

OUFTI - 1

Status and perspectives

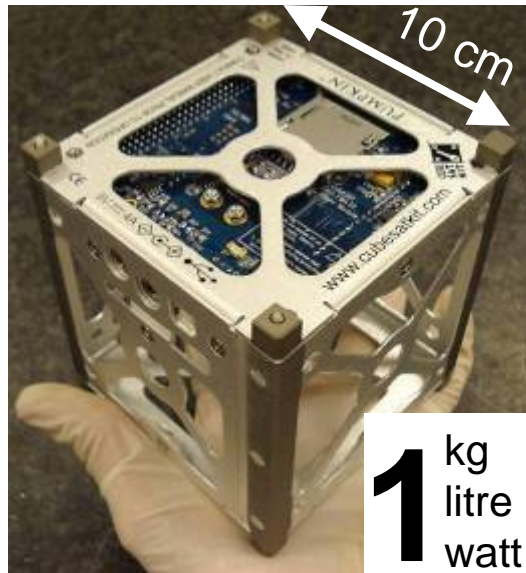


29 June 2011
University of Liège

1. The OUFTI-1 project
2. Technical status
3. Design review
4. 2011-2012 schedule
5. Conclusion

1. The OUFTI-1 project
 - In a few words
 - Objectives
 - Student team
2. Technical status
3. Design review
4. 2011-2012 schedule
5. Conclusion

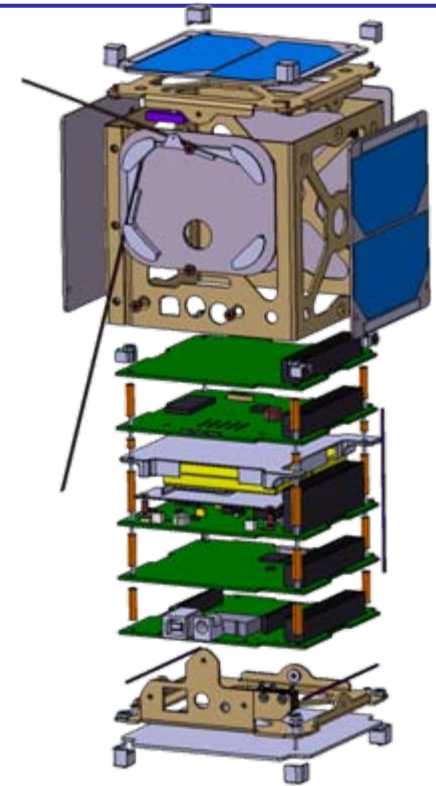
1. The OUFTI-1 project: in a few words



CubeSat standard



Three payloads



Subsystems developed by students



Initially selected for VEGA Maiden Flight

1. The OUFTI-1 project: objectives

Fun and education

Design of the
OUFTI-1 system

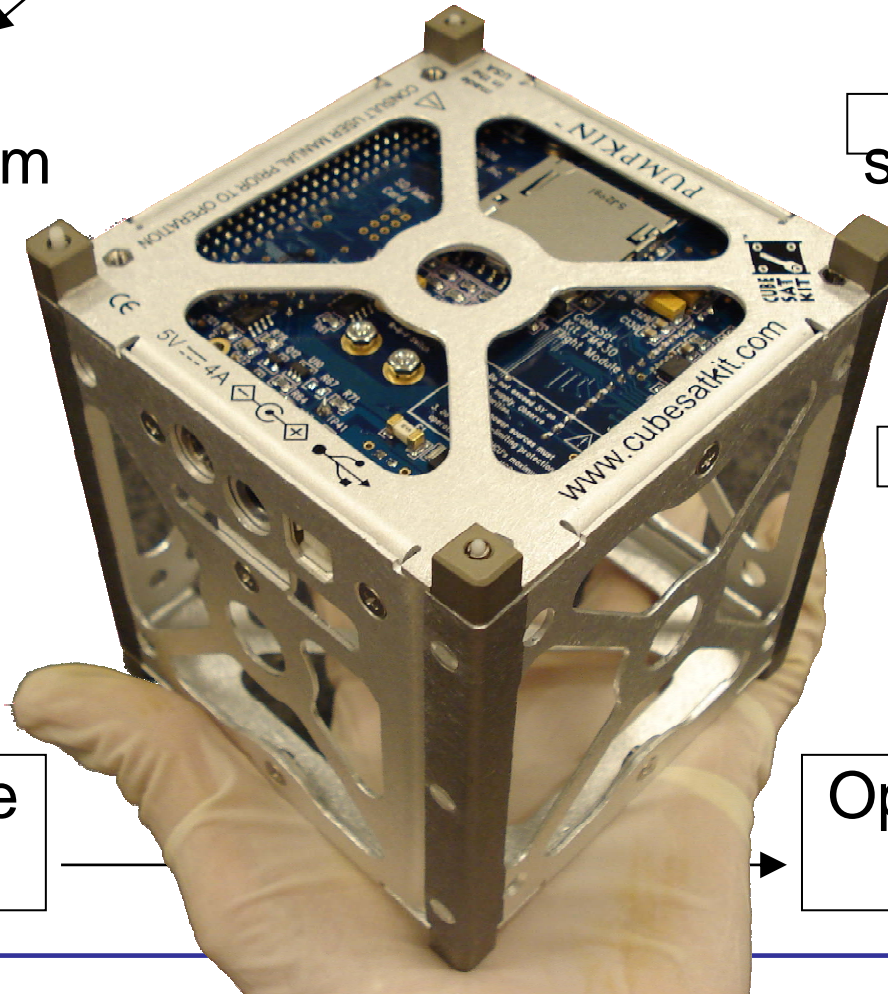
Operating the
secondary payloads

Launch of
OUFTI-1

Having the
D-STAR functional

Satellite alive
in space

Operating the
satellite



1. The OUFTI-1 project: student team



2 universities + 3 engineering schools

1. The OUFTI-1 project

2. Technical status

- STRU
- COM
- EPS
- OBC
- THER
- VIB
- HAM
- SDR

3. Design review

4. 2011-2012 schedule

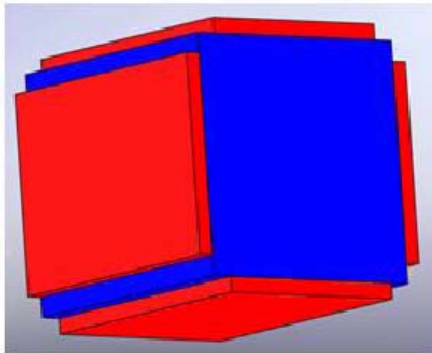
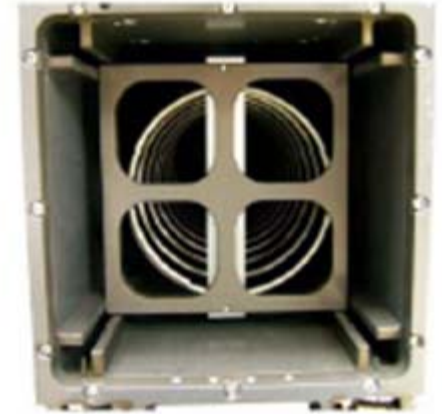
5. Conclusion

1. The OUFTI-1 project
2. Technical status
 - **STRU: Structure and configuration**
 - COM
 - EPS
 - OBC
 - THER
 - VIB
 - HAM
 - SDR
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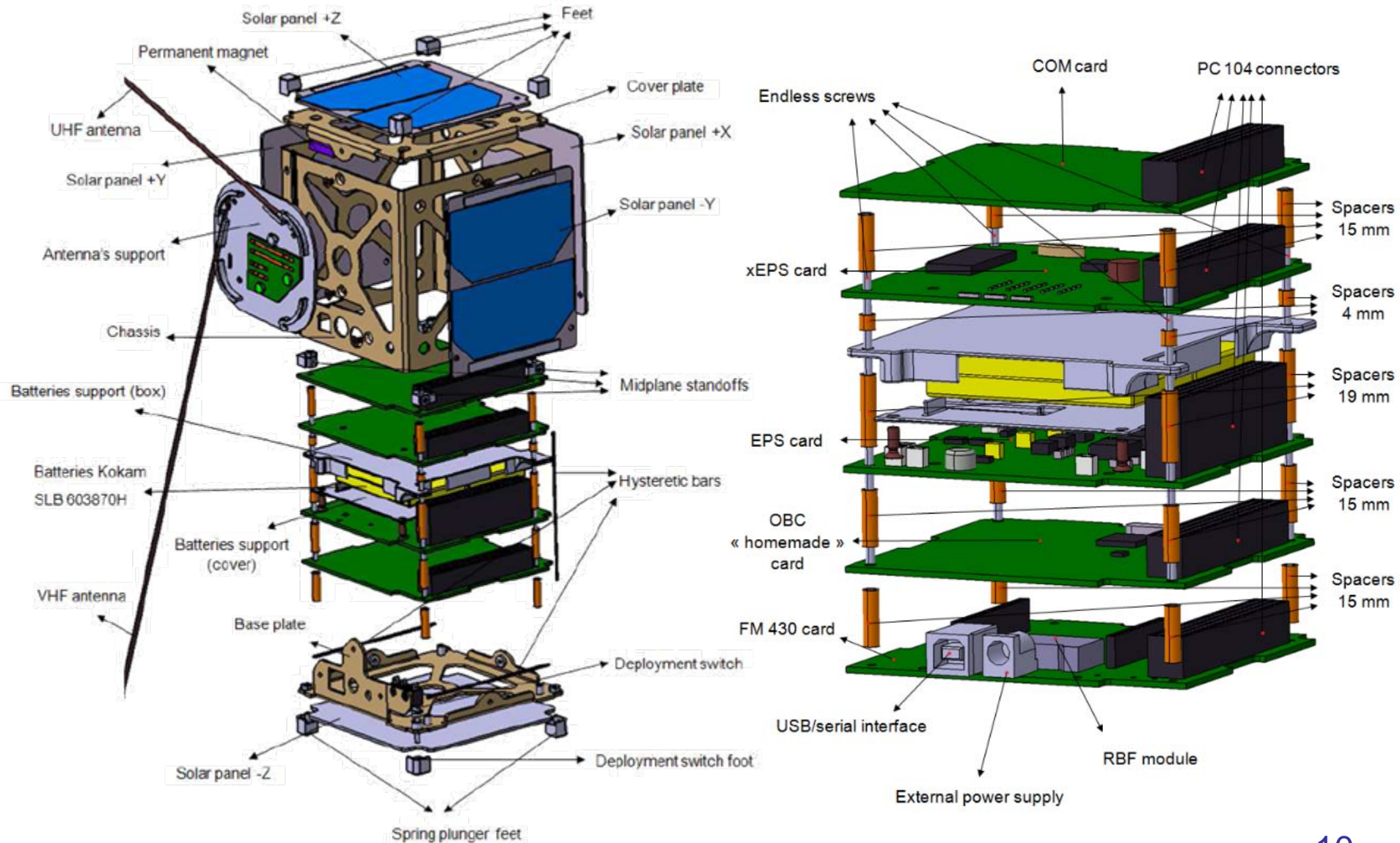
STRU - Structure and configuration

Volume:

- Interface CubeSat – Launcher: P-POD
- Maximum mass: 1 kg
- Available volume:
 - In blue: 100 x 100 x 113.5 mm
 - In red: 6.5 x 83 x 113.5 mm



STRU - Structure and configuration



STRU - Structure and configuration

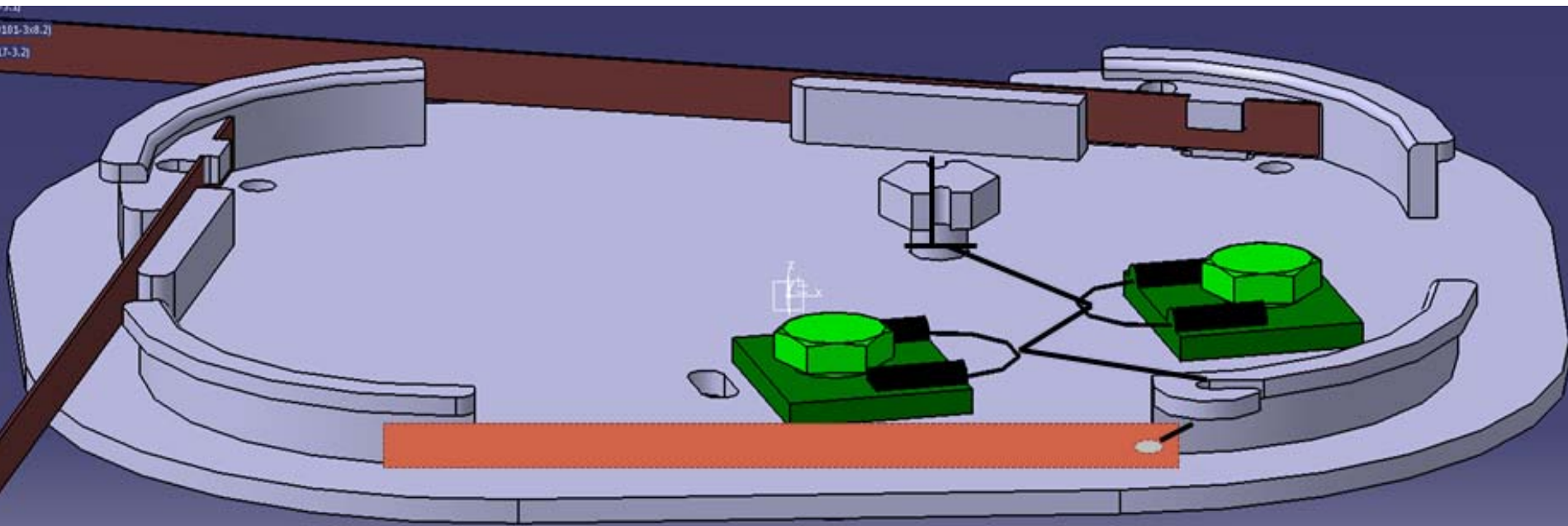


OUFTI-1 mass budget:

Subsystems	Nominal case (g)	Worst case (g)
STRU	438,04	446,80
MECH	45,51	47,22
ADCS	3,79	4,05
THERM	26,4	34,45
EPS	196,13	204,08
OBC	118,04	120,50
COM	50,36	65,42
Cabling	15	30
Adhesive	15	30
OUFTI-1 TOTAL MASS	908,27	982,52

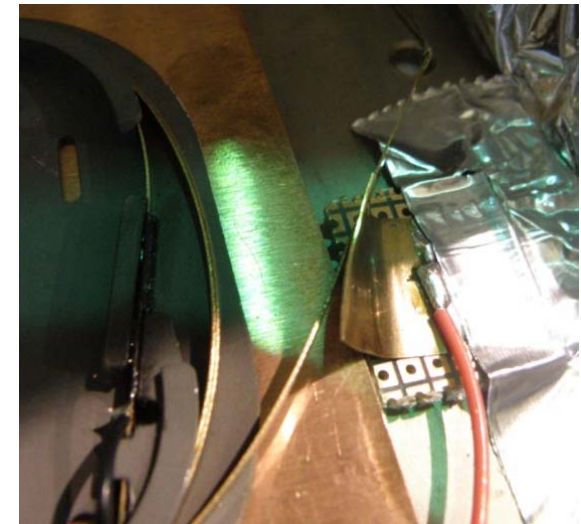
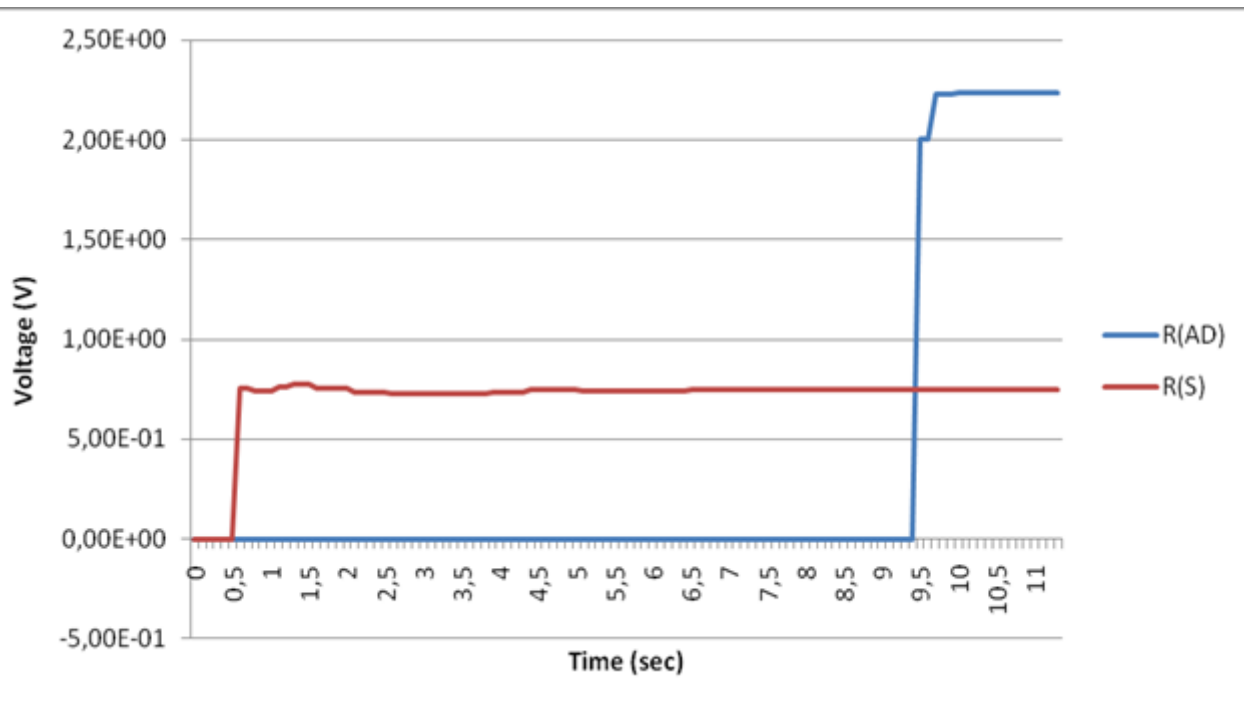
Design:

- 1 antennas support: AlMg3 ¼ anodized
- 2 antennas: Coppro-beryllium → 1 VHF antenna + 1 UHF antenna
- 1 retention wire: Dyneema → Fusion temperature: 144 – 152 °C
- 2 thermal knives: titanium wire



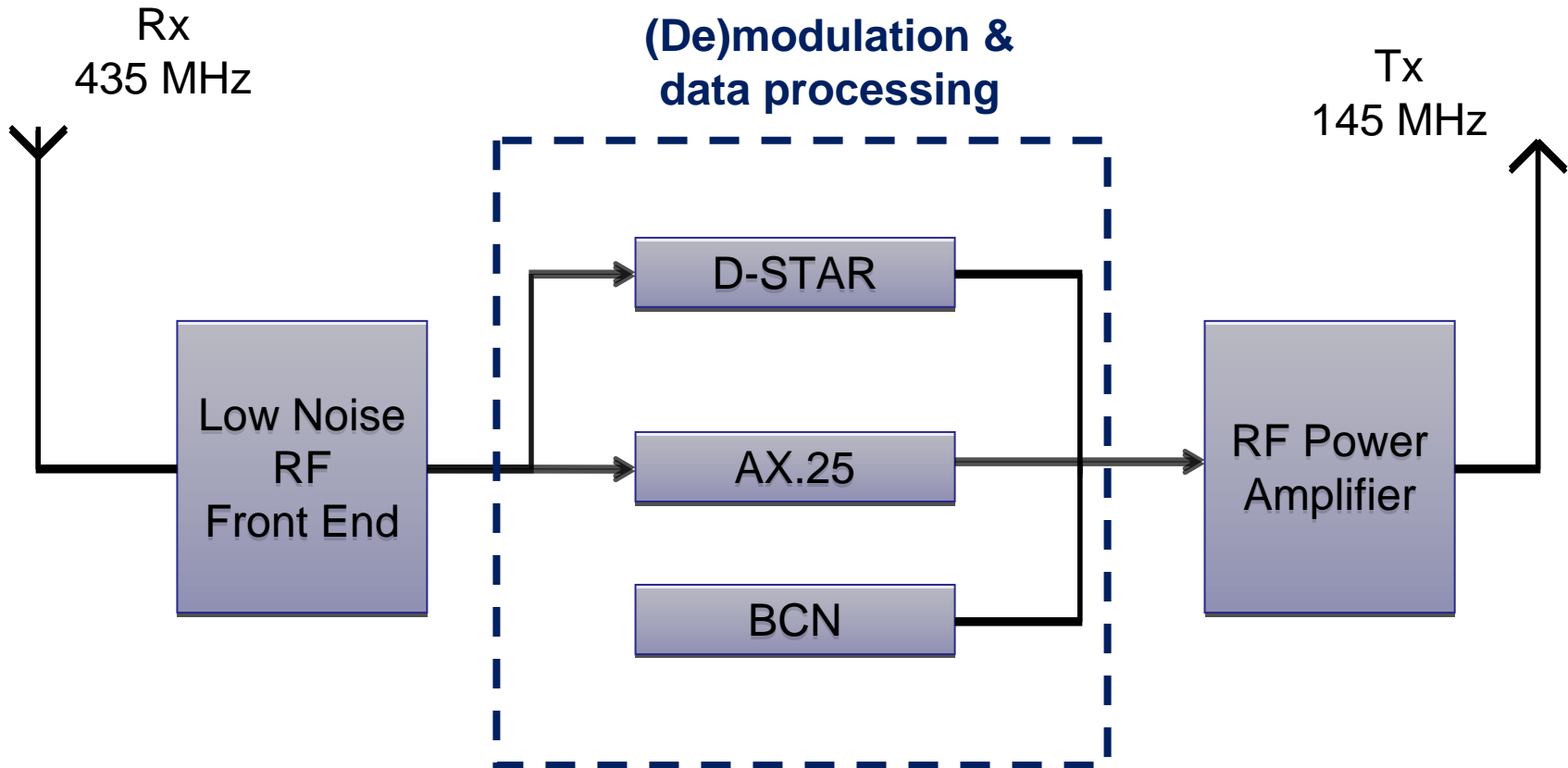
Prototype and tests:

- Complete prototype
- Vacuum environment tests
 - Objective: Thermal knives alimentation time
 - Antennas deployment was detected after 8.9 seconds

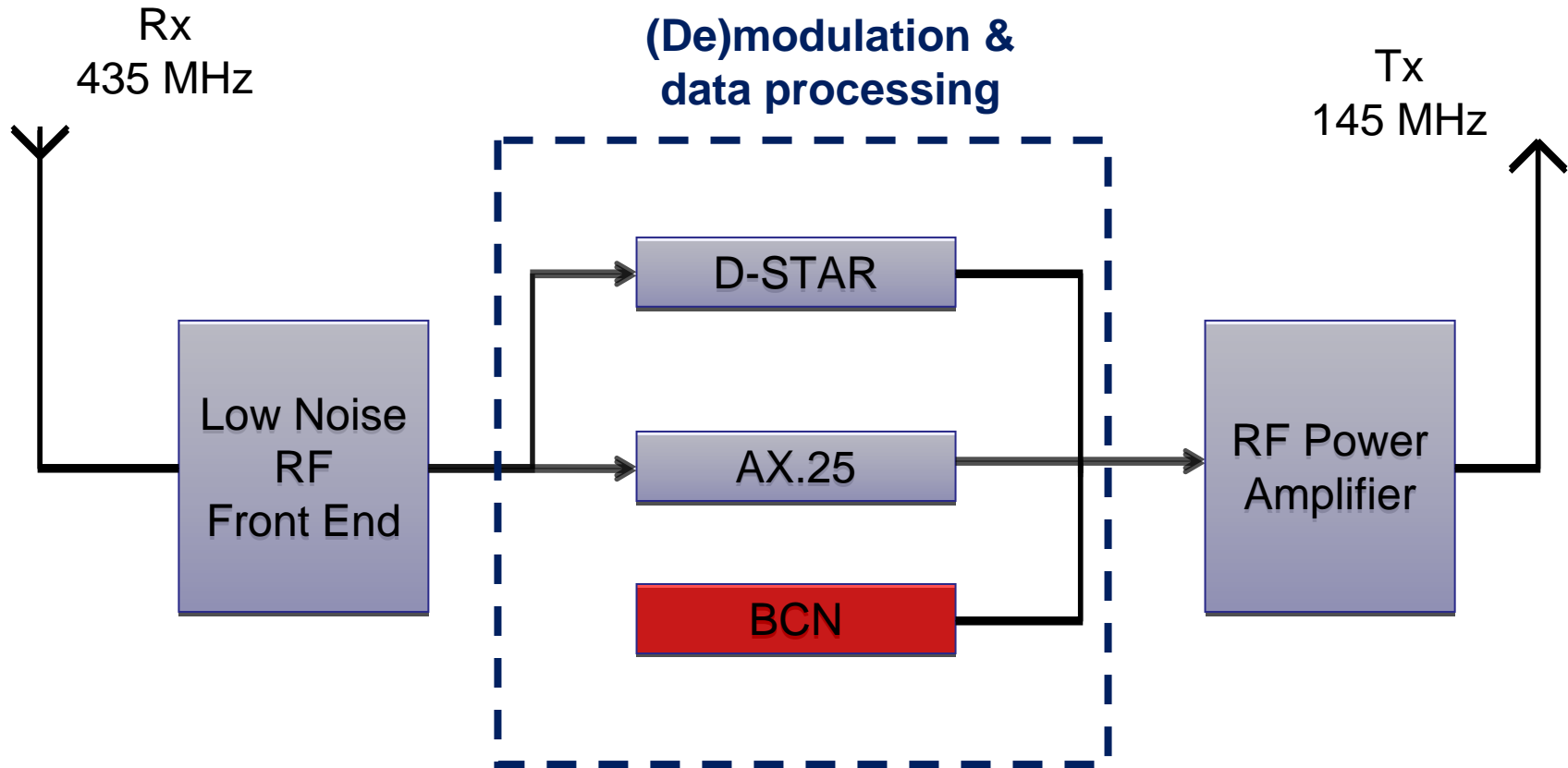


1. The OUFTI-1 project
2. Technical status
 - STRU
 - **COM: Communication subsystem**
 - EPS
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COM – Block-diagram



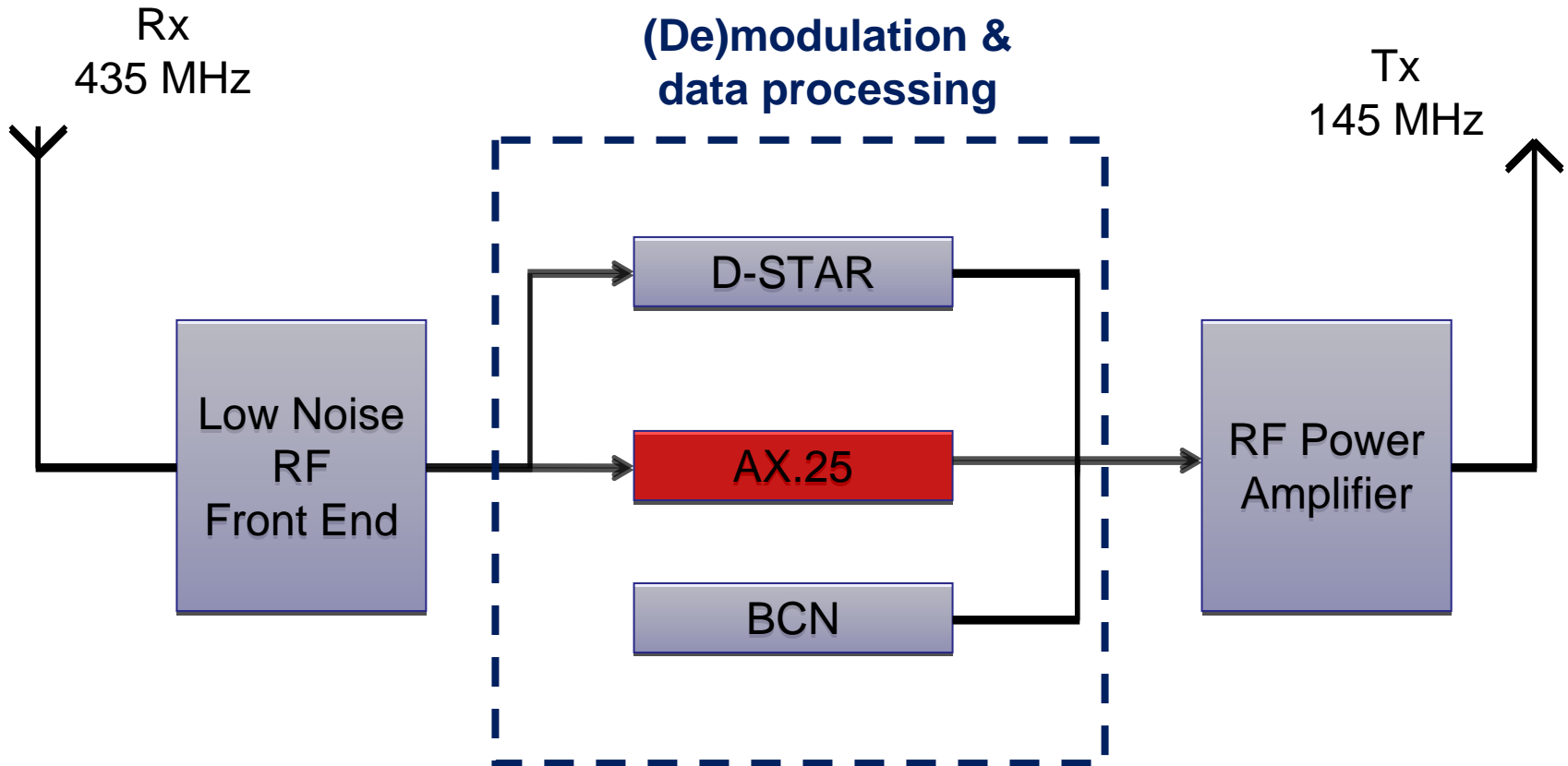
COM – Block-diagram



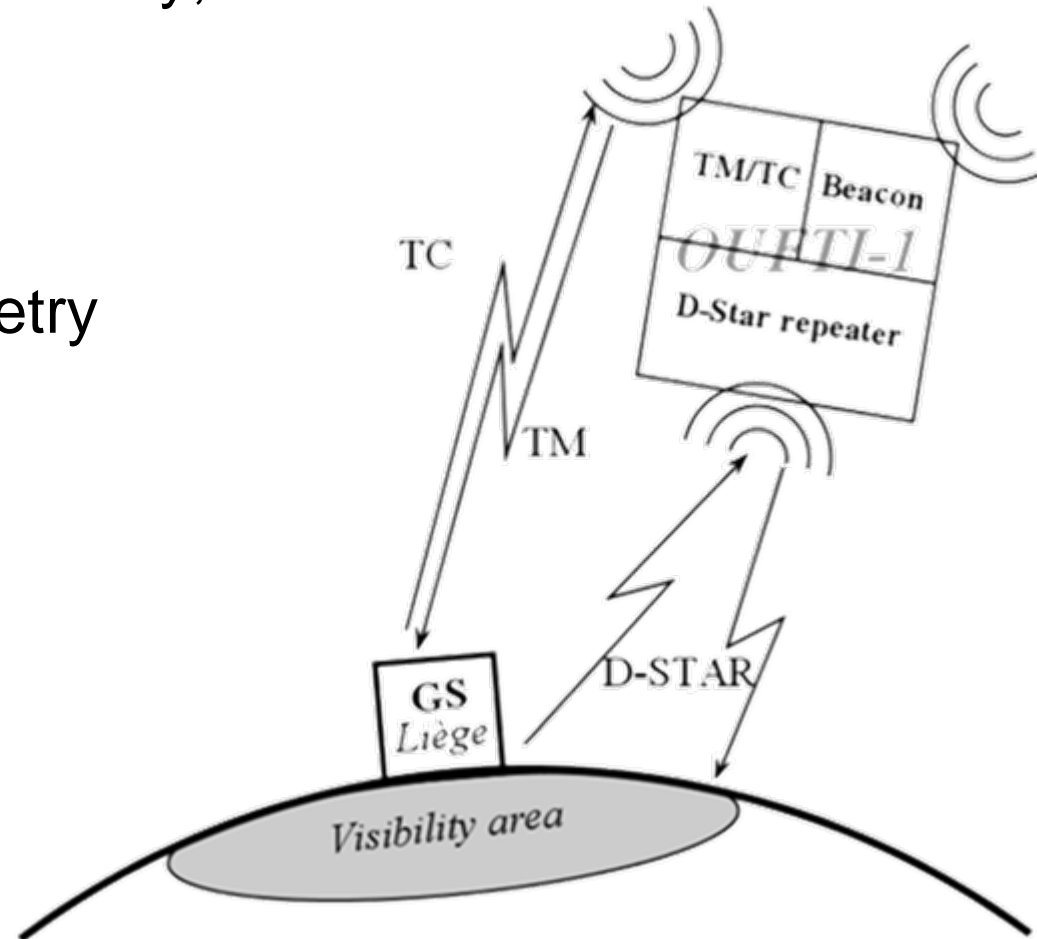
- Continuous emission
- Message in Morse code
- Information regarding satellite health
- Collected and transmitted to Liège by amateur-radio operators all over the world



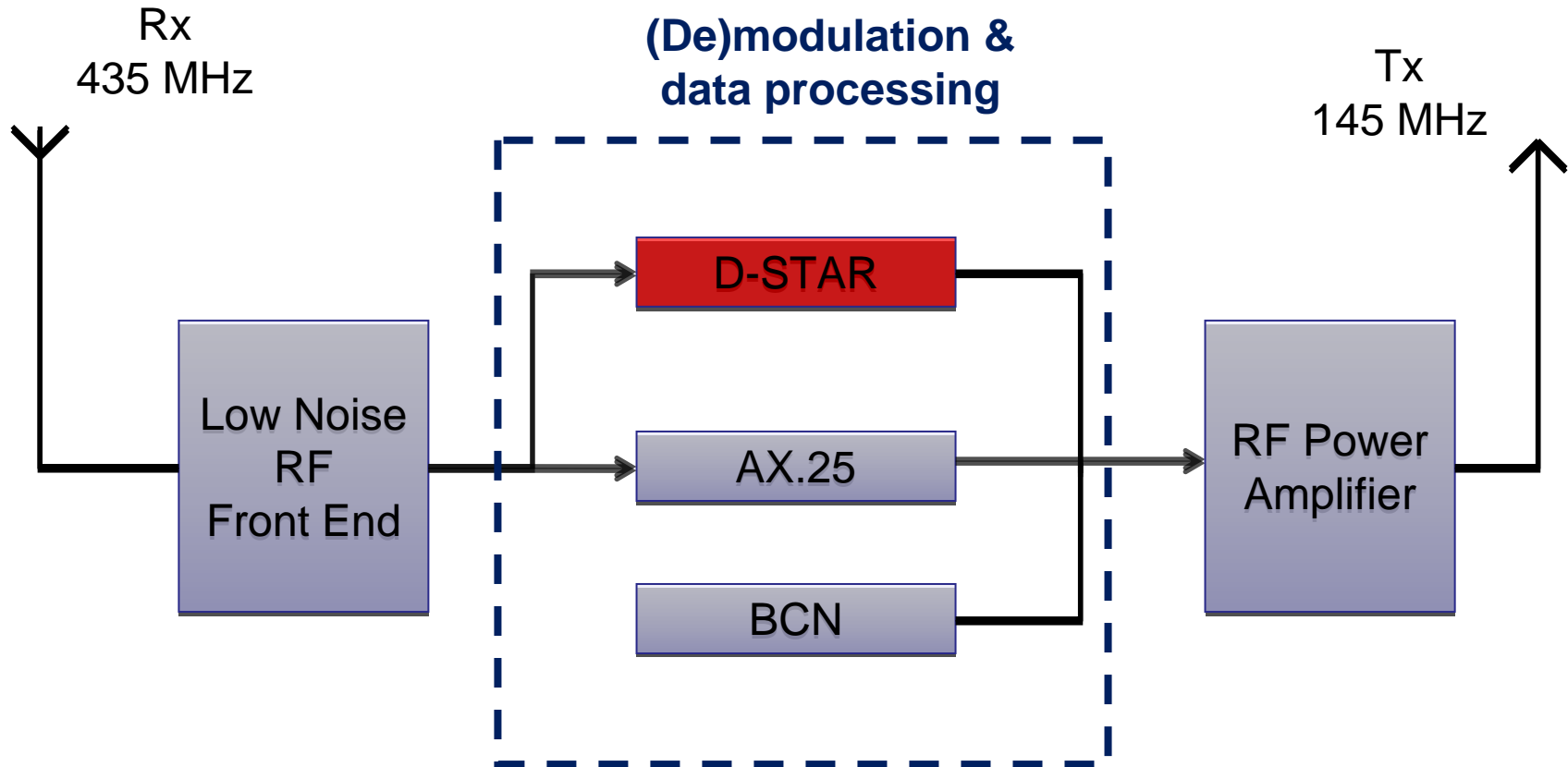
COM – Block-diagram



- Widely used by ham community, especially for satellite communication
- Telecommand and telemetry
- Always listening, priority



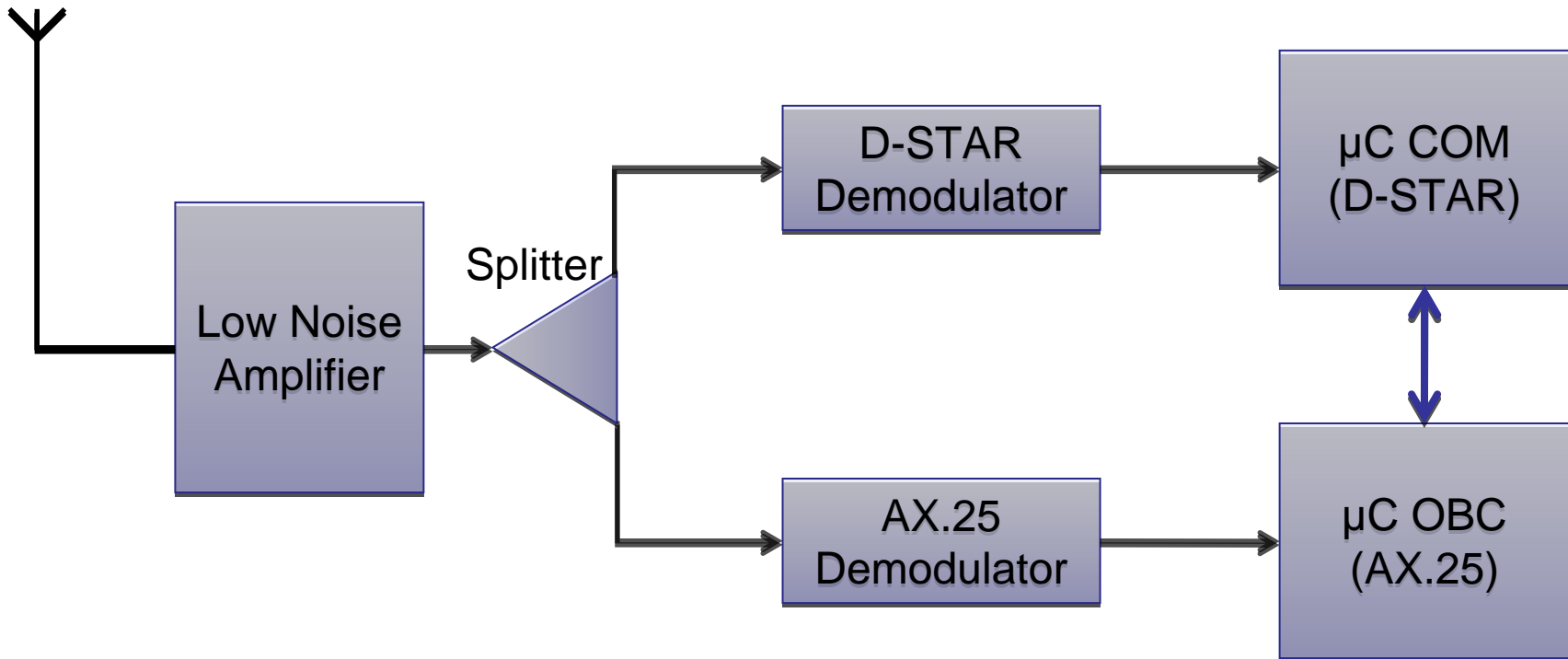
COM – Block-diagram





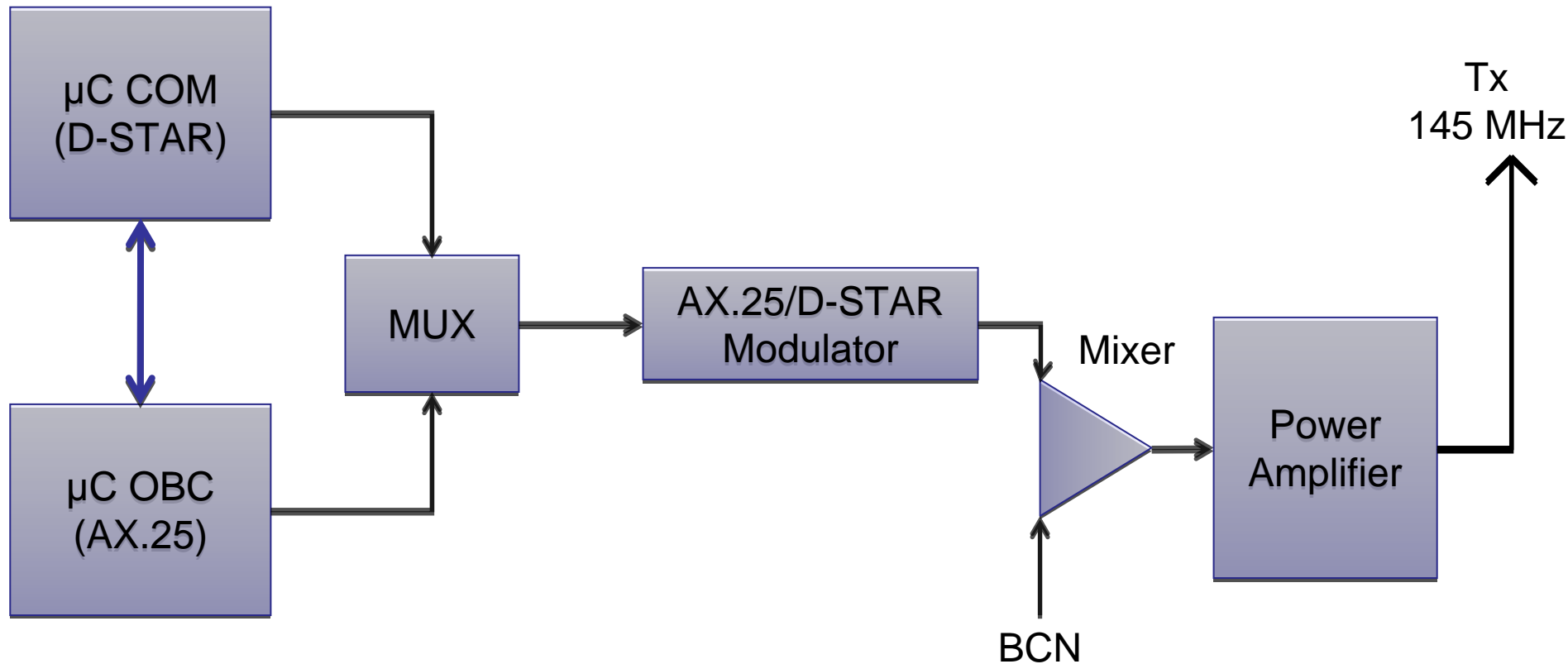
- Main payload of OUFTI-1
- OUFTI-1: first repeater in space dedicated to D-STAR
- Digital transmission protocol
 - 2 modes: Digital Voice (DV) & Digital Data (DD)

Rx
435 MHz



Demodulators: Analog Devices ADF7021

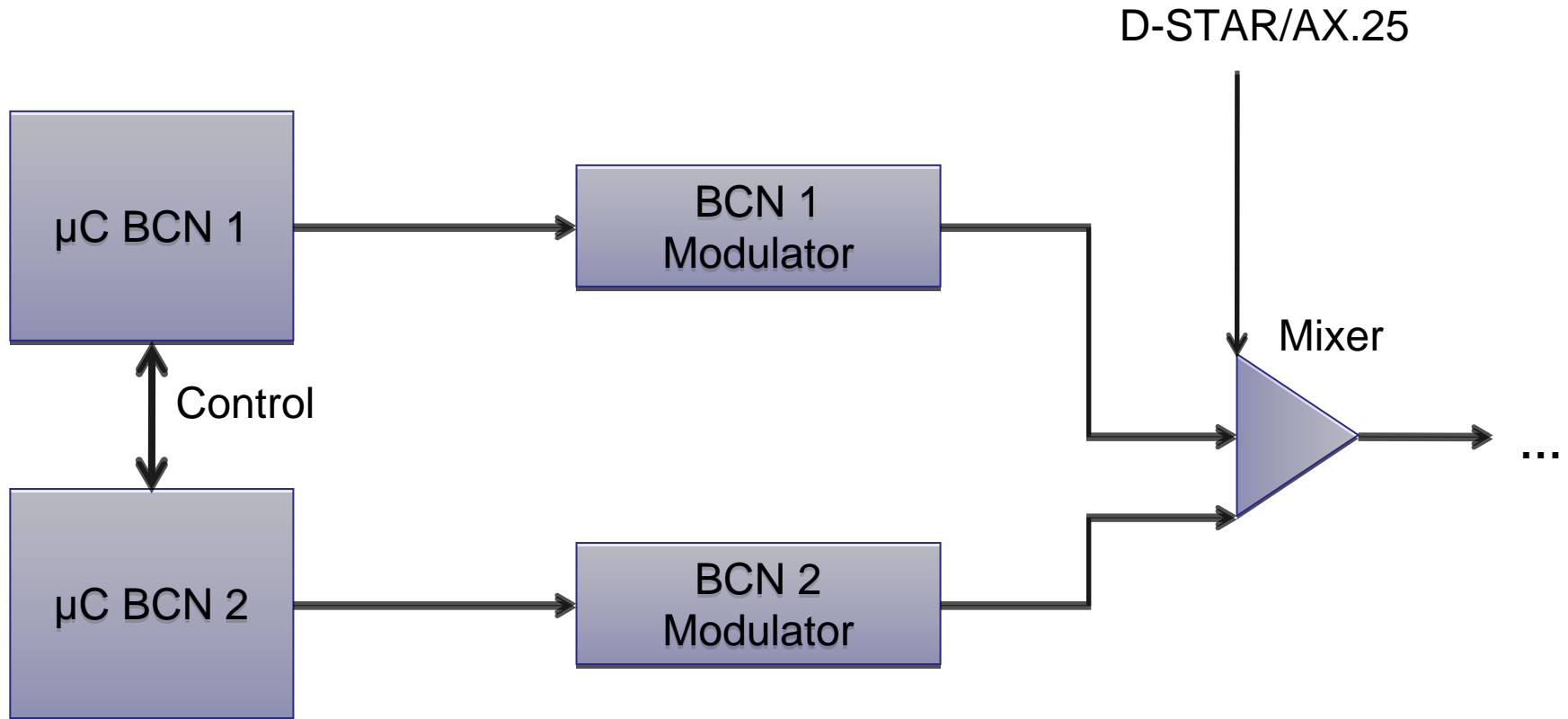
μC: Texas Instruments MSP430



Modulateurs: Analog Devices ADF7021

μC : Texas Instruments MSP430

MUX: Multiplexer



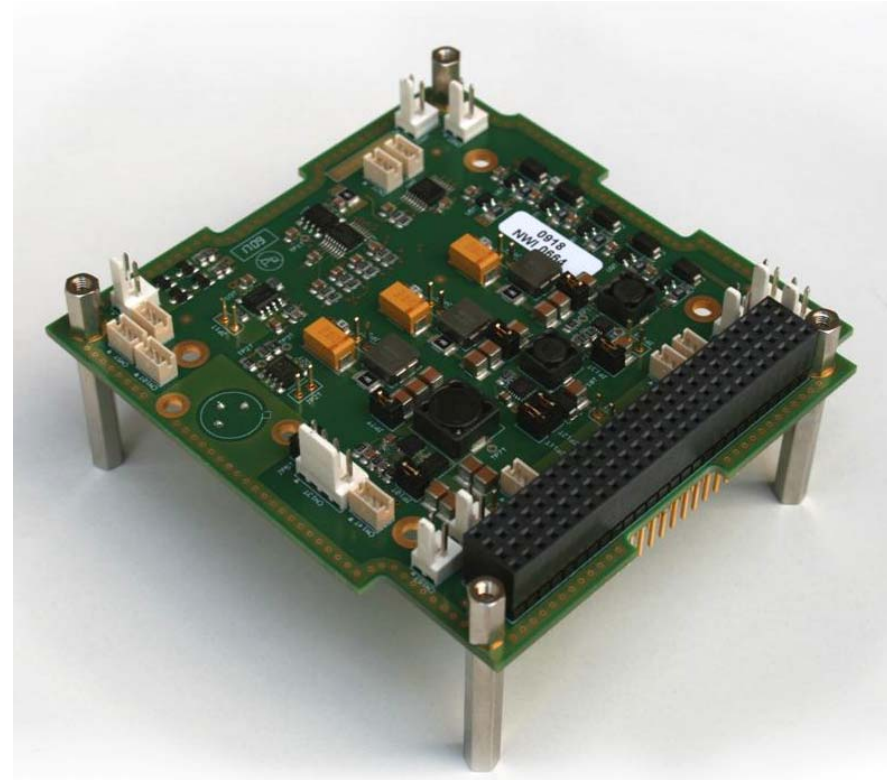
1. The OUFTI-1 project
2. Technical status
 - STRU
 - COM
 - **EPS: Electrical Power Supply**
 - OBC
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Role

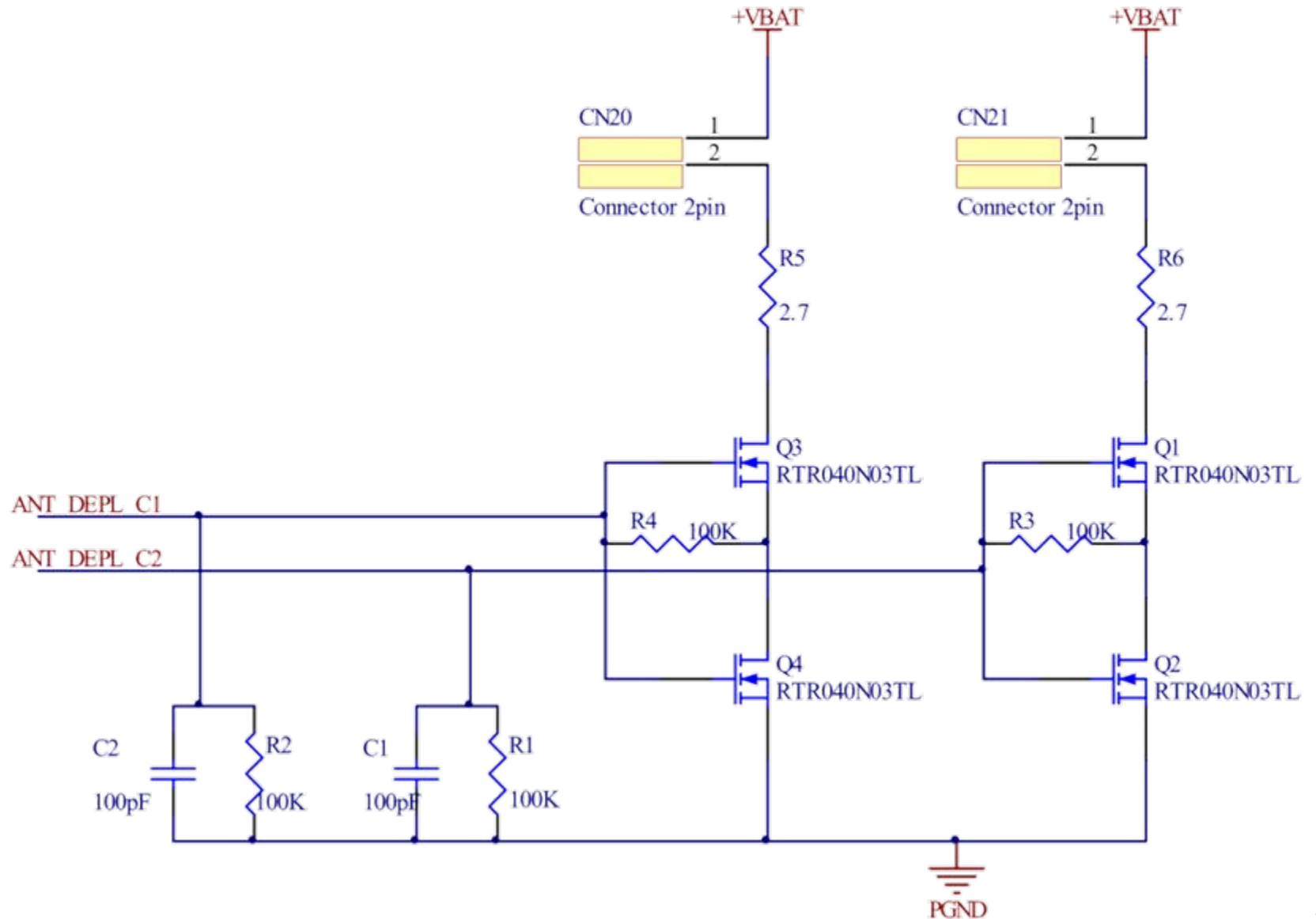
- Power source
- Power storage
- Power conditioning

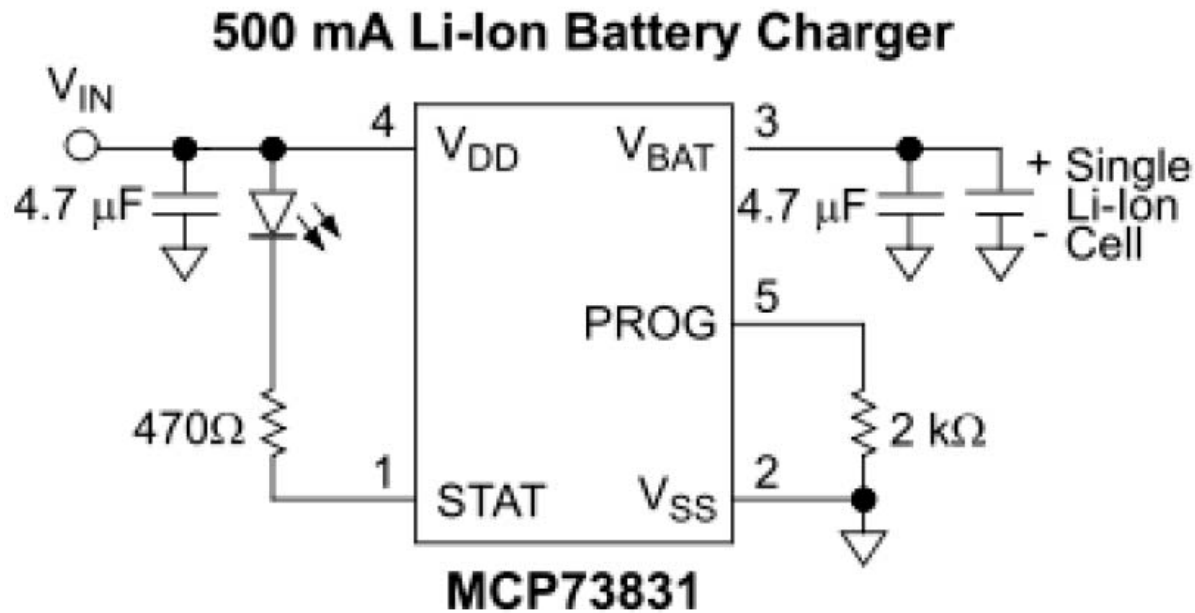
Functionalities

- Antenna Deployment System
- USB Battery Charger
- Measurement Circuit
- Power Budget
- Connectors
- Protection circuits



EPS – Antenna Deployment Circuit





Measurement Circuit

- Voltage, current and temperature measurements

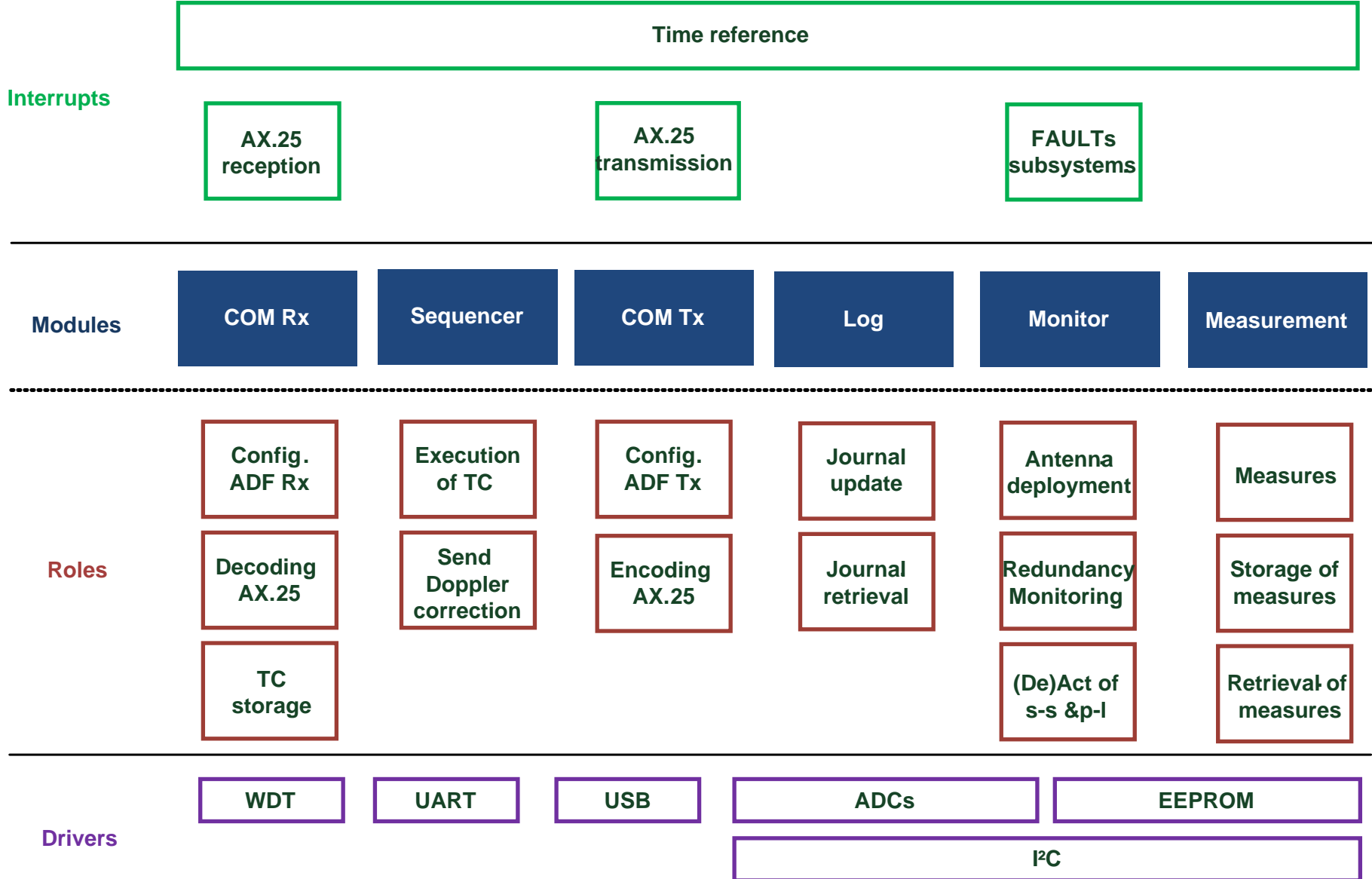
- Adaptations:
 - Current measurements
 - Temperature sensors
 - Voltage dividers

Protection Circuits

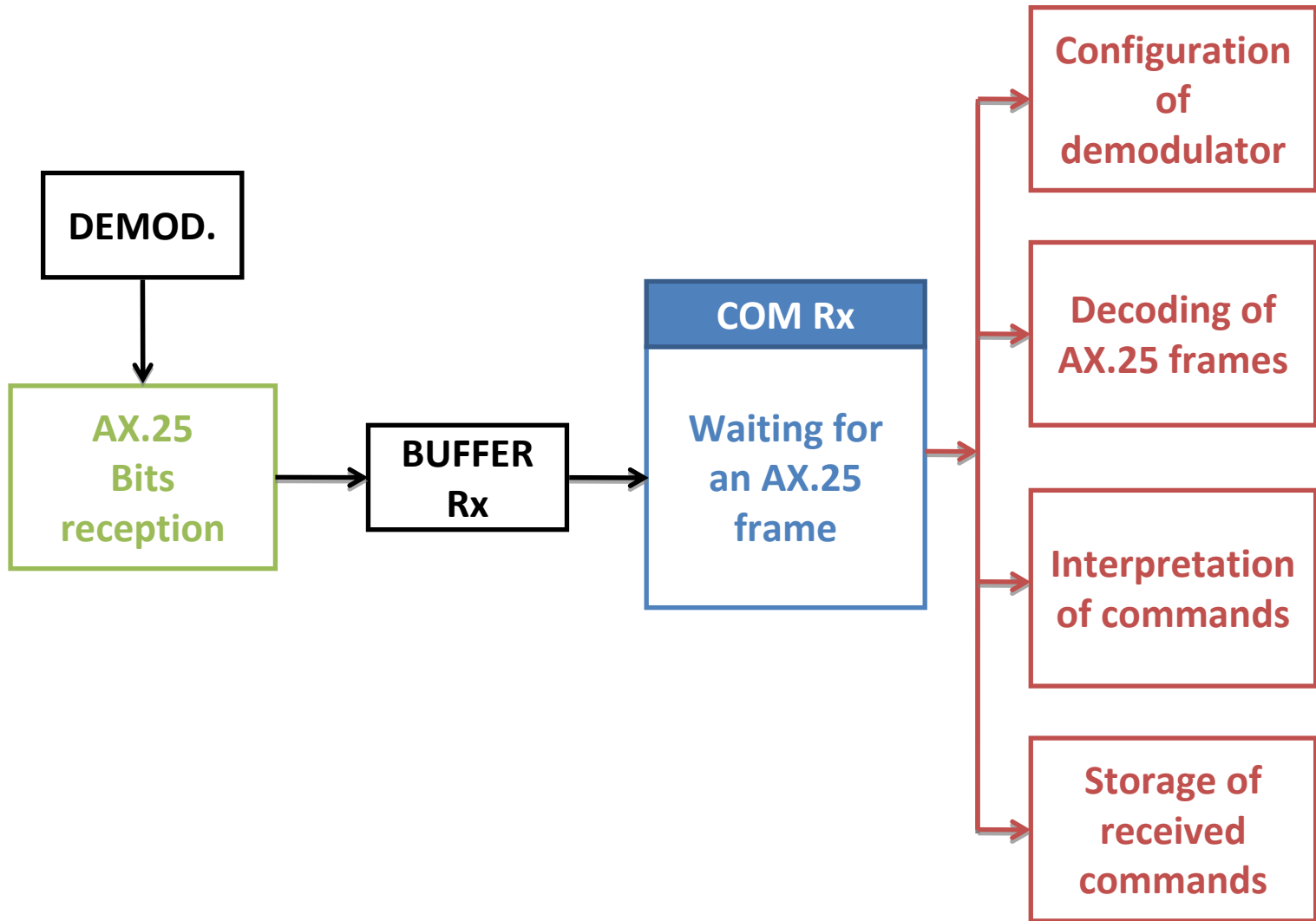
- Replacement of current limiter
- Battery protection circuits moved to EPS board

1. The OUFTI-1 project
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 - STRU
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 - **OBC: On Board Computer**
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 - VIB
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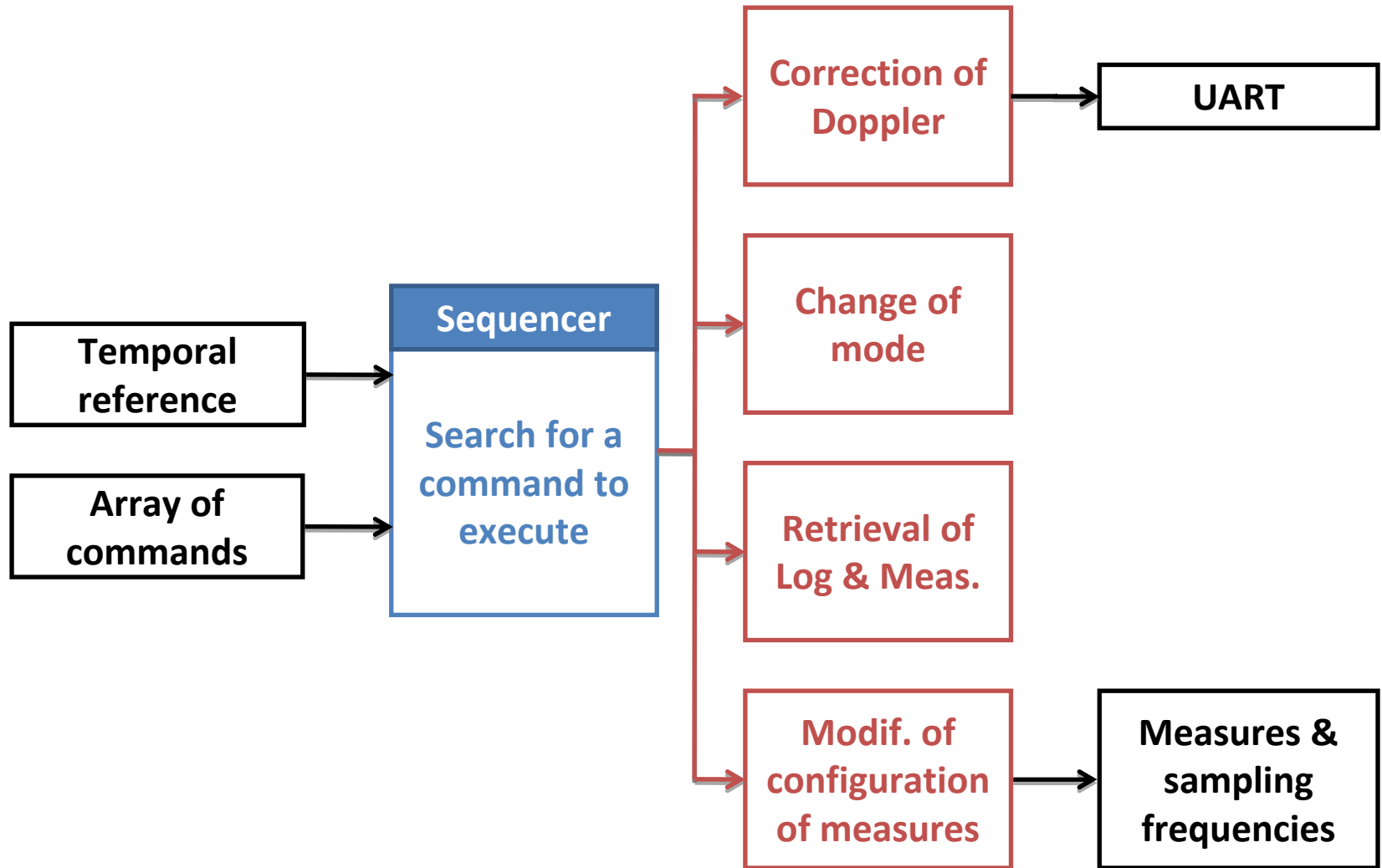
OBC - Software organization



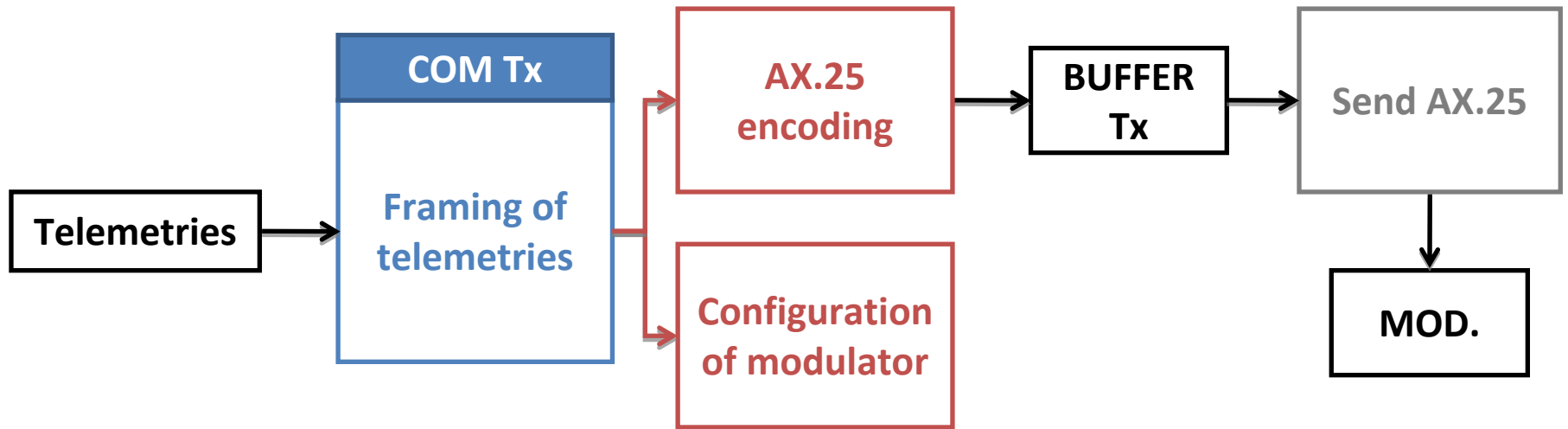
OBC - COM Rx module

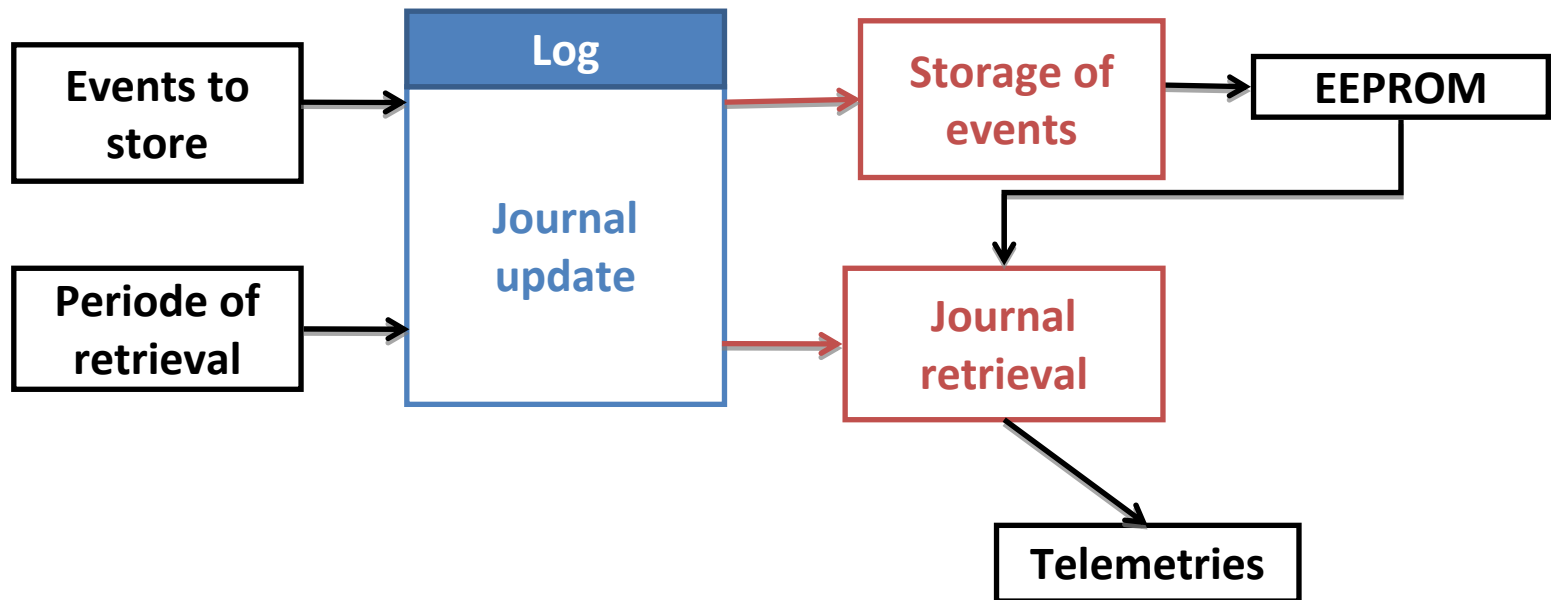


OBC - Sequencer module

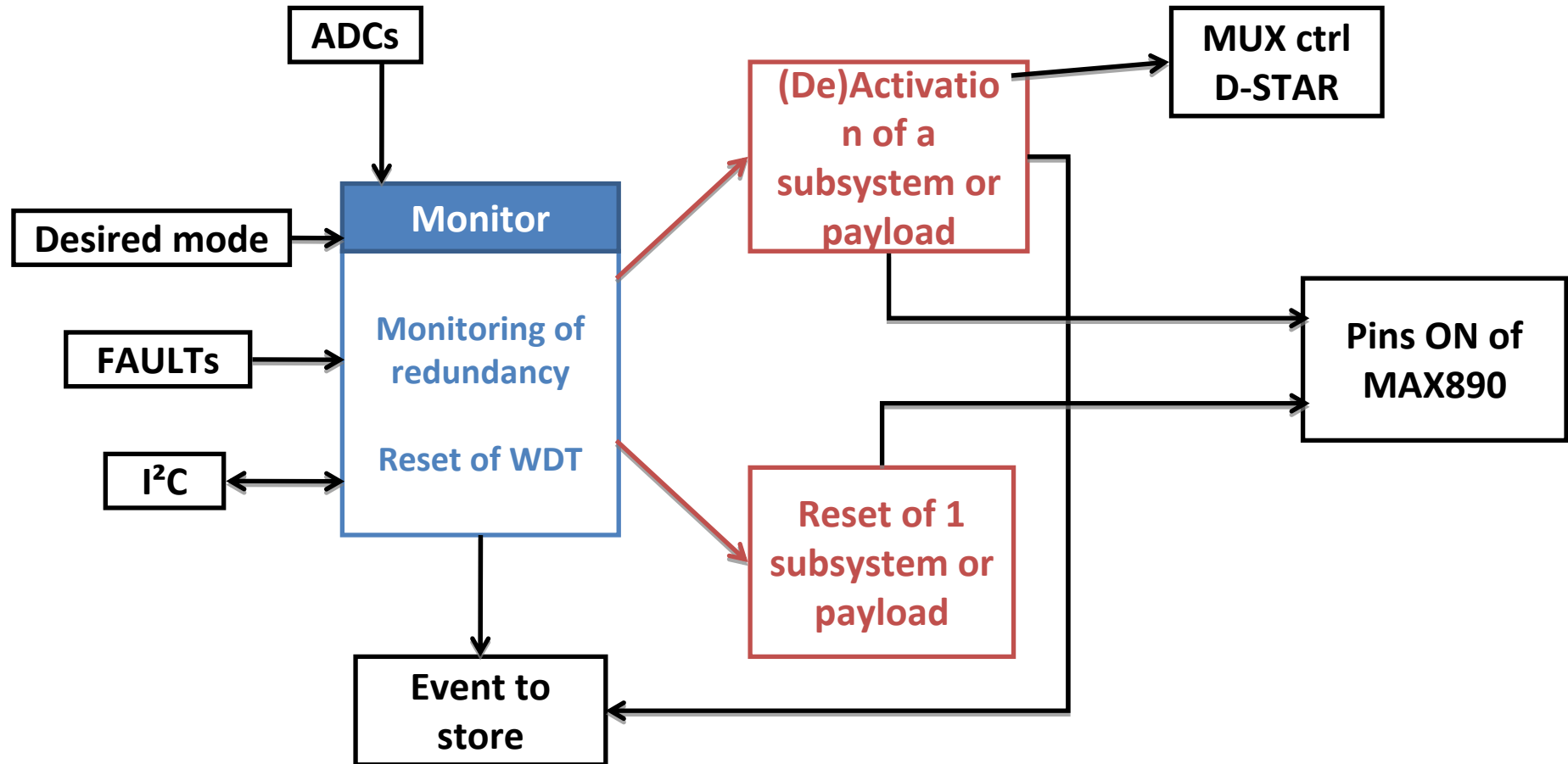


OBC - COM Tx module

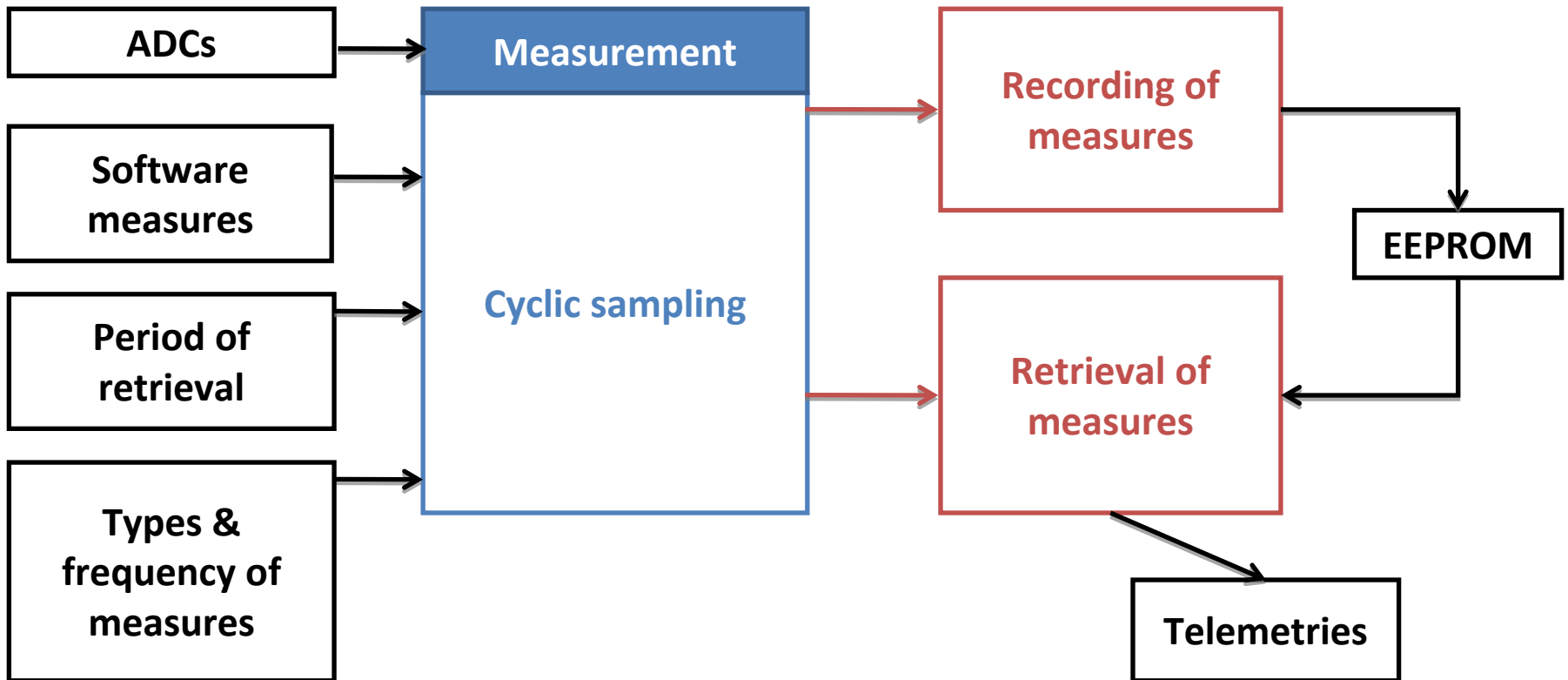




OBC - Monitor module

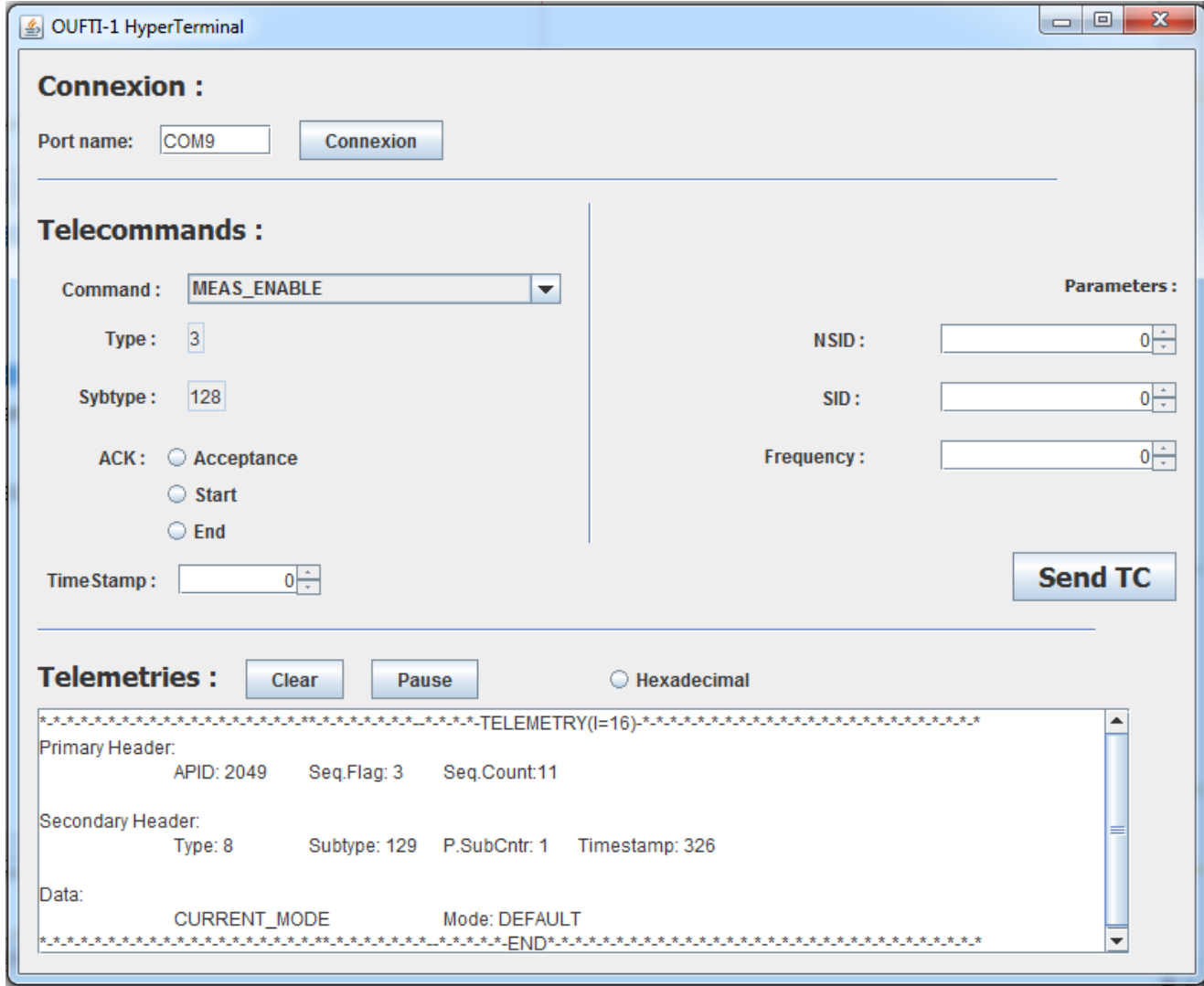


OBC - Measurement module



OBC - Test method

OUFTI-1 HyperTerminal application:



OUFTI-1 HyperTerminal

Connexion :
 Port name:

Telecommands :

Command:
 Type:
 Sybtype:

Parameters:

NSID:
 SID:
 Frequency:

ACK: Acceptance
 Start
 End

TimeStamp:

Telemetries : Hexadecimal

```

*****-TELEMETRY(l=16)-*****
Primary Header:
      APID: 2049   Seq.Flag: 3   Seq.Count:11
Secondary Header:
      Type: 8     Subtype: 129   P.SubCntr: 1   Timestamp: 326
Data:
      CURRENT_MODE      Mode: DEFAULT
*****-END*****
  
```

1. The OUFTI-1 project
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 - **THER: Thermal Control System**
 - VIB
 - HAM
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TCS:

- Mostly passive
- Active TCS for the batteries

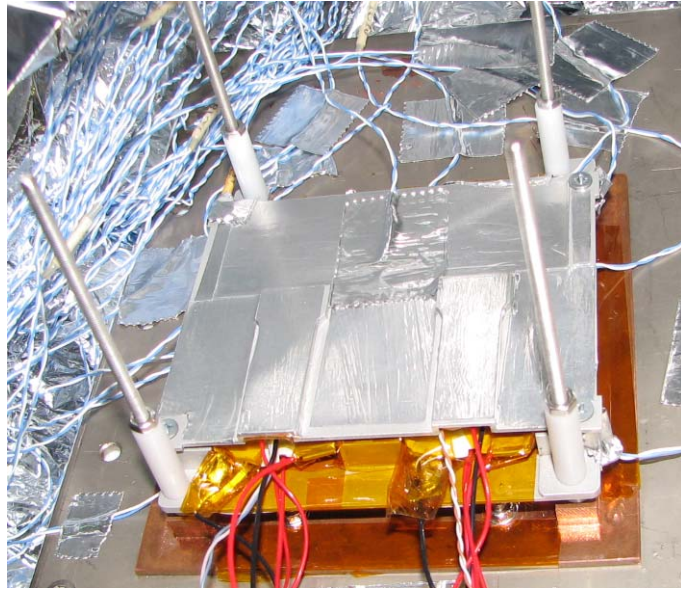
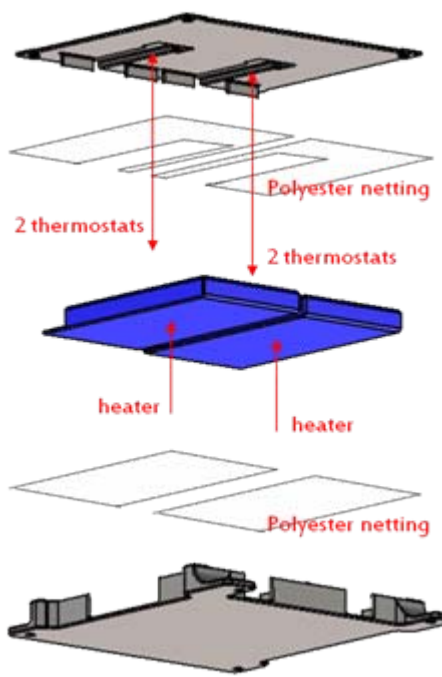
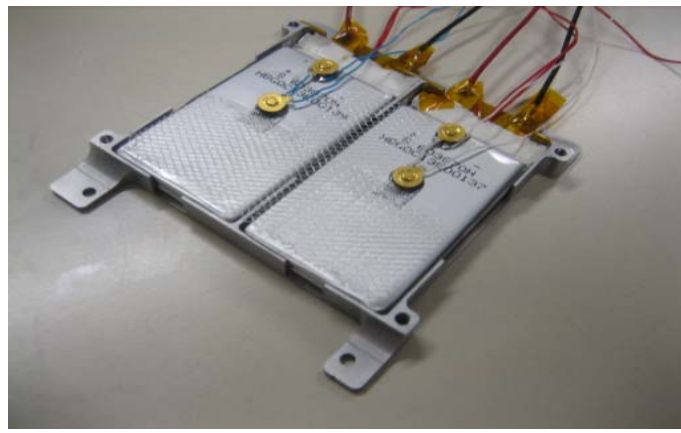
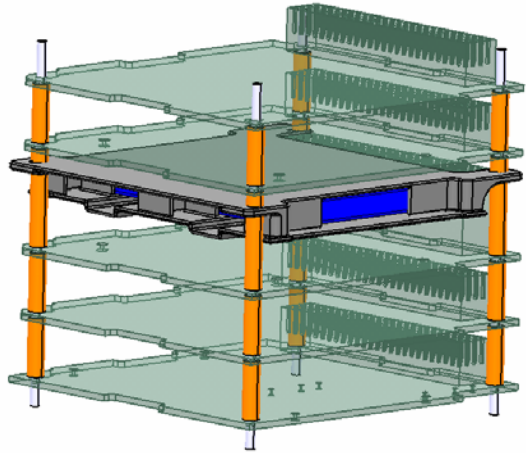
THERMAL ISSUES:

- Low temperature of the batteries ($\cong -15^{\circ}\text{C}$)
- Detrimental dissipation of the EPS transistor ($\cong 5.5\text{W}$)
- Hotspot COM amplifier ($\cong 80^{\circ}\text{C}$)

PROPOSED SOLUTIONS:

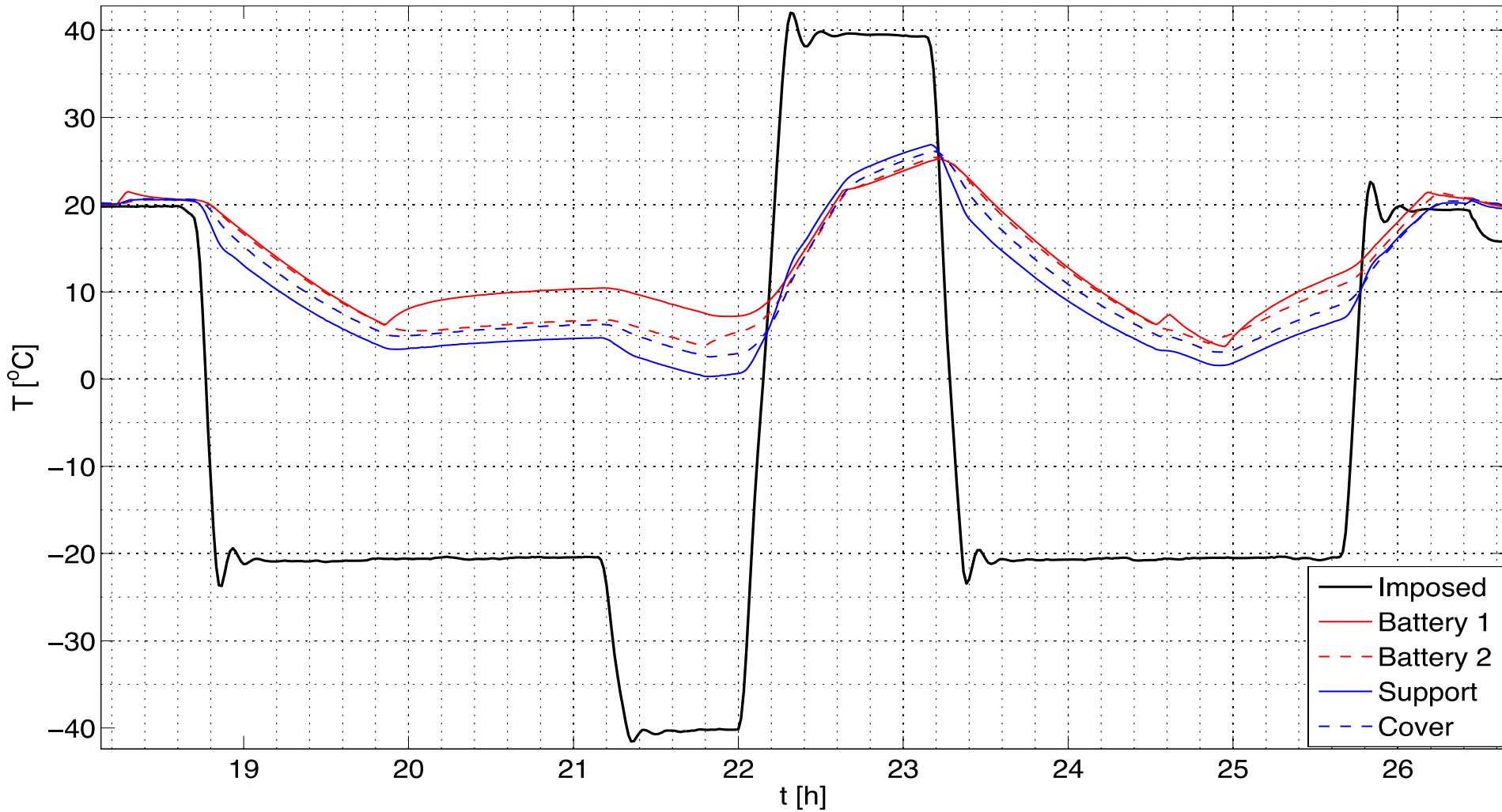
- Heaters + Thermostats + Insulation
- Partial shunt of the power + Strap
- Still unsolved

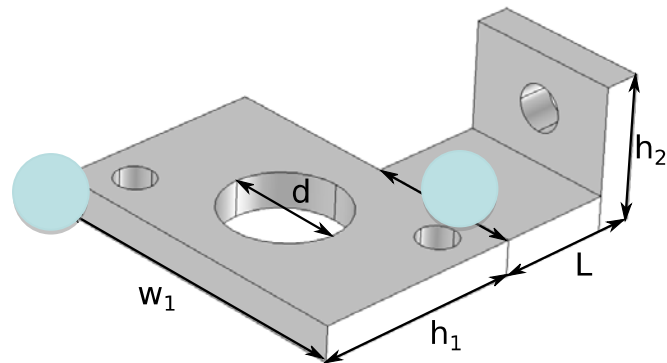
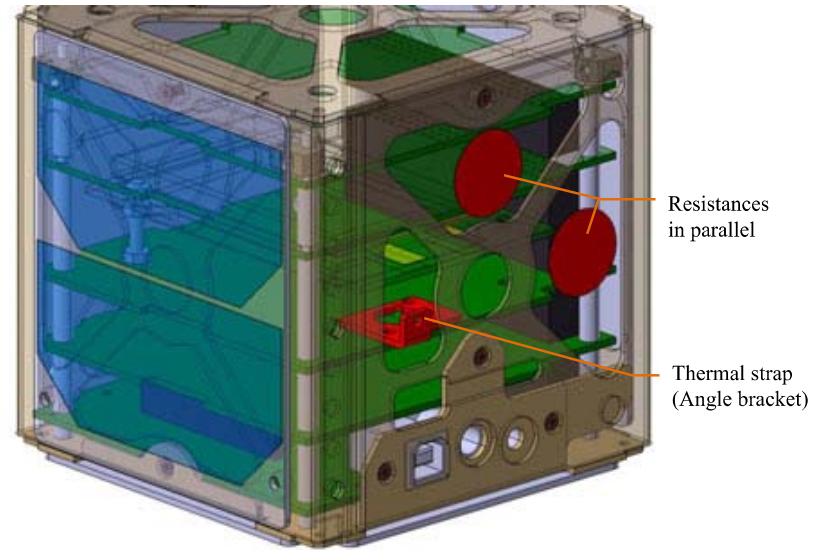
THER – Batteries TCS



THER – Results of the test

Experimental Temperatures



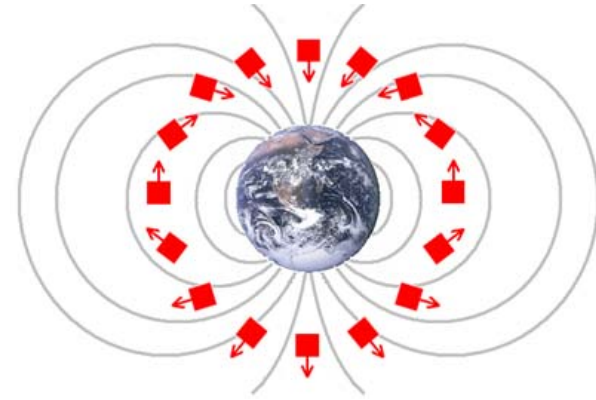
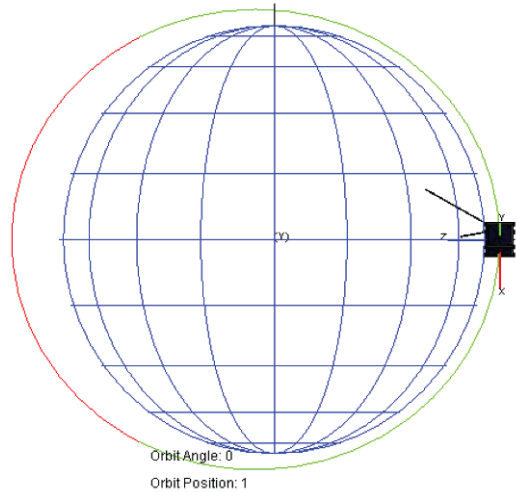
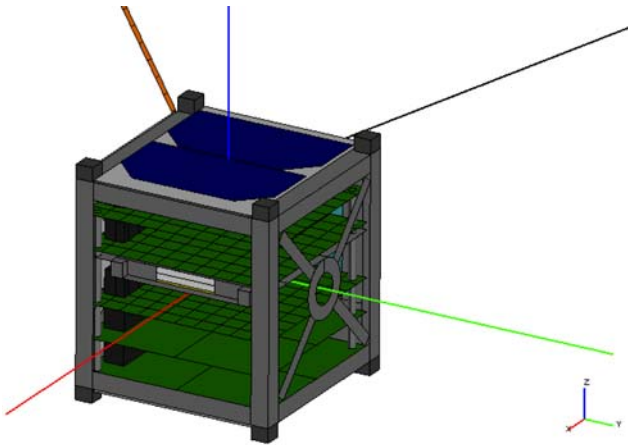


$$\min_{t, w_2}(M)$$

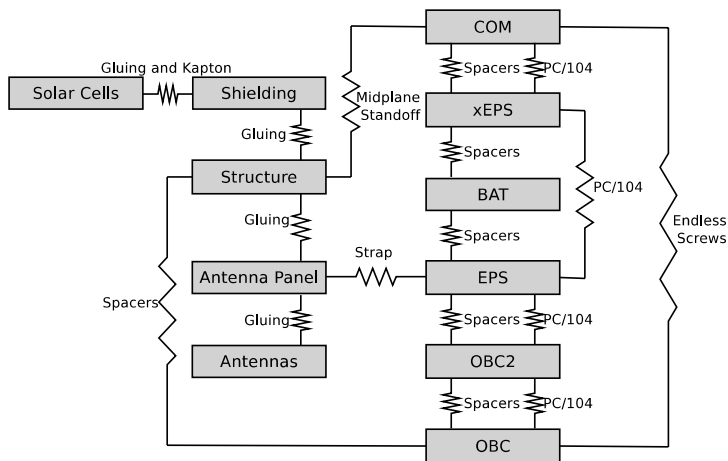
$$\text{with} \left\{ \begin{array}{l} GL(t, w_2) \geq GL_{\min} \\ w_2 \leq 8\text{mm} \\ w_2 \geq 0 \\ t \geq 0 \end{array} \right.$$

THER – Numerical model

- Geometrical Mathematical Model (GMM)



- Thermal Mathematical Model (TMM)



Parameter	Case		
	Cold	Hot1	Hot2
Solar constant [$W \cdot m^{-2}$]	1322	1414	1414
Eclipse time	35'	0	0
Solar Cell Efficiency	30%	27%	27%
OBC	0	0.05	0
OBC2	0	0.05	0
EPS	0	$0.625 + P_e$	P_e
xEPS	0	0.3	0
COM Amplifier	0	1.75	0

Power [W]

OUFTI-1 thermal issues:

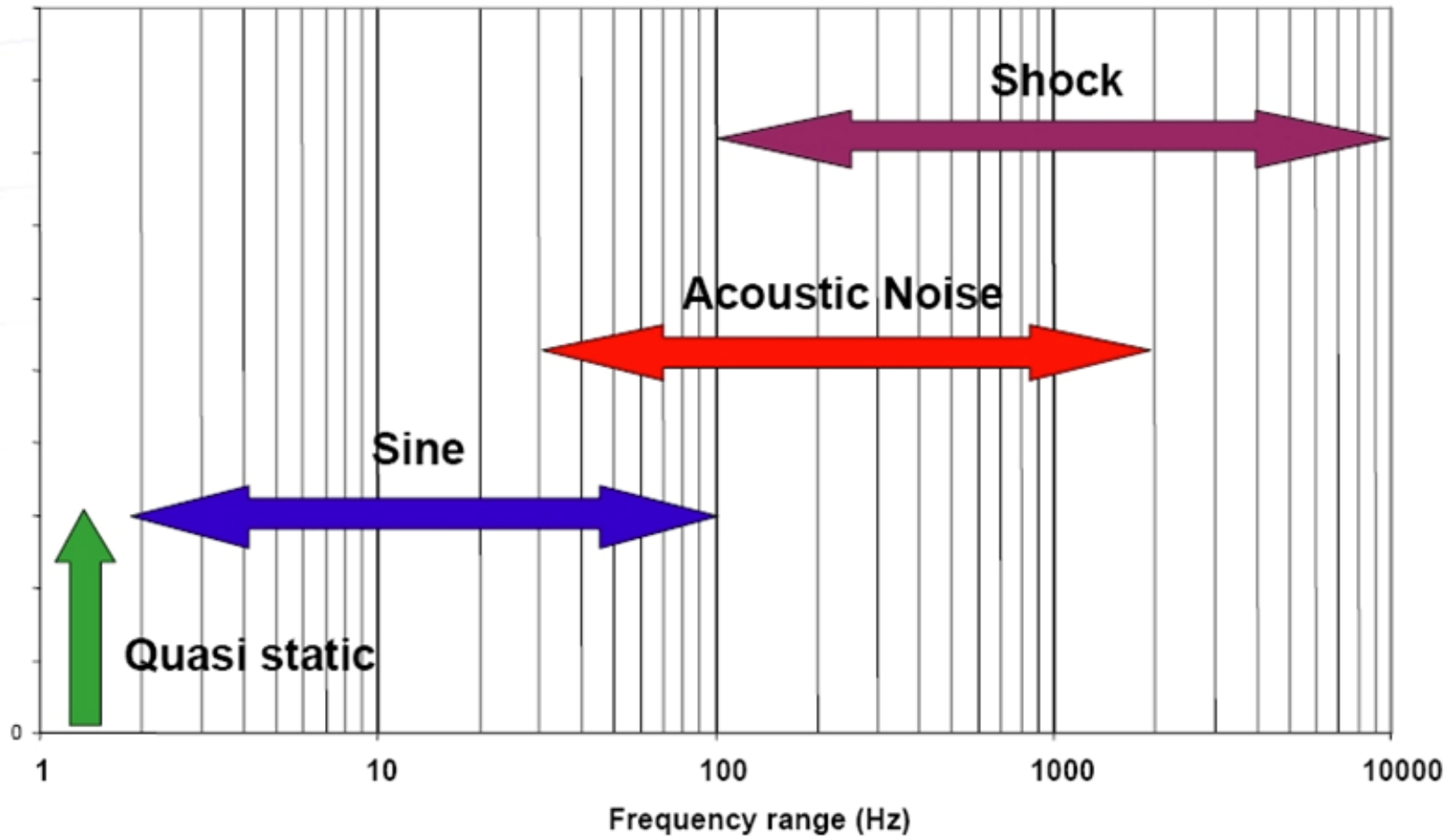
Issue	Design	Manufacturing	Validation
Batteries	✓	✓	✓
EPS Transistor	✓	x	x
COM Amplifier	x	x	x

Numerical model:

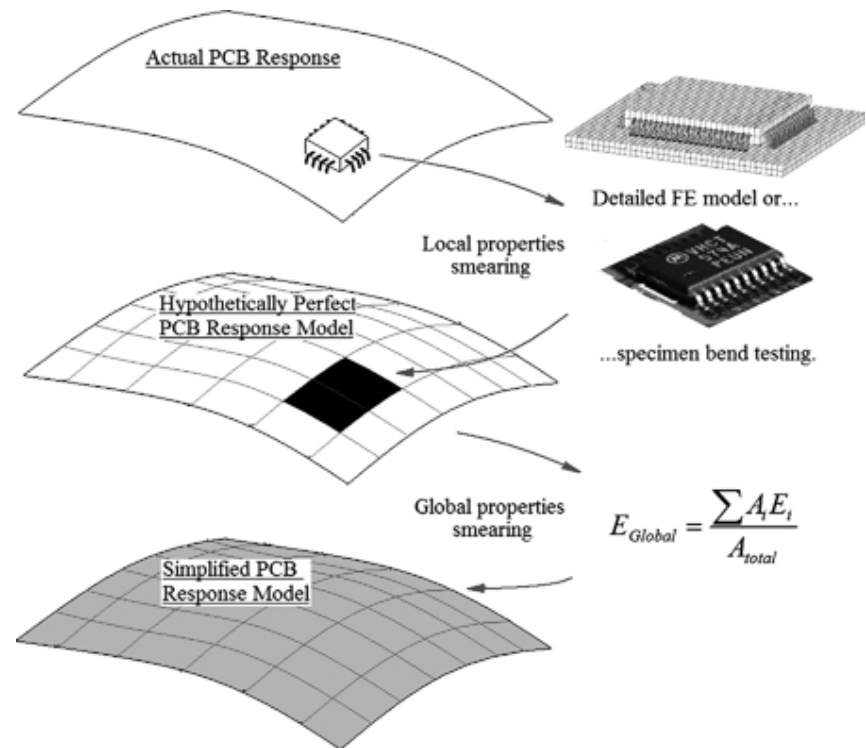
- Batteries and Transistor issues fixed
- No new issues
- Thermal design range [-40, 70]°C

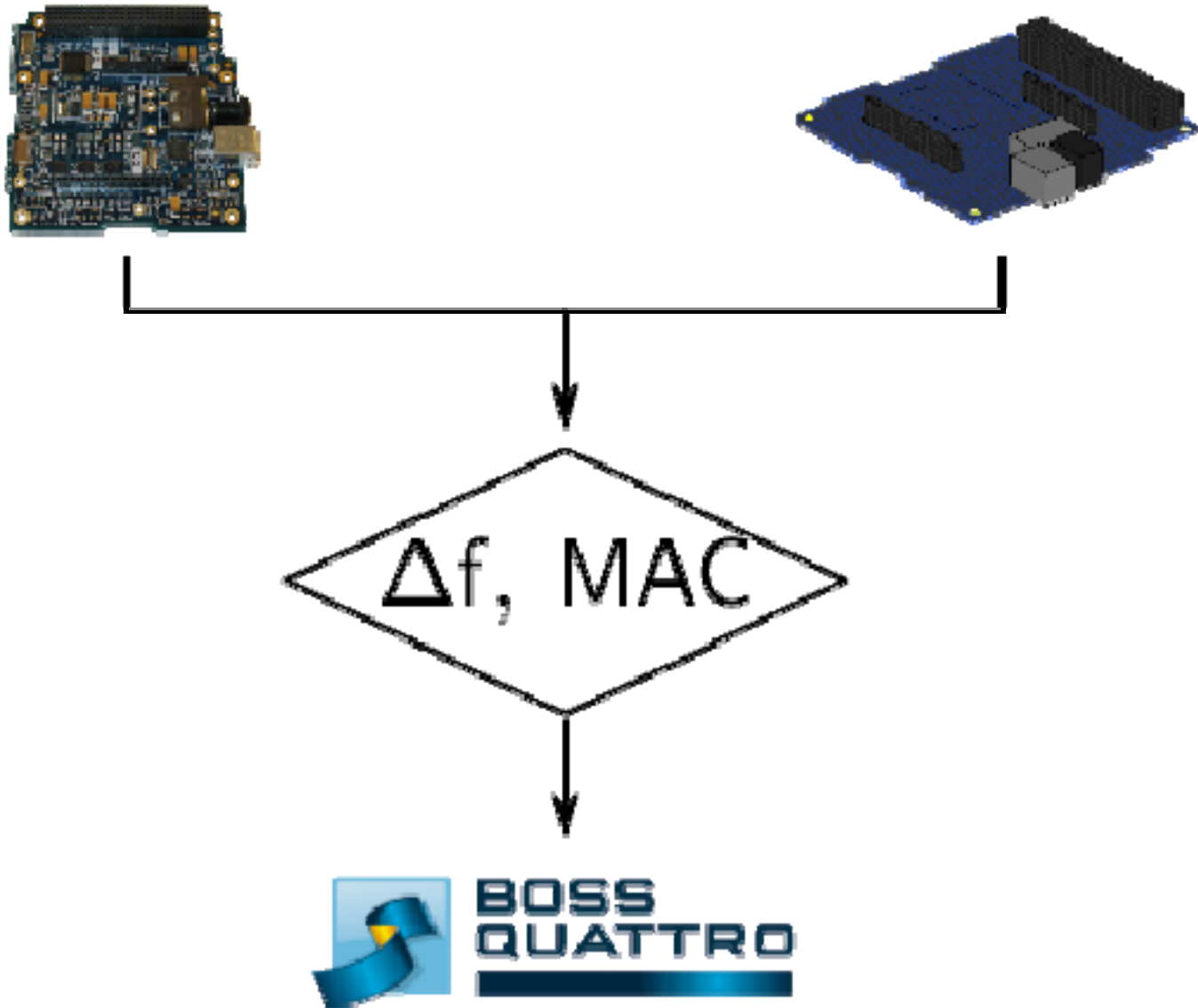
1. The OUFTI-1 project
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 - **VIB: Vibrations**
 - HAM
 - SDR
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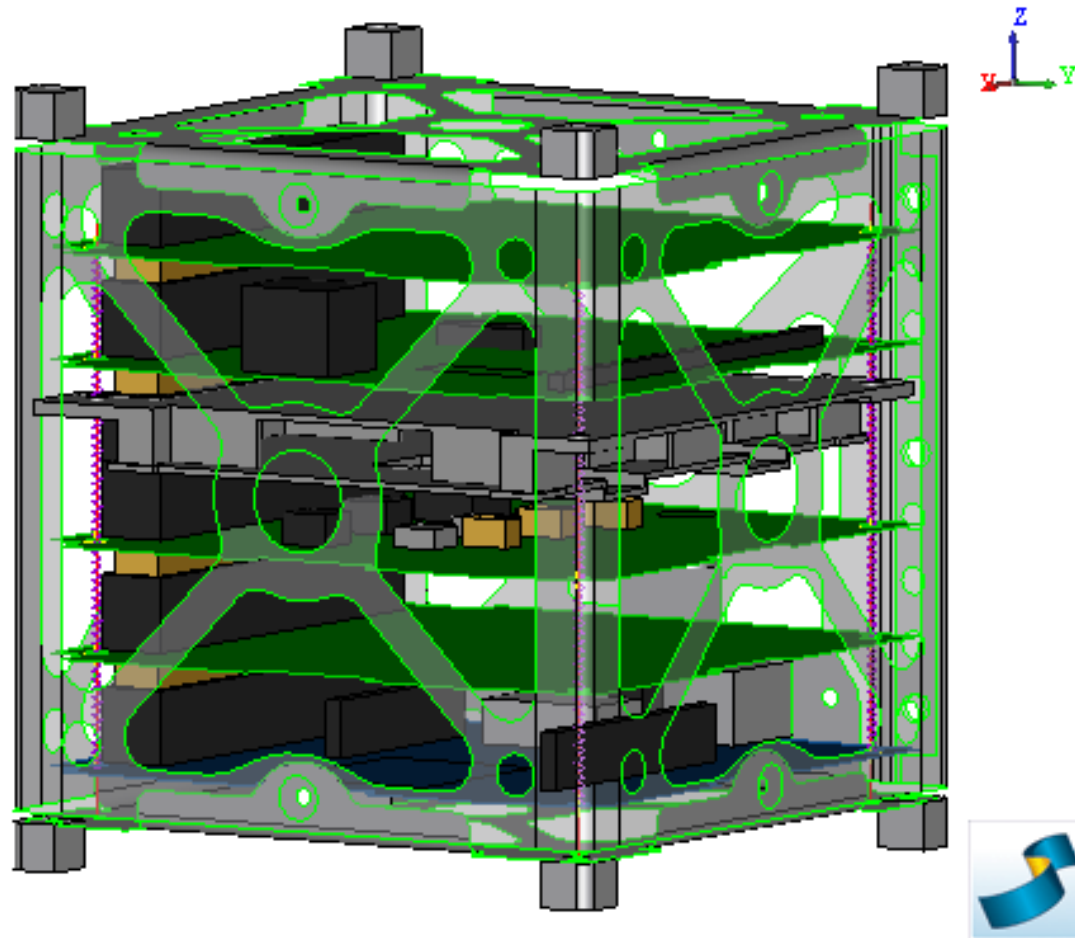
VIB - Launch environment



- Several simplification techniques:
 - Simple method
 - Global mass smearing method
 - Global mass and stiffness smearing method
 - Local smearing method







- Several analysis were performed:
 - Modal analysis
 - Fundamental frequency above the prescribed lower value
 - Quasi-static accelerations analysis
 - All margins of safety found positive
 - Sine accelerations analysis
 - All margins of safety found positive

1. The OUFTI-1 project

2. Technical status

- STRU
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- VIB
- **HAM: D-STAR on a classic ham transceiver**
- SDR

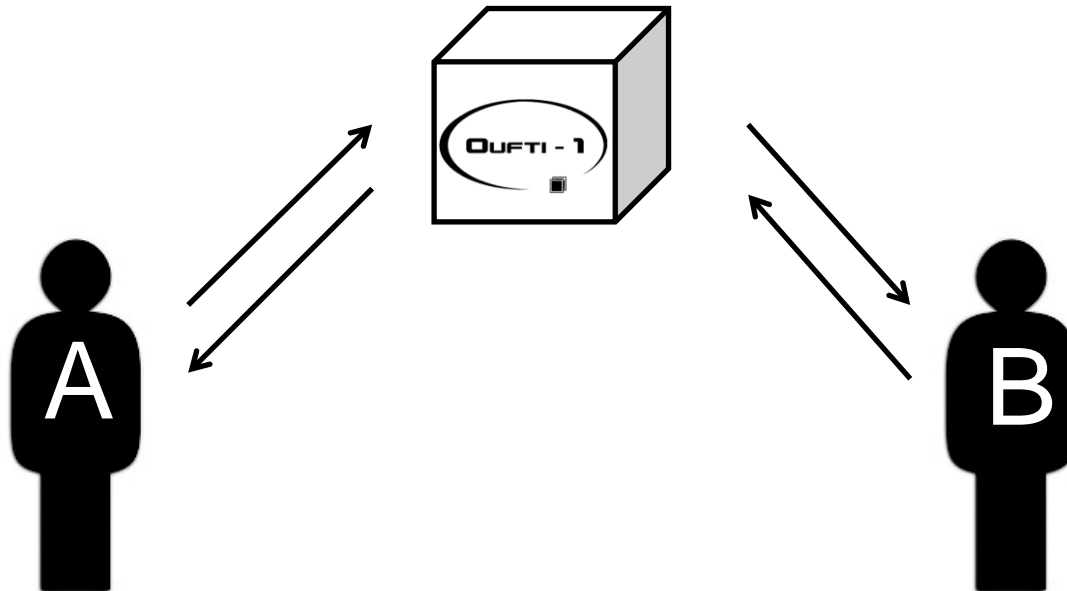
3. Design review

4. 2011-2012 schedule

5. Conclusion

→ Implementation of the D-STAR protocol on a classic ham transceiver.

- D-STAR communications through OUFTI-1



- Easy access to the spectrum
- Return to the amateur-radio community

→ Space constraints

- **Link budget**

- Power
- Error rate

- **Doppler effect:**

Frequency deviation

- 3,9 kHz for VHF
- 11,6 kHz for UHF

$$f_{\text{received}} = f_{\text{transmitted}} \sqrt{\frac{c - v}{c + v}}$$

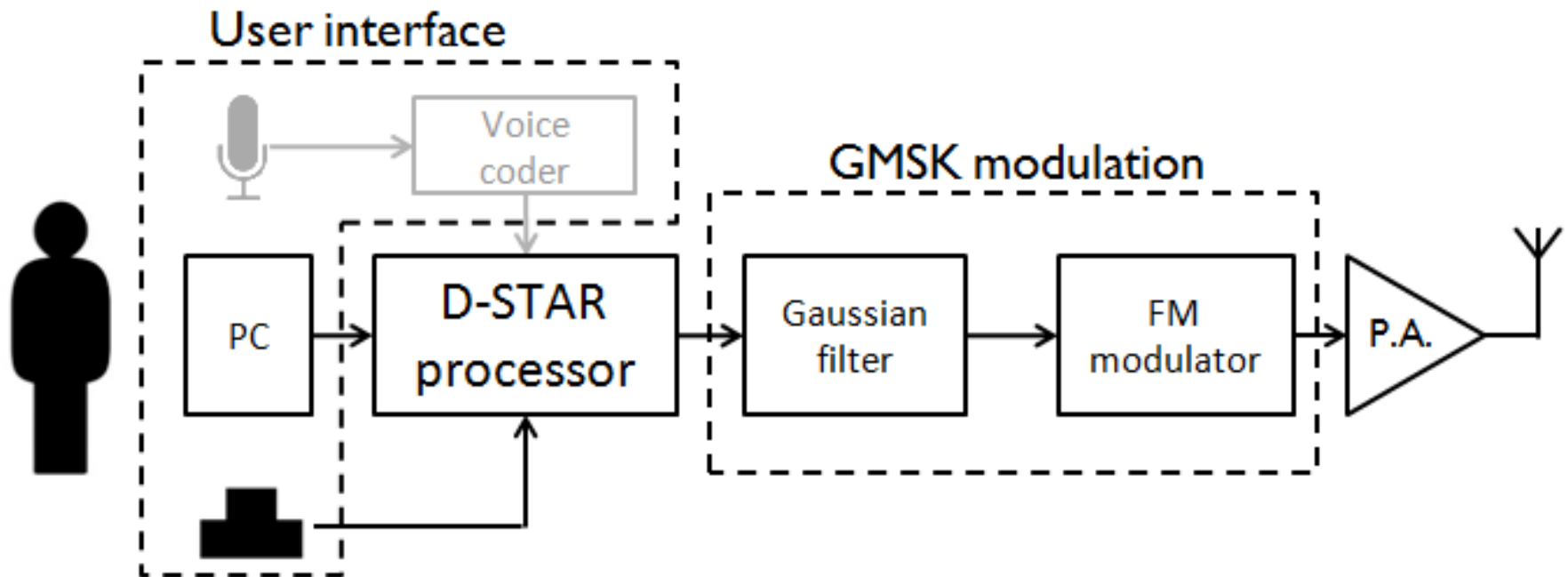
Adaptation of a dedicated D-STAR transceiver

- Step of 5kHz or 6,25kHz
- limited documentation
- Change HW and SF
- Unpractical

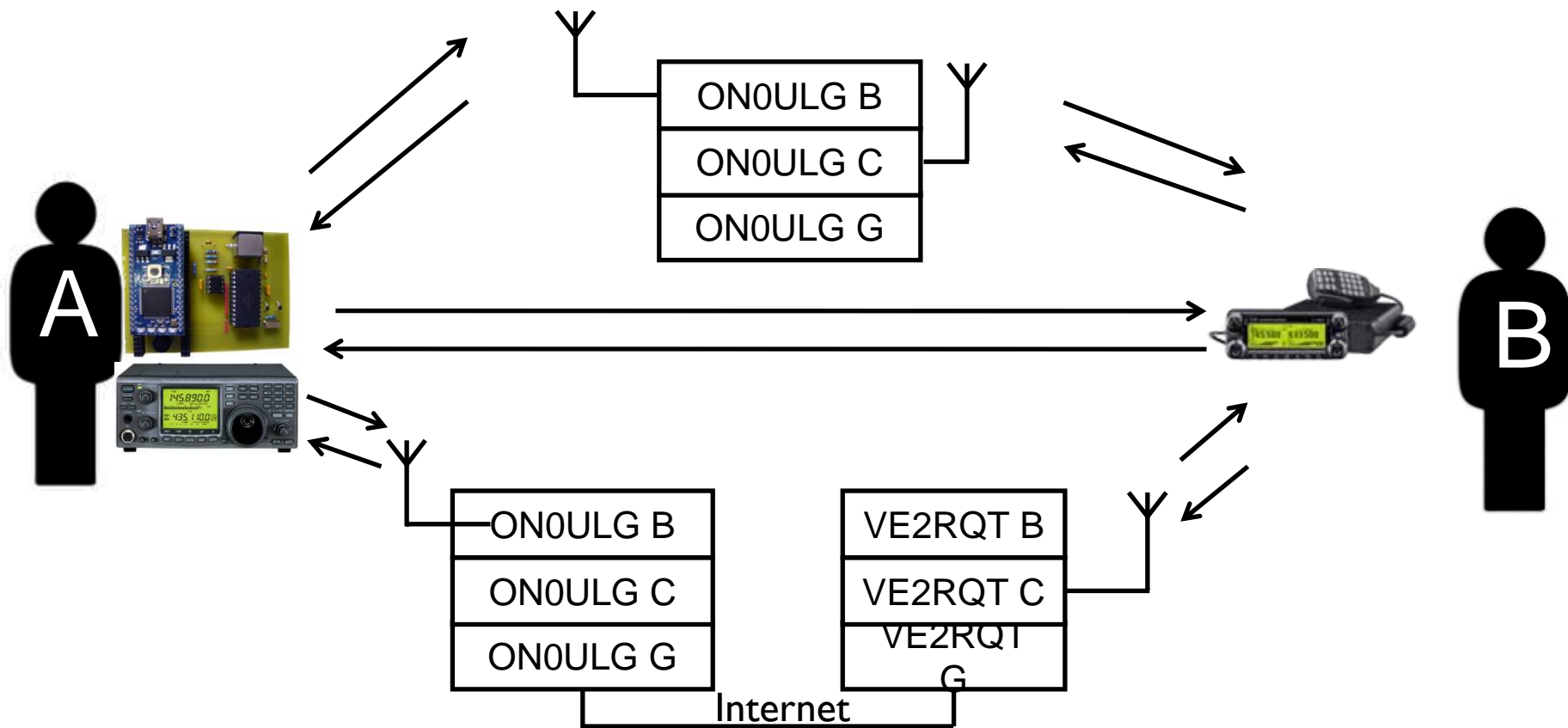
Adaptation of a classic transceiver

- Step of 0,1kHz
- D-STAR protocol well known
- External circuit
- Plug and Play

- Tx mode



HAM - Tests within the complete system



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- **SDR: Software Defined Radio**

3. Design review

4. 2011-2012 schedule

5. Conclusion

To provide knowledge on software defined radio's (SDR) for the OUFTI-1 project.

Three main points:

- SDR concept
- Demonstration of the use of an SDR for two protocols:
AX.25 and D-STAR
- Spatial constraints

- Data conversion
- Radio tasks defined in software
- Flexibility
- Reprogrammability

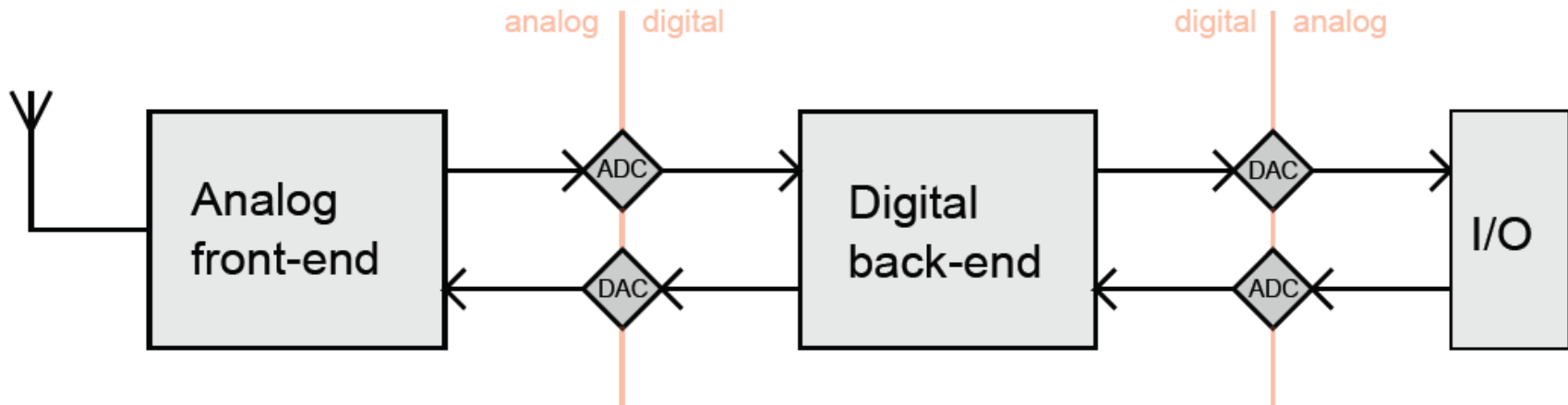


Figure: Typical block-diagram of an SDR.

USRP (Frequency conversion) + PC (Baseband digital signal processing)

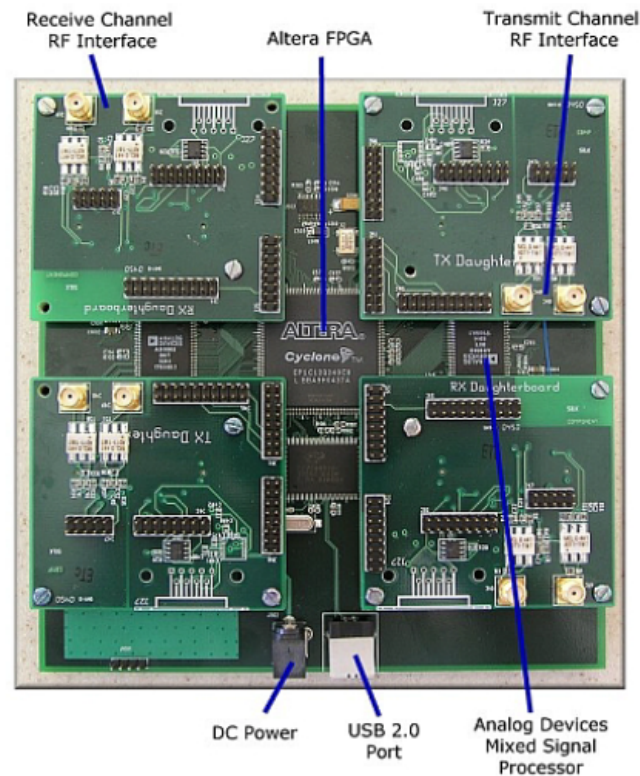


Figure: USRP motherboard hosting four daughterboards.

- Encoding/Decoding routines
- Baseband modulators/demodulators (GMSK, 2-FSK, and FM)
- Results (demonstration)

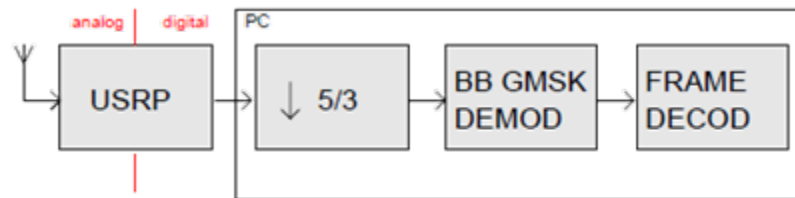


Figure: SDR D-STAR receiver.

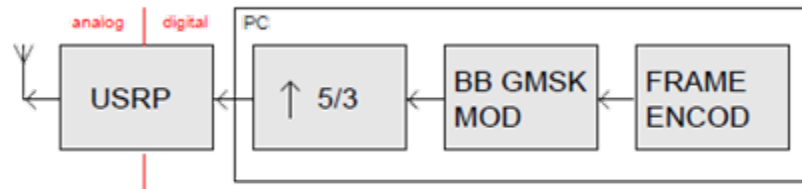


Figure: SDR D-STAR transmitter.

Constraints:

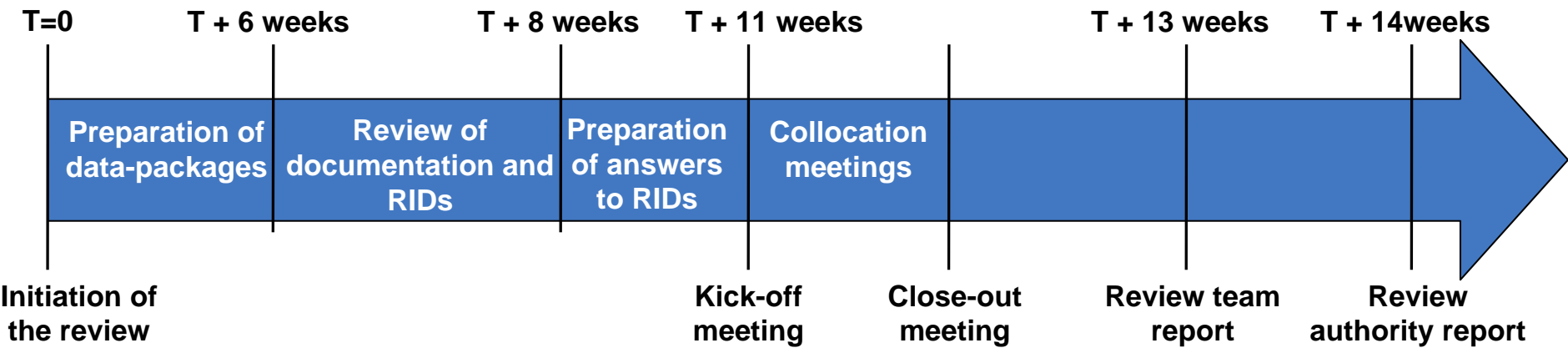
- Size, weight
- Power consumption
- Radiations
- Reconfiguration strategy
- Doppler correction



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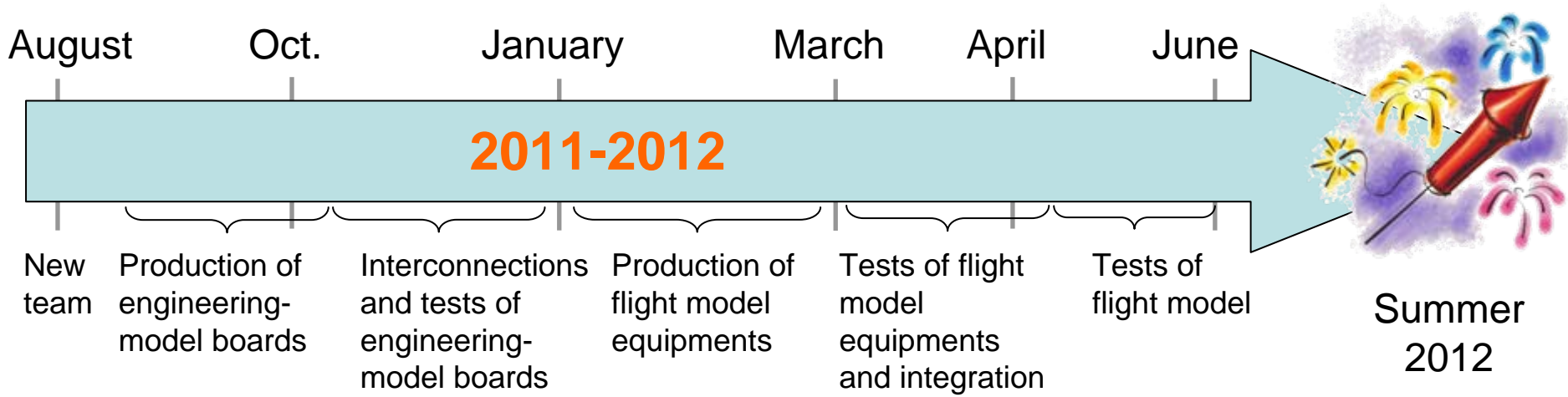
Design Review (Feb.-May 2011)

- Based on ECSS standard
- 14-week long
- External experts (CSL, Thales, Spacebel, ...)
- Weekend of work and meetings at EuroSpace Center (Redu)



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4. 2011-2012 schedule



5. Conclusion

- Design almost completed
- High technical complexity
- Strongly motivated team
- Professional approach
- Ambitious schedule





www.oufti.ulg.ac.be



Thank you for your attention !

