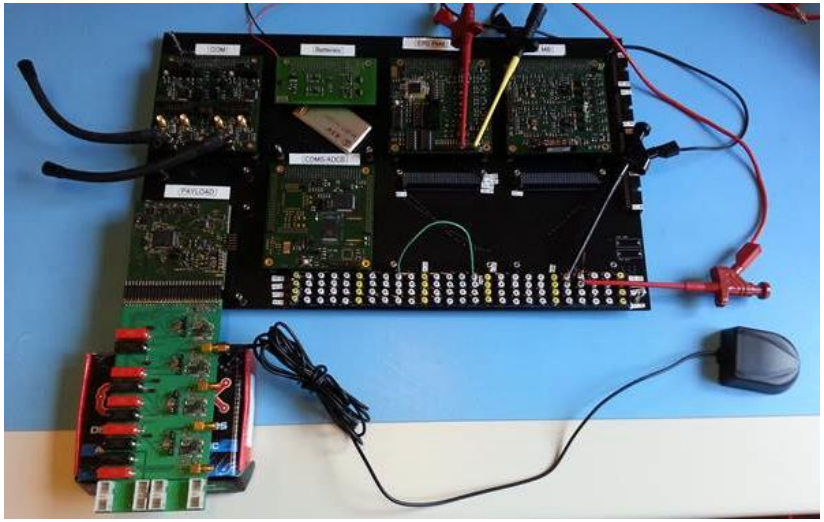


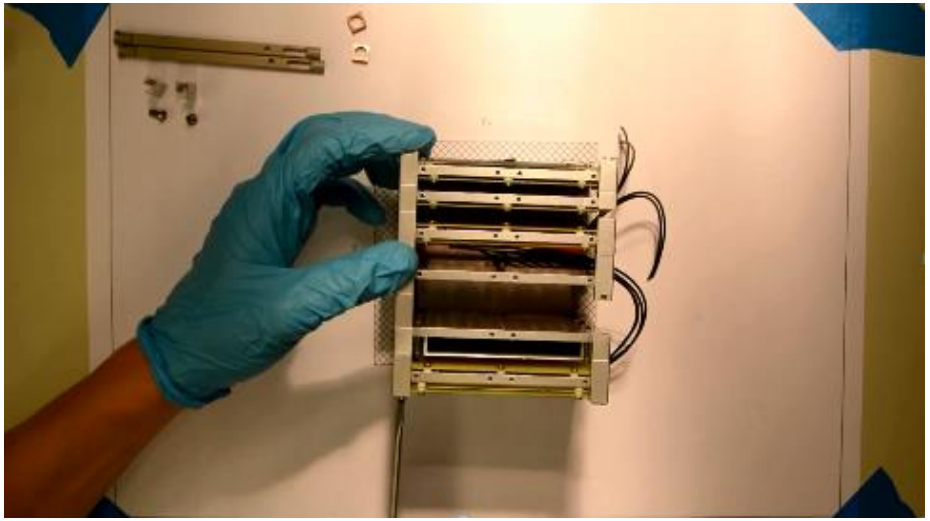


And then: CubETH (2012 - …)

- System engineering and several subsystems done at EPFL
- Global navigation receivers compatible with all constellations
- Over 90 students and counting
- Launch targeted 2017





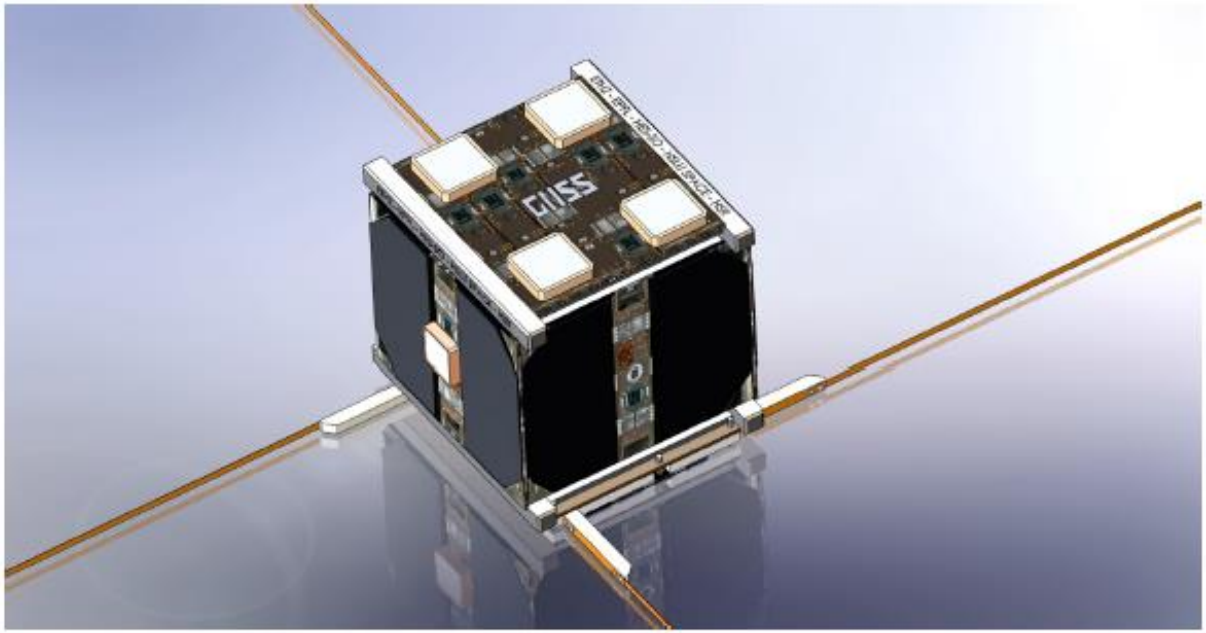


Structure concept by ELSE SA

CubETH Key facts

Project Partners	
Payload	ETHZ, HSLuzern, HSRapperswil
Syetems Engineerin	Swiss Space Center
AIT	Swiss Space Center
Industrial partners	uBlox, RUAG, Saphyrion, CSEM
Academic partners	LEMA, RISD,

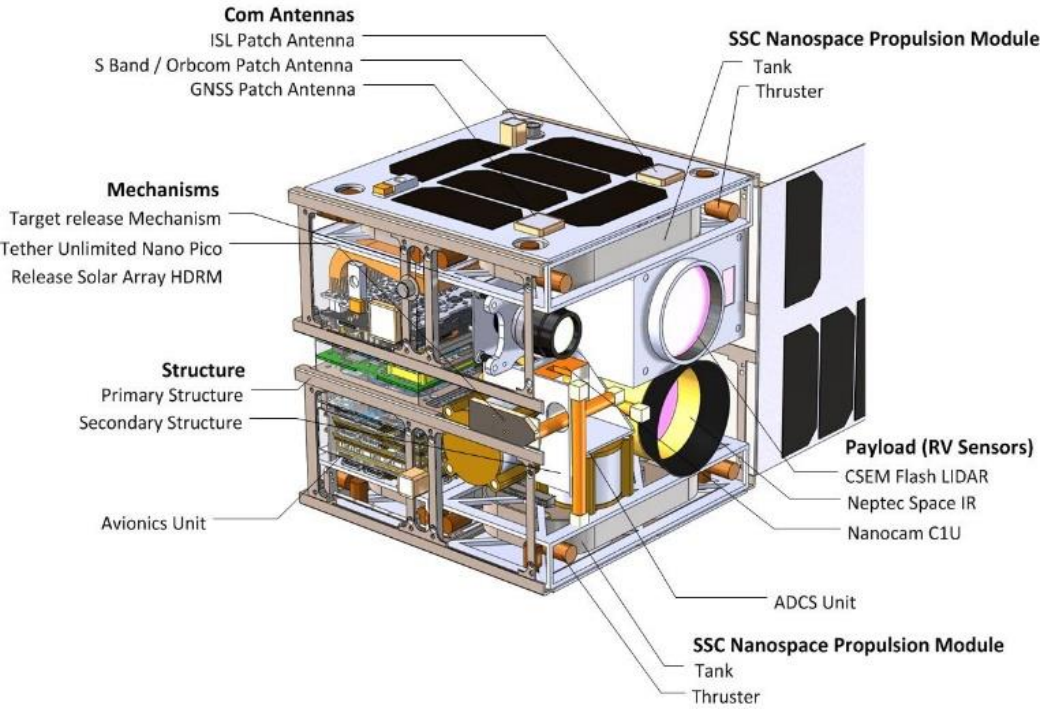
- Key science and technological objectives
  - **Precise Orbit Determination**
  - **Attitude Determination using GNSS**
  - **Demonstrate reception of Galileo signals in space**
  - **Experiments: radio occultations, reflectometry, air density**



Cubesat Overview	
Volume	1U (10x10x10cm)
Mass	1.3 kg (per standard, TBC)
Power	1.7 W (SwissCube)
Data rate	9600 bps
Payload	11 uBlox GNSS receivers
	6 antennas
Operations	Distributed Ground Station
Orbit	500km, SSO, 2AM/2PM
Launch	2016 (TBC)

And… CADRE: CubeSat ADR experiment (2014)

- Objective: Testing debris removal technologies using CubeSats
- ESA IOD mission
- Will demand the rendezvous of two spacecraft, launched together but then separated
- Is revamped in 3 smaller IOD missions



Chaser 8U CubeSat, ~ 16 kg, 70W peak

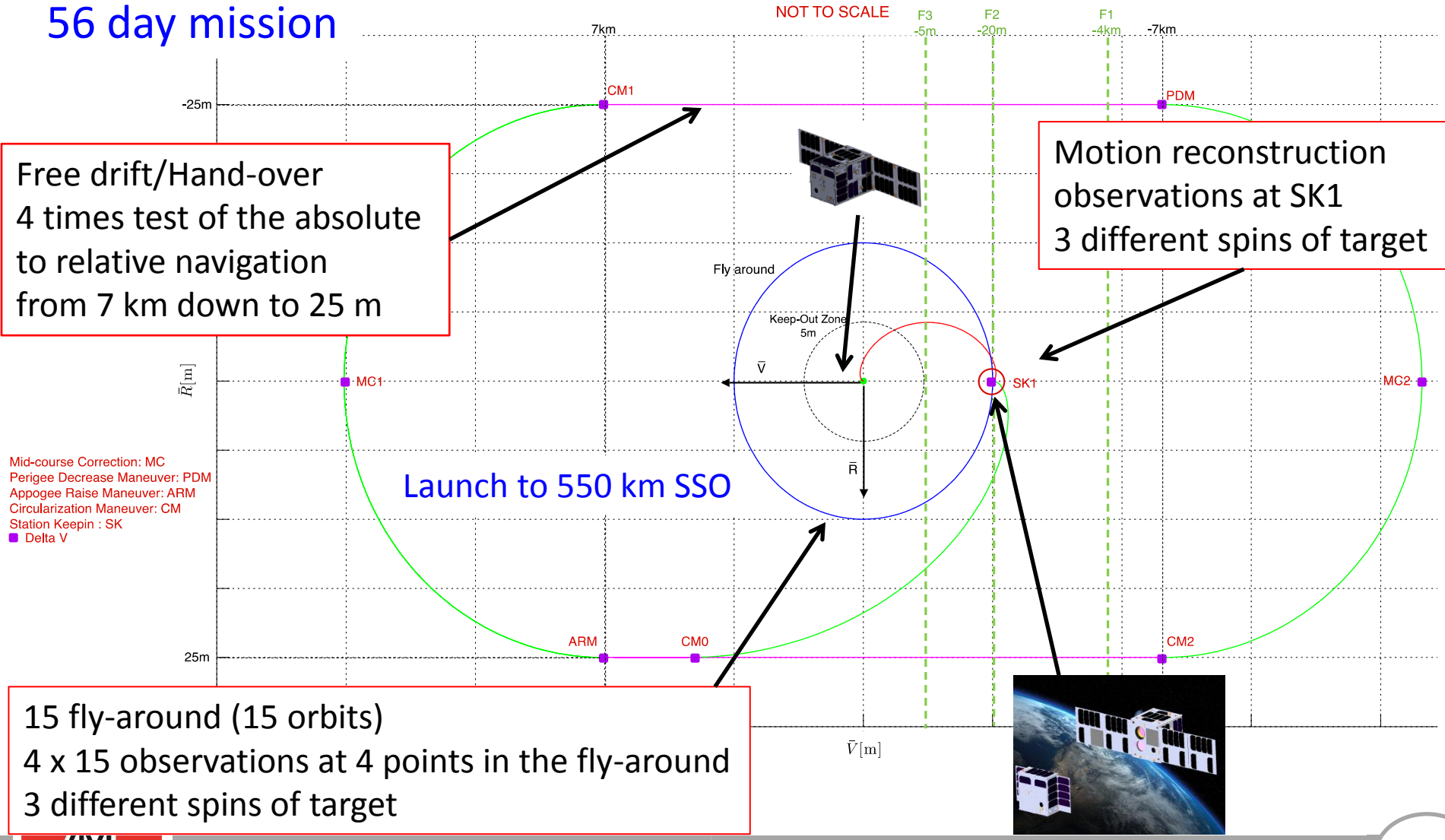
Target 4U CubeSat, ~ 4 kg, 15 W peak

CADRE mission and demonstration objectives

- Tests of Rendezvous sensors
  - Testing of the rendezvous (close and far range) sensors
  - Validation of on-board ranging algorithms
  - Demonstration of motion reconstruction of an uncooperative target using 2-D or 3-D vision-based motion reconstruction algorithms
  - Validation of the hand-over between relative and absolute navigation
  - Demonstration of close range operations.

CADRE Mission scenario

56 day mission



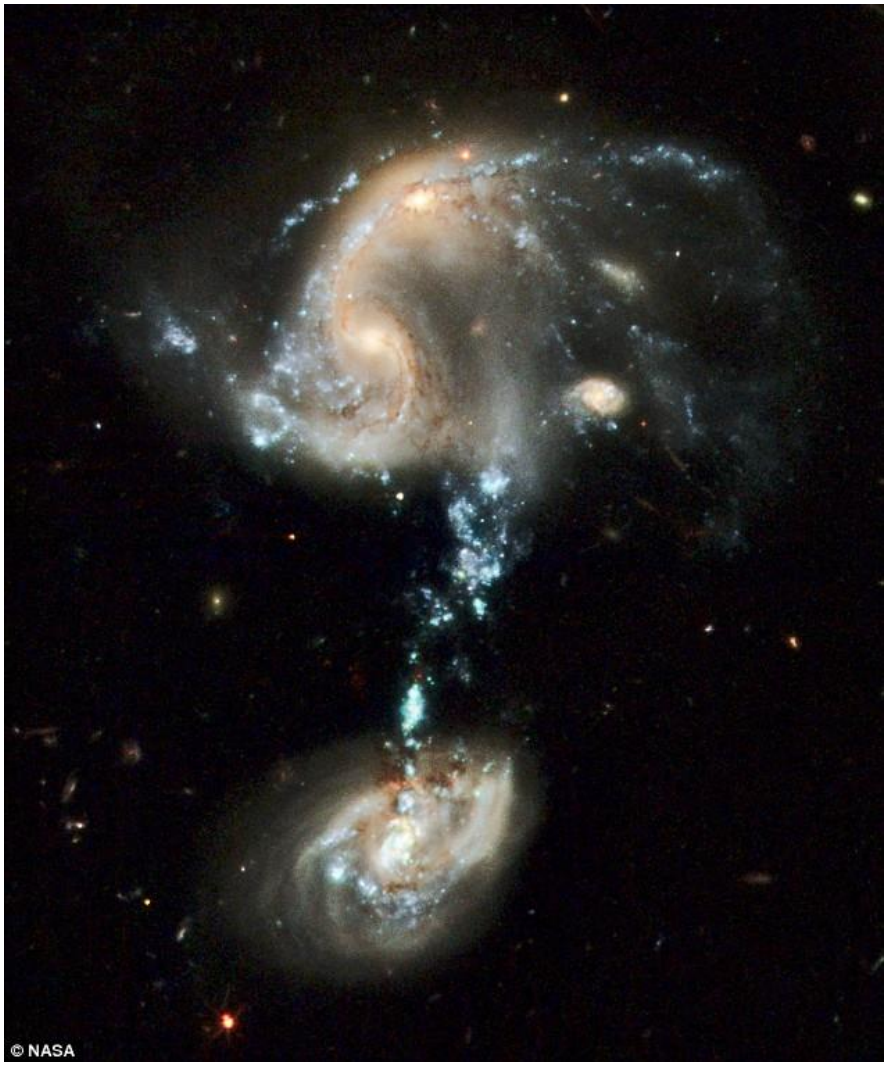
Free drift/Hand-over
4 times test of the absolute to relative navigation from 7 km down to 25 m

Motion reconstruction observations at SK1
3 different spins of target

15 fly-around (15 orbits)
4 x 15 observations at 4 points in the fly-around
3 different spins of target

Never forget the essentials...

Questions?



SwissCube keys to success…

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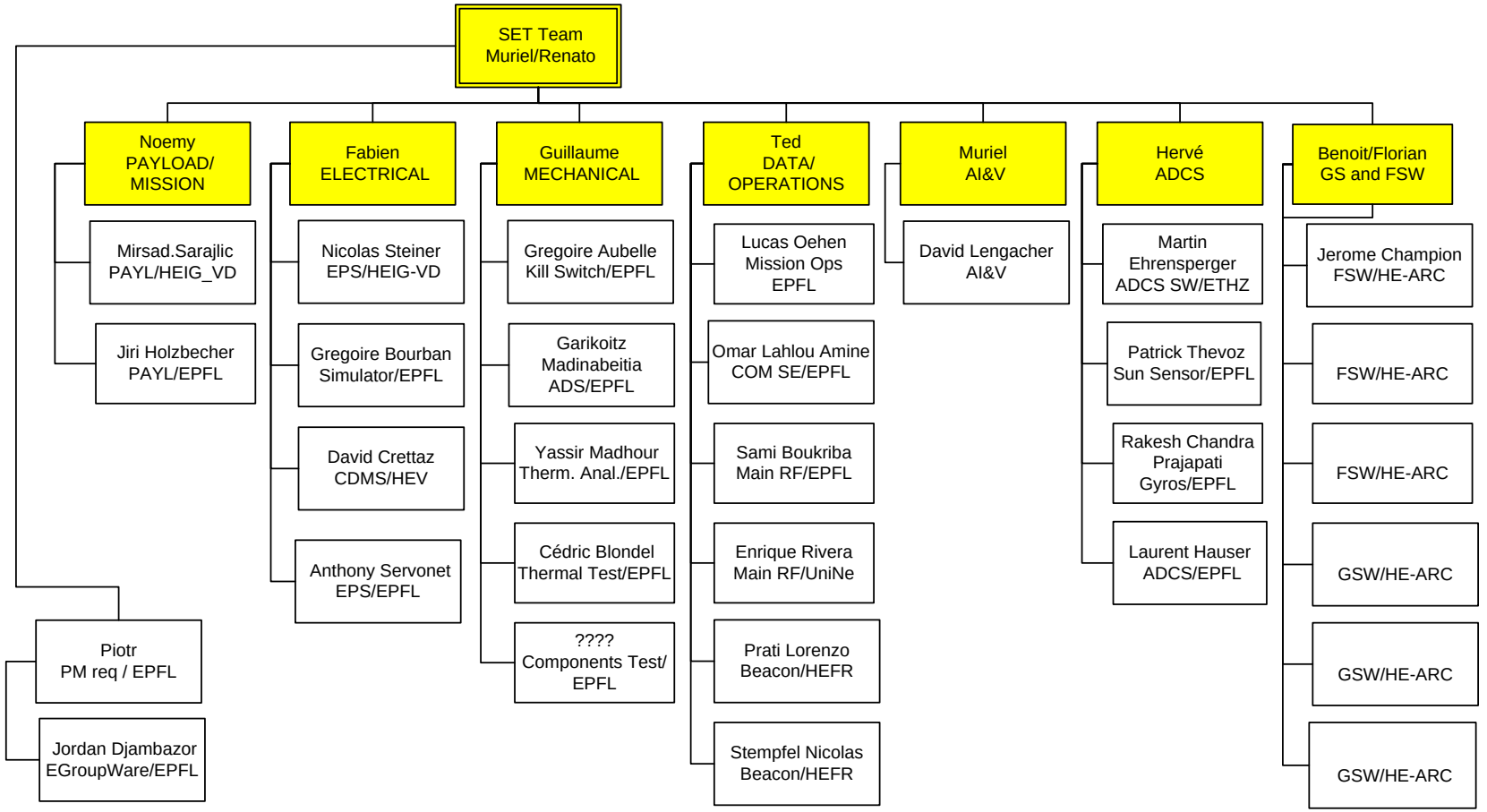

SwissCube keys to success…

- # 1: a good SE team and continuity
- # 2: Clear and prioritized list of mission objectives

  - **Mission Objective 1**
    - **The project shall design, build, and test a satellite. The success criterion is: deliver a fully tested satellite to the launch site.**
    - **This objective assumes the development of both a ground and space system. (+ Every subsystem of the satellite designed from scratch)**
  - **Mission Objective 2**
    - **The project shall launch the satellite and communicate with it using the ground and space systems. The success criterion is: establish a radio connection with the developed ground system and download telemetry.**
  - **Mission Objective 3**
    - **The project shall operate a scientific or technology demonstration payload. The success criterion is: receive data from the payload and confirm operations.**

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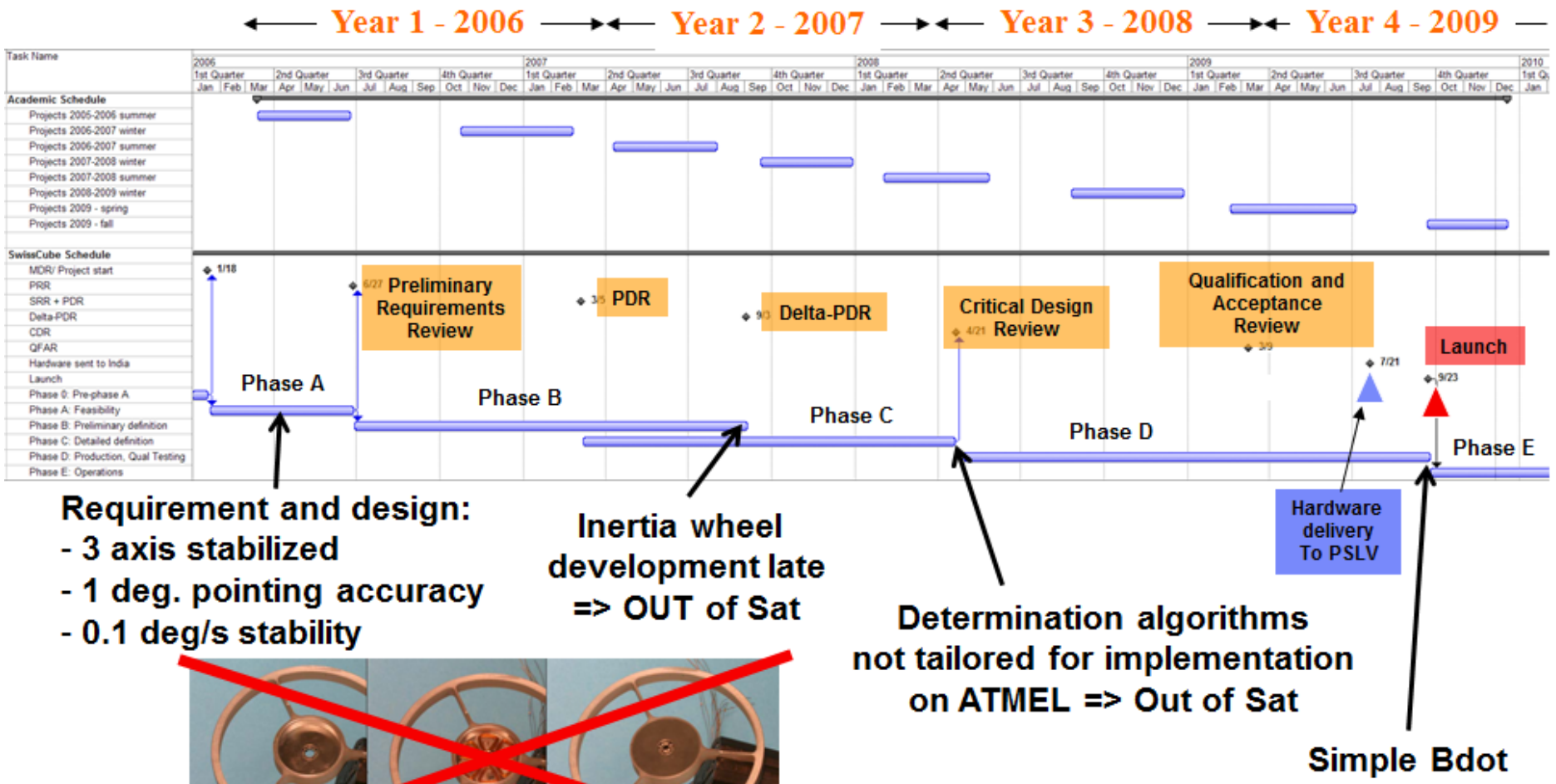

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