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MOVE-II The Munich Orbital Verification Experiment II

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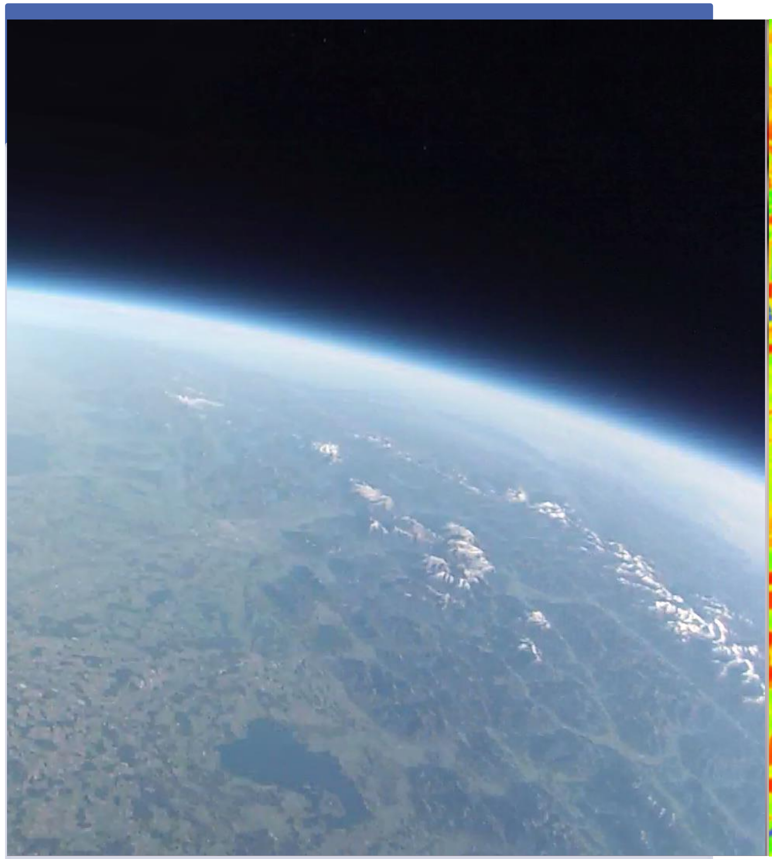
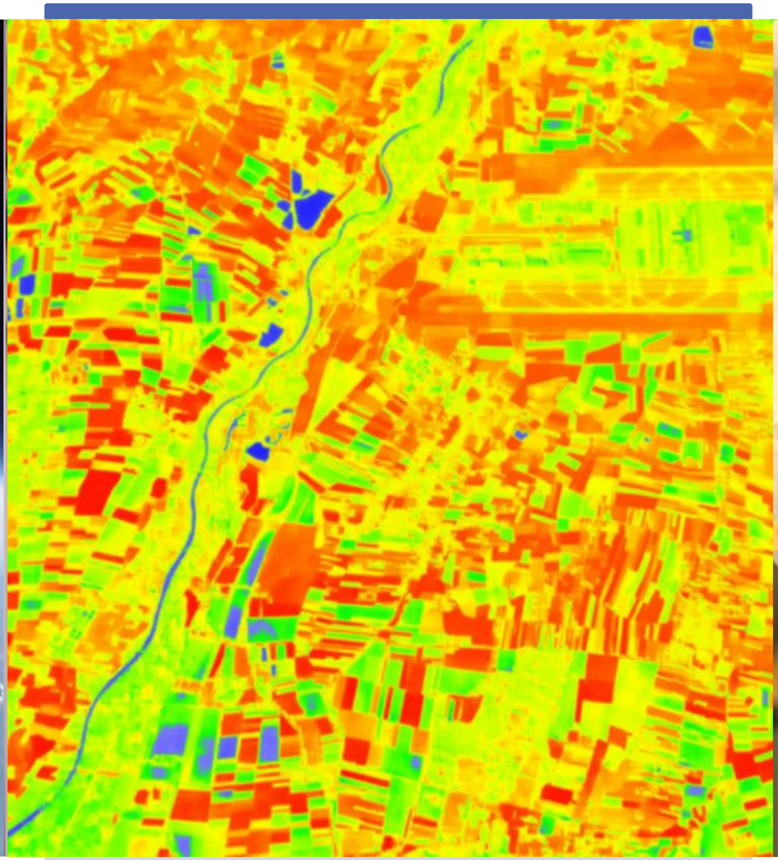
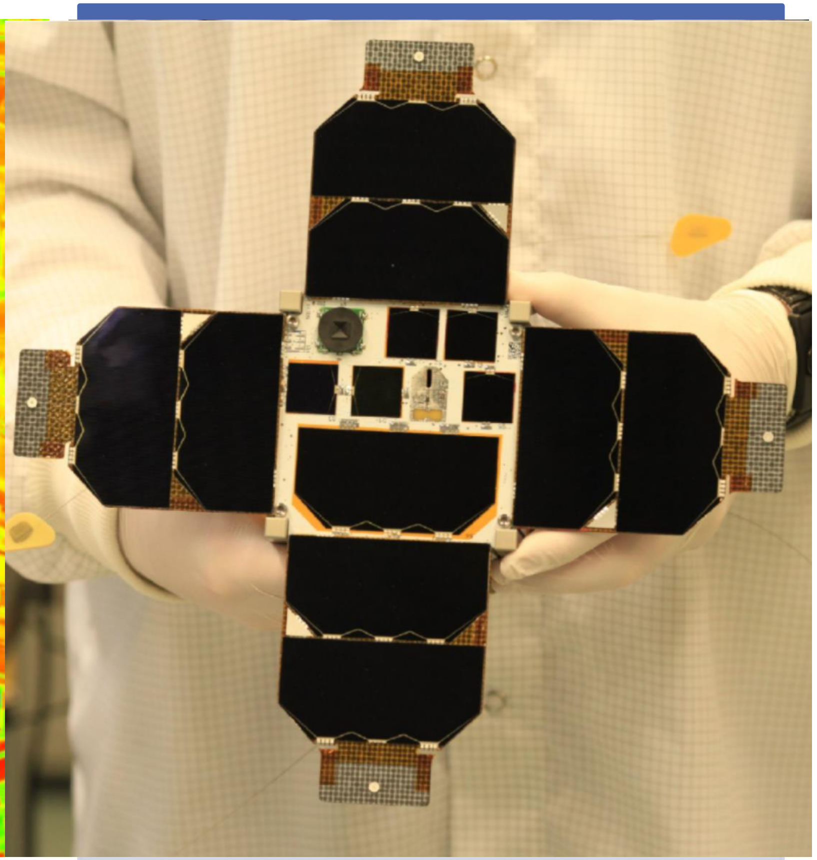
Roadmap

- Overview Munich Orbital Verification Experiment
- Technological Advancements
- Testing Approach
- Programmatic Aspects

Overview of the Munich Orbital Verification Experiment







Programmatic Goal: Hands-on Education for Students

- More than 130 Students involved so far (maximum: 110 at the same time)
- 51 Master Theses, Bachelor Theses etc. written on the project
- 25 publications on conferences and journals
- More than 52‘600 hours of logged (mostly volunteer) work

Technological Goal

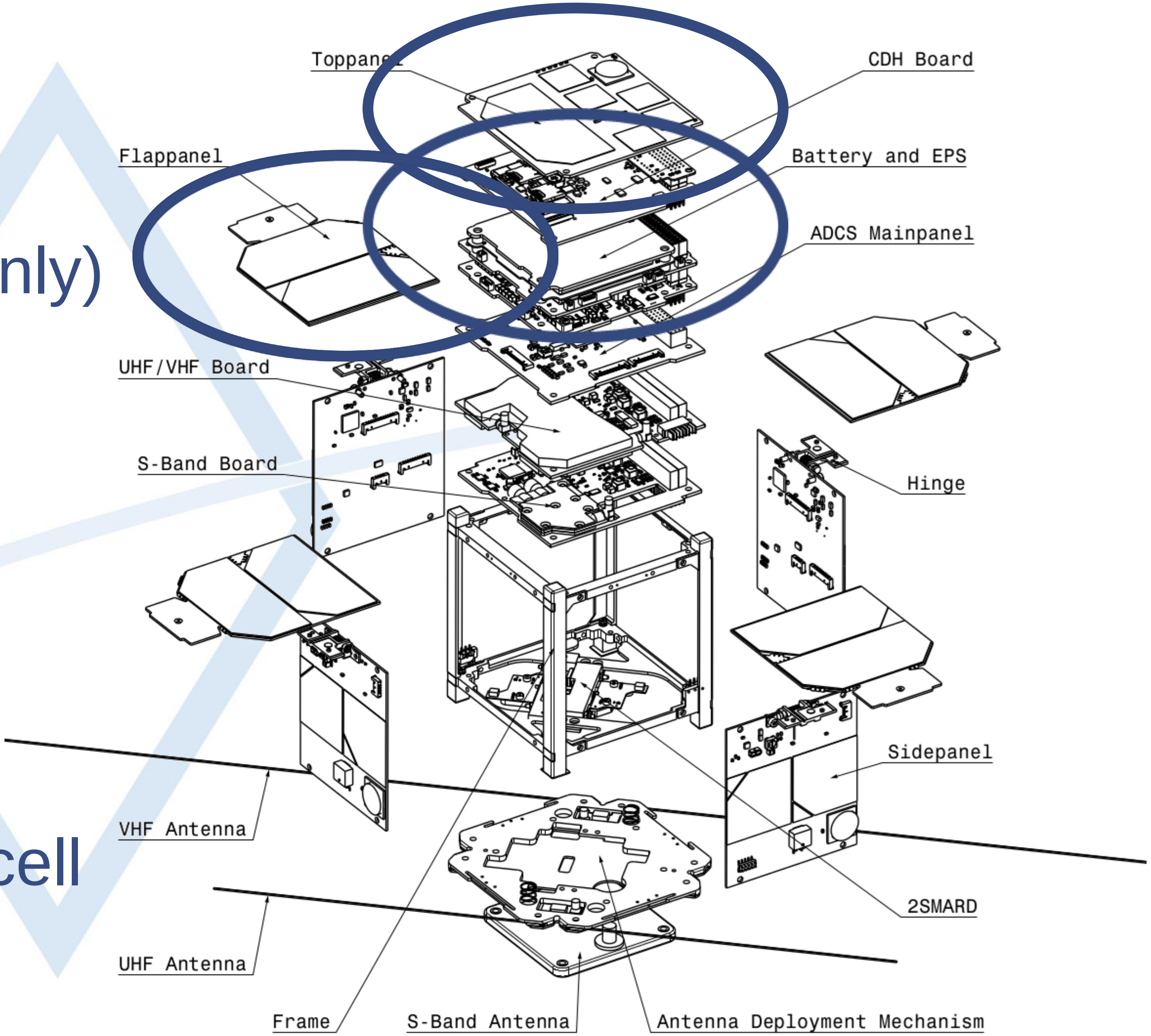
Verification of a bus-system for demanding scientific and technological CubeSat missions

COM: FPGA based SDRs
UHF/VHF (full duplex)
S-Band (half duplex/downlink only)
Both in-house

COTS: Battery, EPS, OBC

Deployables: Solarcells and antennas,
resettable, redundant shape memory alloy mechanism

Main payload: 4-junction solar cell

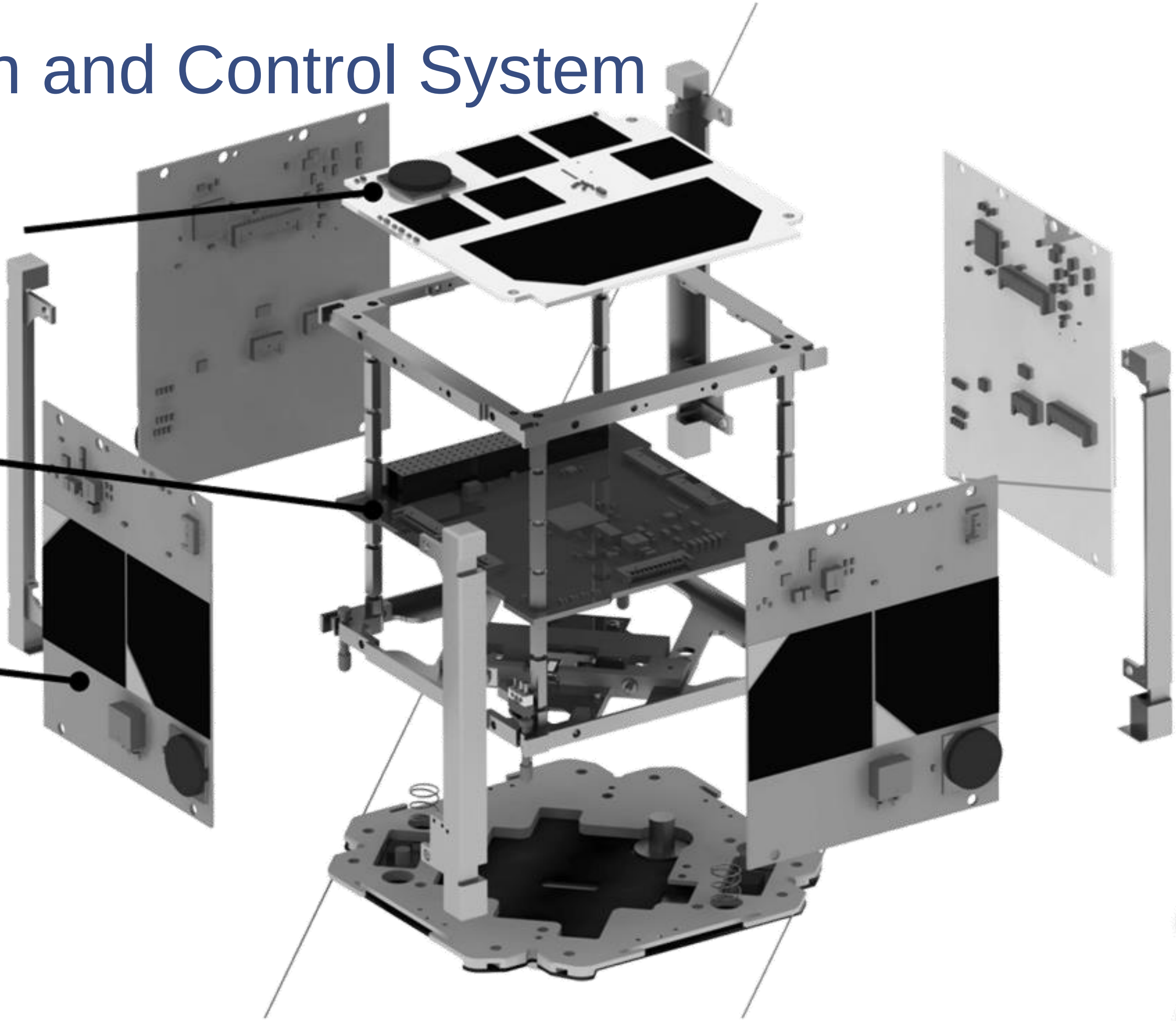


Attitude Determination and Control System

1 Toppanel (shared with payload)

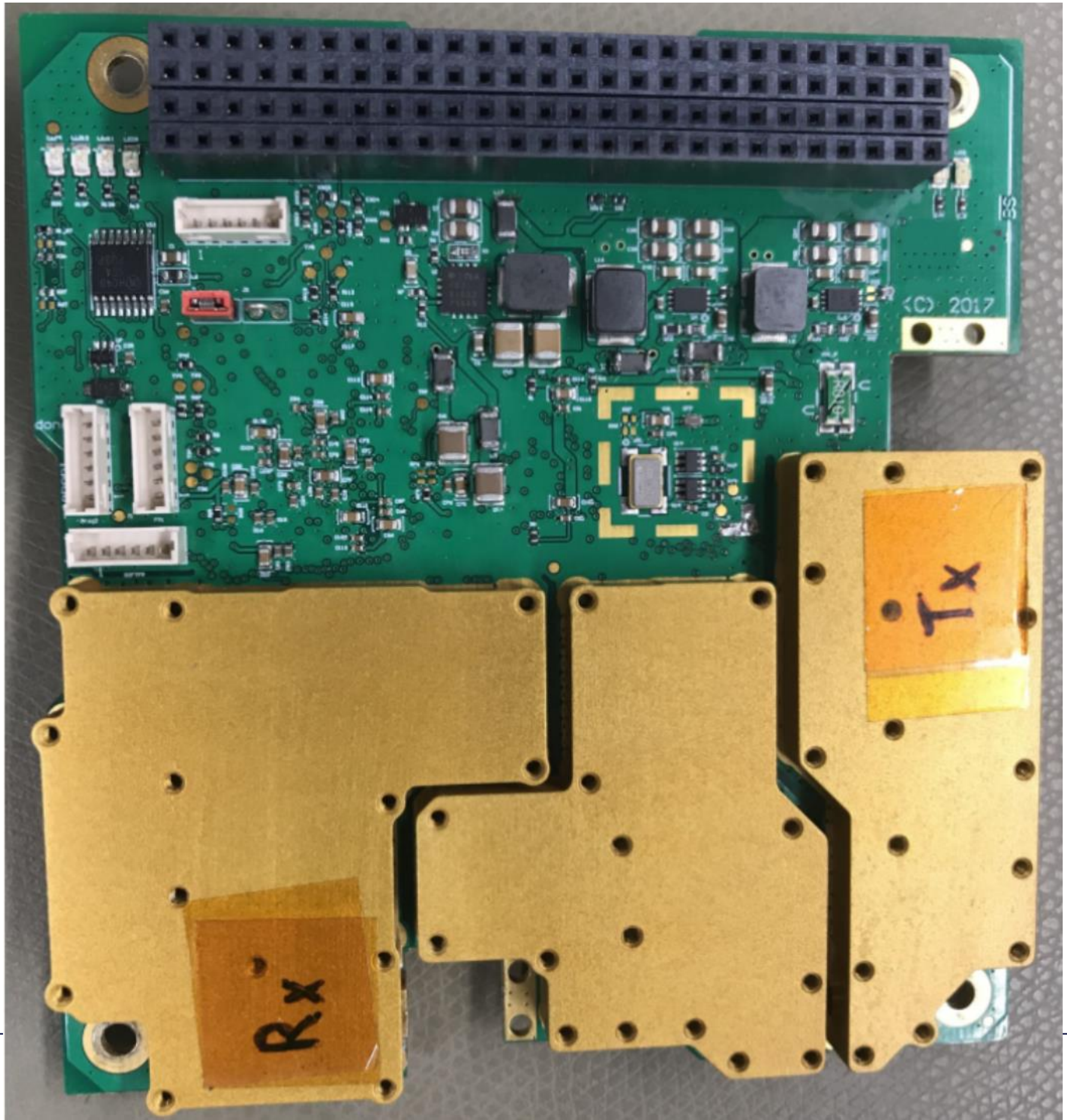
1 Mainpanel (in stack)

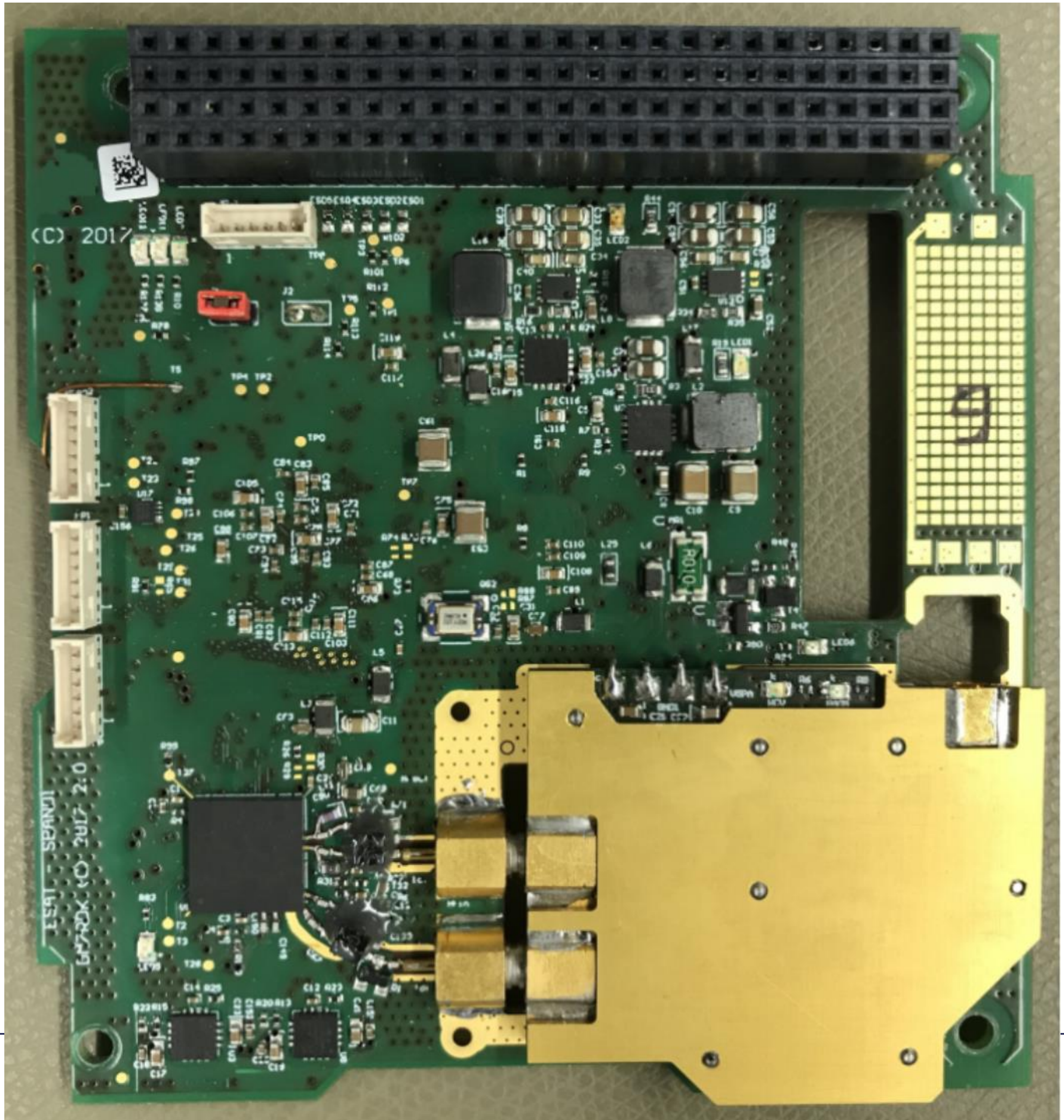
4 Sidepanels



Communication

- Custom layer 2 protocol: Nanolink (opposing AX.25)
  - Virtual channels with guaranteed data rates
  - Automatic repeat request protocol
  - Tailored for moderate signal quality in low bandwidth-delay applications
  - Telecommand with authentication
- UHF/VHF transceiver for telemetry and telecomand: 25kb/s (theoretical maximum) (in-house development)
- S-Band transceiver for future demanding payloads (3Mb/s downlink, 150kb/s uplink)
- FPGA based SDRs, reprogrammable in orbit


(C) 2017
Tx
Rx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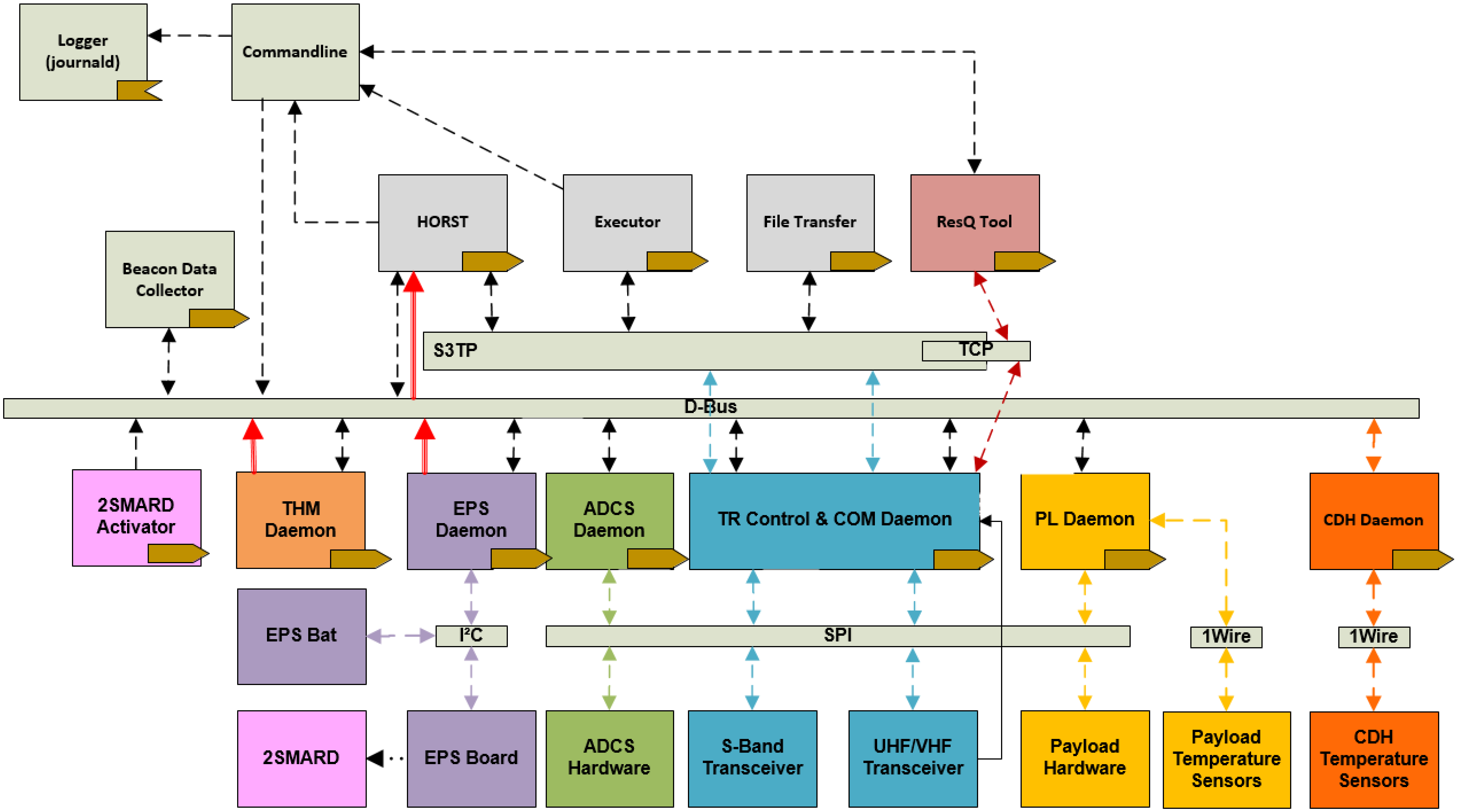
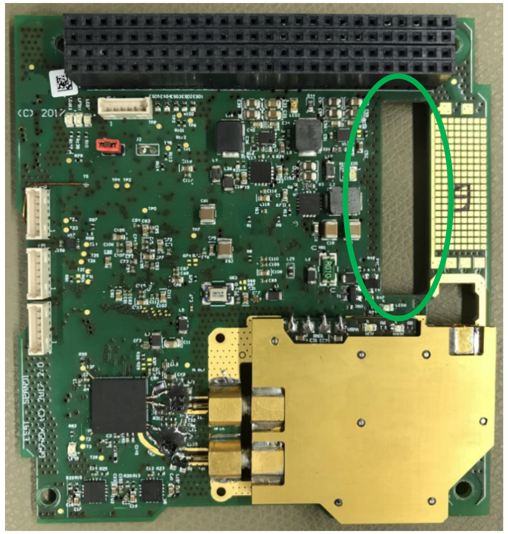
Central Data Handling

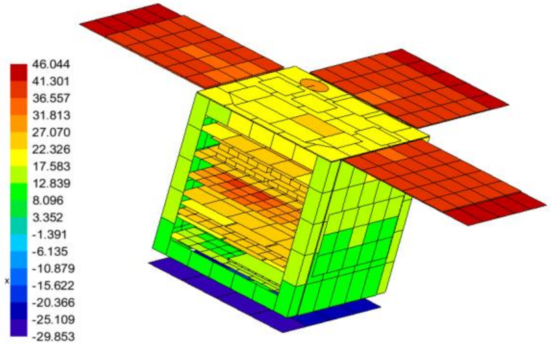
- ARM-9 processor running a custom Linux distribution
- FRAM and flash storage , carrying two SD-card slots (equipped with 132GB of storage in total)
- Modular software architecture enabling updates of single components
- Minimum viable product approach to enable integrated tests from early on
- Image stored multiple times (deterministic runtime-based selection)
- Kernel stored multiple times (random-selection at boot)

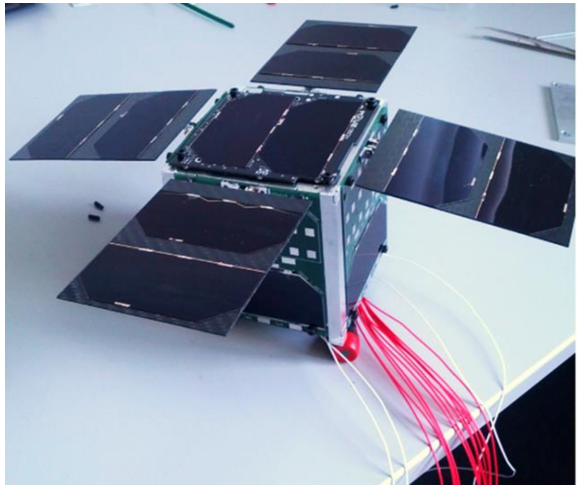

Logger (journald)
Commandline
HORST
Executor
File Transfer
ResQ Tool
Beacon Data Collector
S3TP
TCP
D-Bus
2SMARD Activator
THM Daemon
EPS Daemon
ADCS Daemon
TR Control & COM Daemon
PL Daemon
CDH Daemon
EPS Bat
I²C
SPI
1Wire
1Wire
2SMARD
EPS Board
ADCS Hardware
S-Band Transceiver
UHF/VHF Transceiver
Payload Hardware
Payload Temperature Sensors
CDH Temperature Sensors

Testing Principles I: Early Integration, Dress Rehearsals and Mock-Ups

- Define stacking by preliminary TVAC testing
- Find all collissions before the production of qualifiable hardware
- Verify integration procedure before the production of qualifiable hardware

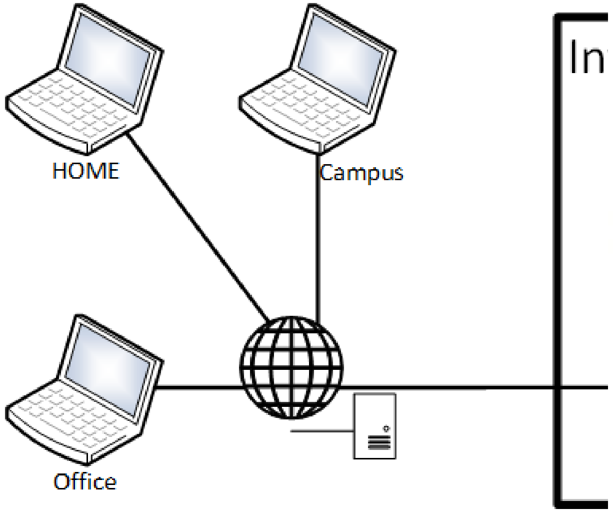


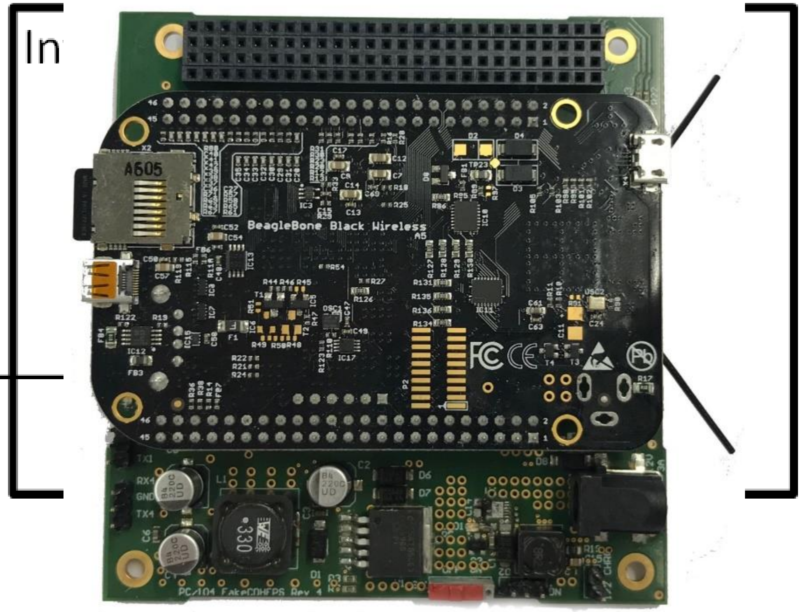




Testing Principles II: Maximum Availability and Ease-of-use for Testing Equipment

- Remote Accessability of:
  - Command-line interface
  - Logic analyzer
  - Power supply
  - Multimeter
  - Camera
  - Thermal vacuum chamber
- Development of Fake CDH/EPS
  - Basic EPS and CDH abilities
  - Used to test and develop ADCS
  - Featuring a Beaglebone Black, wifi, SSH, internal battery
  - Current iteration: Debug output of all 6 ADCS panels, visualization of all available values via grafana GUI, Slackbot to inform about low battery





Testing Principles III: Test-as-you-fly, Visualize, Gamification

Notification Service APP 10:18 PM
Statistics for Nov 30, 2017 of the EM OPS interface:
185 commands have been issued (of which **114** were successfully completed and **74** were maintenance commands)
12 files have been downloaded (of which **0** were successfully completed)
25 files have been uploaded (of which **5** were successfully completed)

Top Commanders are:
1 [redacted] (125)
2. [redacted] (20)
3. [redacted] (17)

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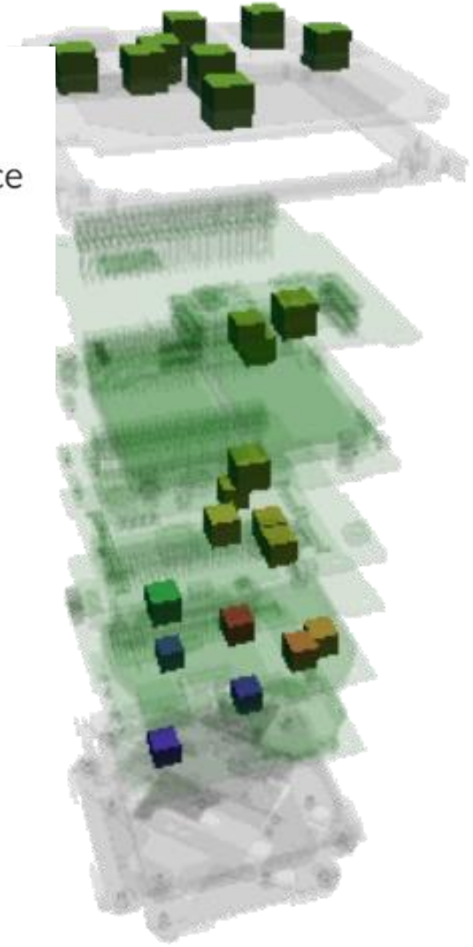

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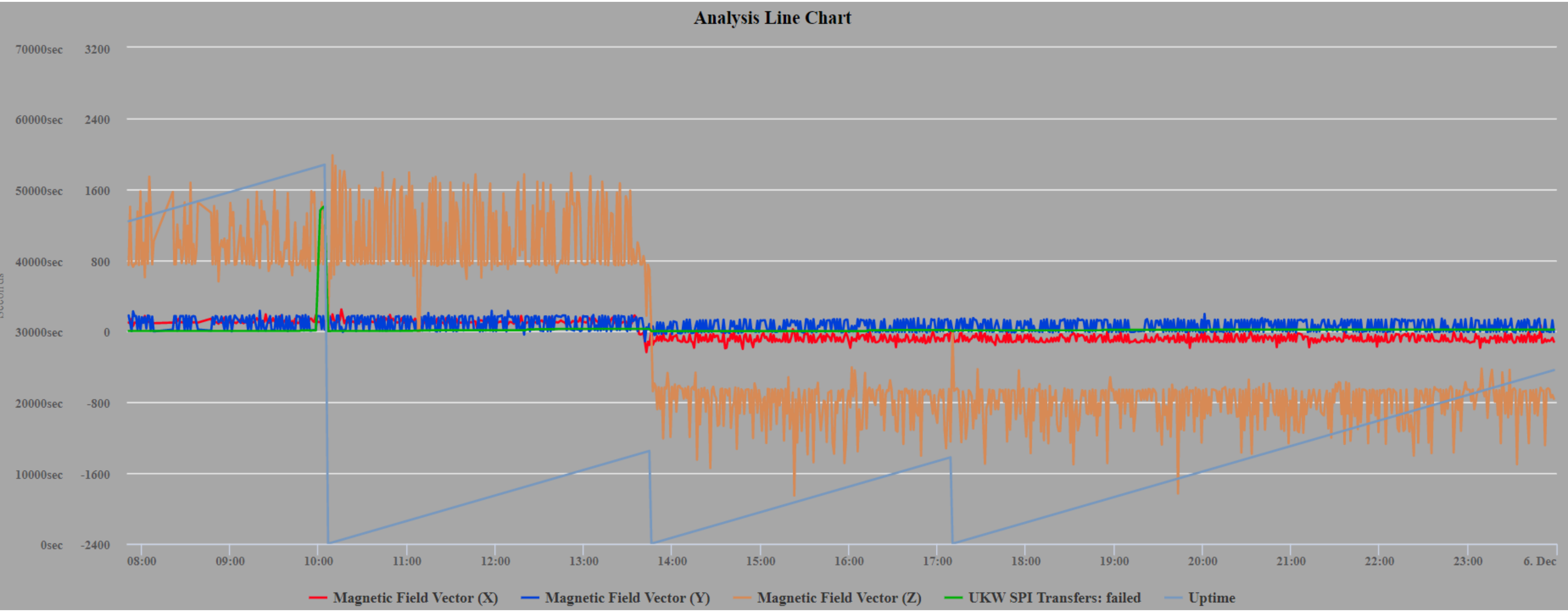

Programatic Aspects

- Motivitation through actively creating team spirit, good working environment, challenges and gamification of testing, distribution of responsibility to the team
- Launch in 2018 (SpaceX Falcon9, ISL, SSO-A)
- Use remaining time for dedicated operators training
- Eventually set up hardware-in-the-loop for operational training (power supply, attitude control, ...)

Thanks for your attention!

Get more insights at www.move2space.de

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esa education

Verification through Hardware-in-the-loop tests