Modular SDR platform for high performance space missions

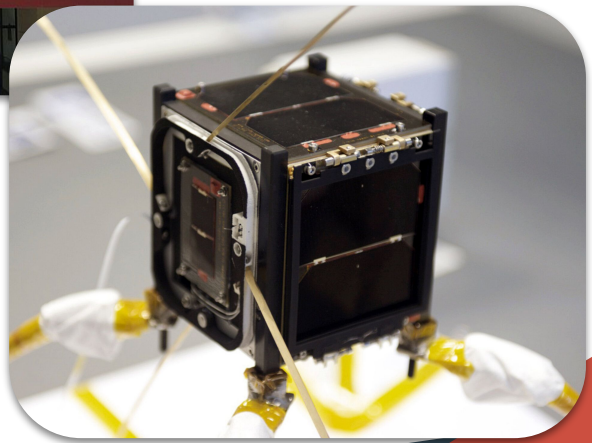
Introduction

Telecommunications engineer from University of Vigo

Electronics area manager at Alén Space

Core team of telecommunications engineers from University of Vigo

Responsible for the design of the **first spanish nanosatellite: XatCobeo**



Alén Space now

Vigo, (Spain) headquarters

+40

people in the team

Clean room

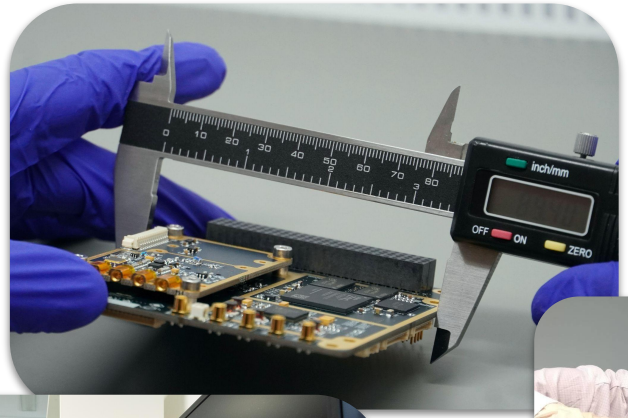
- ISO 7
- 38 m^2

Ground Station for operations

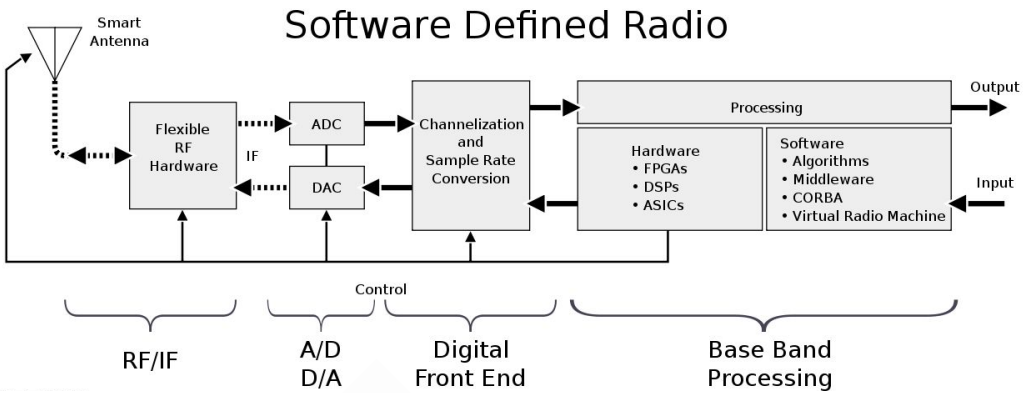
- UHF half duplex circular polarization
- Full duplex S-Band
  - TX 2.025 GHz - 2.110 GHz
  - RX 2.2 - 2.29 GHz

What we do

- **Communication solutions**: design and manufacture
  - SDRs, payloads, OBC/TTC, ground segment equipment...
- **Platform** integration:
  - 1U, 2U, 3U, 6U...
- Full **missions**:
  - From phase 0 to operations



The beauty of SDRs



- Replace traditional analog components by software elements
  - ADC/DACs as close as possible to the antenna
- Once in digital domain, you can do "mostly everything" with software or hardware (FPGA) algorithms

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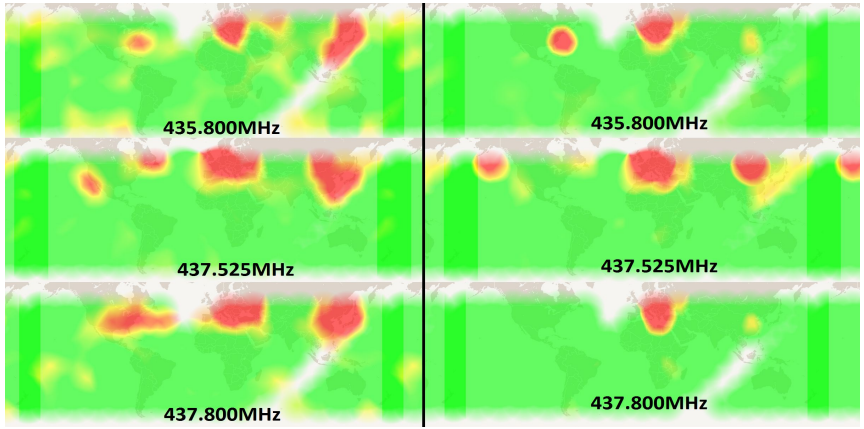
Serpens mission (2015)

IoT/M2M **payload** (437 MHz)

Environmental data **sensors**: Europe, America and Antarctica

... Strong interference over Europe



- Better performance in **southern hemisphere**
- **spectrum monitoring** campaign
- Interference **geolocation campaign**

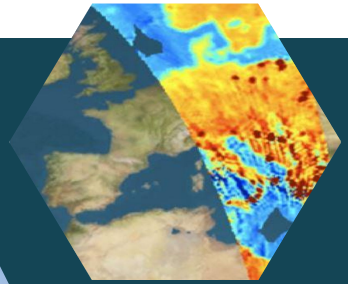
... we need a better communications payload

TOTEM SDR

- **Zynq-7000 SoC** + Wideband transceiver
  - Tuning range: 70MHz - 6 GHz
- Multiple RF ports: x3 RX and x2 TX
- 4Gb ECC RAM
- Embedded **Linux**
- **CCSDS** Packet Utilization Standard support layer
- Radio applications / waveforms development
  - **GNURadio** support

ADS-B receiver

AIS receiver



Spectrum monitoring

IoT communications

DVB-S2 transmitter

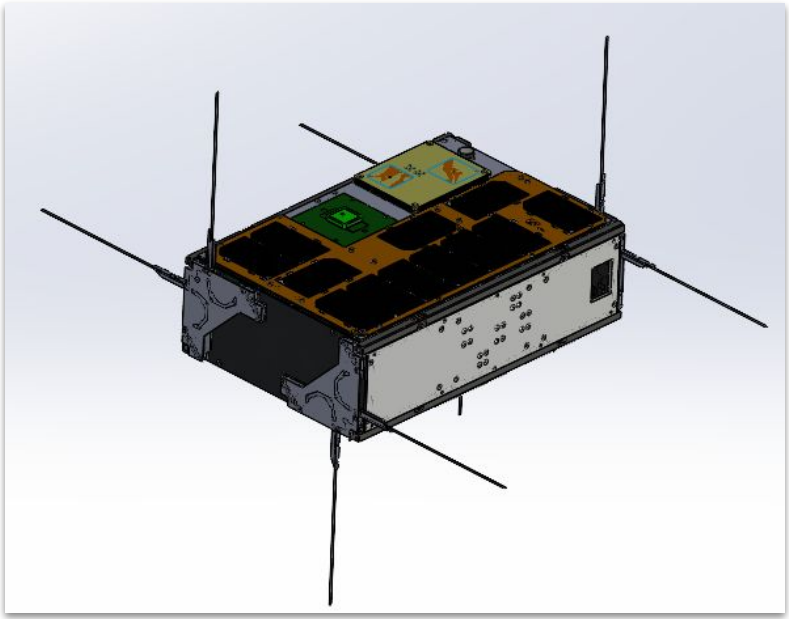
New platform → new payloads

Cubesat missions are more ambitious

- Bigger platforms and constellation
- Pointing accuracy, propulsion, flight formation...
- Enhanced payloads
    - In orbit updates, multiapp, etc

New SDR payload for new needs

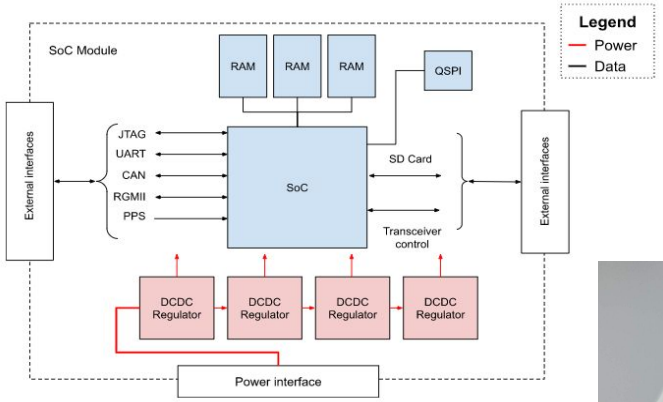
- Modular and flexible → Adapt more easily to mission needs
- Enhanced interfaces → Platform, ground testing
- Compact design
- New RF frontends
- Heritage and **know-how** with SDRs



TREVO

- **Zynq UltraScale+** family + Wideband TRXs
- **Multicore** processing and FPGA flexibility
- Interfaces: CAN, UART, I2C, GPIOs, 1000 Base-T for SoCs...
- Mass **storage**: 2x microSD slots
- 4GB DDR4 RAM
- TREVO control software
  - Set of services to operate the payload based on PUS
- Embedded **Linux**
- SKD based on **Yocto**
  - Base layer from Alén Space that provides support for our boards
  - Additional package definitions: libiio, libad9361-iio, soapysdr, etc.
- Radio applications / waveforms development
  - **GNURadio** support

TREVO - Architecture

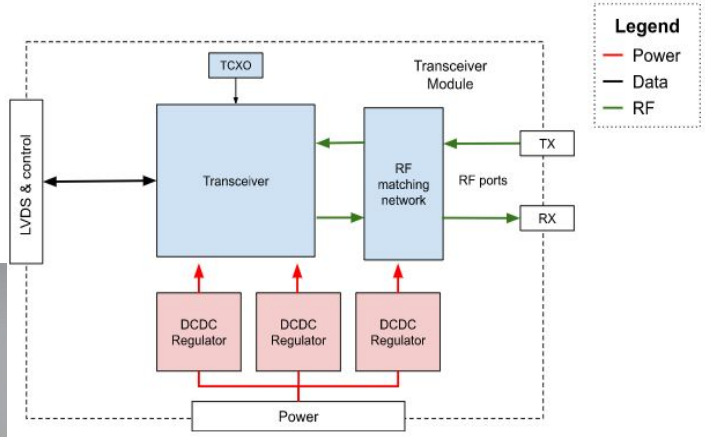


SoC

- SoC with TRX interface (LVDS)
- Housekeeping
- SD, UART, CAN, I2C, PPS, RGMII

Motherboard

- Power distribution
- Monitoring (HK)
- Umbilical
- Frontends control



TRX

- x2 simultaneous TX & RX ports
- RX matching network to specific freqs.
- Housekeeping

Typical configurations

- x1 SoC + x1 TRX or x2 SoC + x2 TRX
- x1 SoC + x3 TRX

Developing radio applications

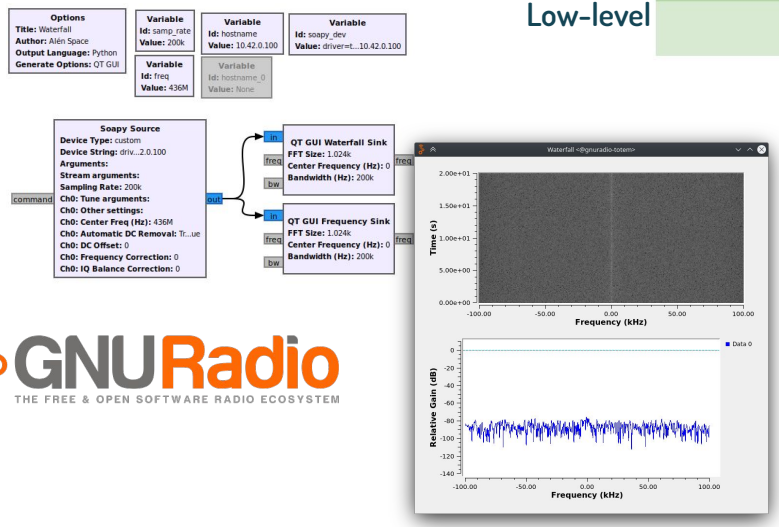
Software

Applications run by software
Different “entry” levels for TRX

Easiest — GNURadio sink/source

SoapySDR module

Low-level — libiio



GNURadio
THE FREE & OPEN SOFTWARE RADIO ECOSYSTEM

FPGA

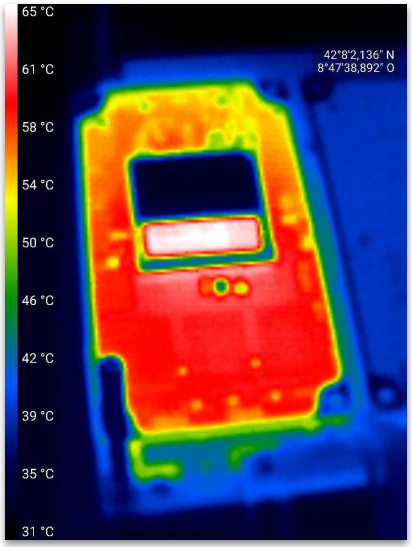
- For applications with high bandwidth requirements, part or most of the signal processing can be moved to the programmable section (FPGA) of the device.
- Algorithms accelerated by hardware

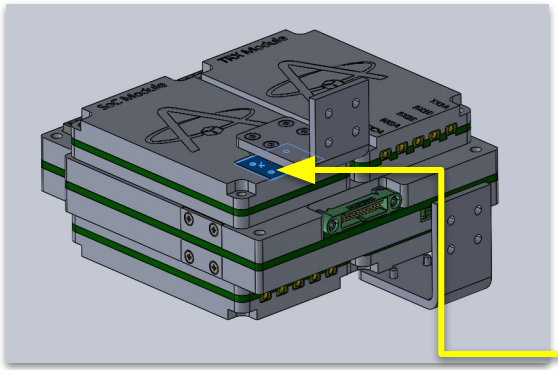
VIVADO®

A great power comes ... with lot of heat

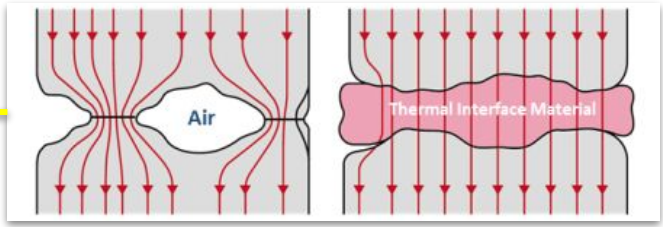
Depending on **the final use of the SoC**, the power consumption and power dissipation may vary a lot.

The main challenge is to **evacuate heat under vacuum conditions**. Thermal fillers are therefore used to improve heat conduction to the outside of the equipment, and radiators are used to dissipate heat away from the platform.





- Use of **thermal fillers** between ICs-shielding and shielding-thermal straps
  - Cho-TERM / Indium foil
- **External radiator**
  - Especially critical **with RF frontends**

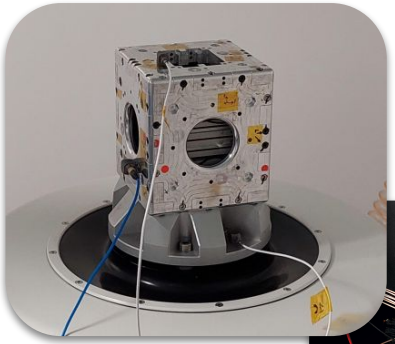


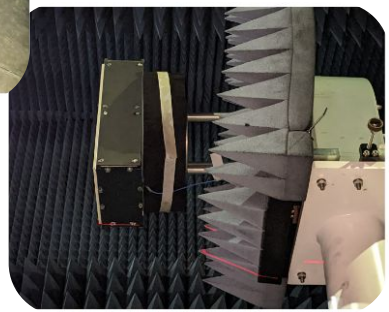
Thermo-vacuum tests are required to correlate the thermal analysis.

Testing the payload

Vibration

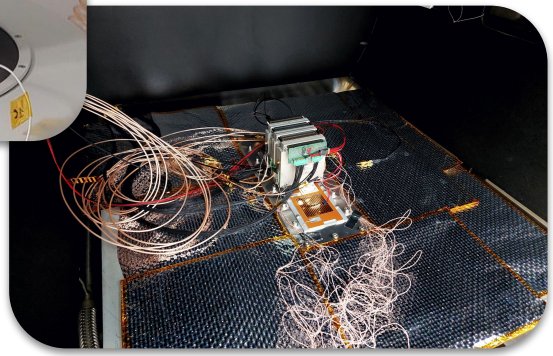
- Acceleration (quasi-static) test
- Sine vibration test
- Random vibration





EMC

- Conducted & Radiated
- Immunity (internal and external)
- Noise floor



Thermal tests

- Thermal cycling test
- Thermal vacuum test
- Thermal balance test

Real use cases

- **Sateliot** payload for 5G NB-IoT
  - World's first 5G NB-IoT LEO Satellite (under commissioning)
  - One **payload** with x2 SoC - x2 TRX
    - **TREVO Feeder link** S-band (CCSDS Modem) →modem following certain subset of standards from CCSDS and encapsulating IPv4 traffic over CCSDS

- Alén Space 6U cubesat → **Satmar**
  - **VDES payload**
    - New maritime communication standard
  - **Spectrum monitoring**
    - UHF and L-band
- Other companies
  - **ADS-B payload**
  - **TREVO Feeder link**

Future challenges

- Keep **working closely with our customers** to understand their needs
  - Product improvement
- **Adapt quickly** to their needs
  - Not easy in the new space era (quick, fast and cheap), while keeping high quality standards
- **Shortage** stock, logistics ...
  - Involved local suppliers is key for success
- **Improve product** documentation and **support**
  - SDRs are attractive but also overwhelming for some users

Thank you