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ISTNanosat

The "glue" project that seeks to foster the enthusiasm of IST students for space science and technology

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Overview

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Road to the ISTnanosat Project

- IST – AMRAD/AMSAT-CT consortium (2009)
- Aerospace, Telecommunications (e.g. Satellite communications), Electronics, Computer Engineering education
- A lot of useful knowledge from Amateur Radio activities and
- Experience with past projects most in the European context
- Tracking facilities - CS5CEP (Portuguese Space Centre) located at IST – Taguspark campus

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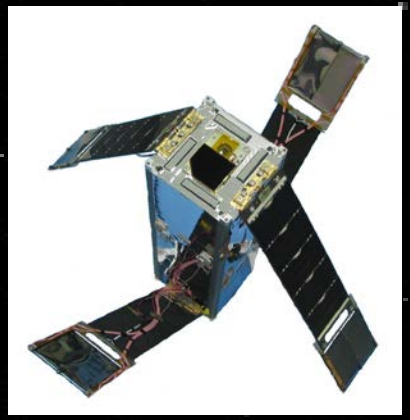
Road to the ISTnanosat Project

- Start tracking satellites and serving as relay station (telemetry) for Cubesat missions (e.g. Delfi-C3)
- Why not tracking our own satellite?
  - ISTnanosat project was born (2011)
    - Motivation: enhance the hands-on experience on emergent space technologies



CS5CEP

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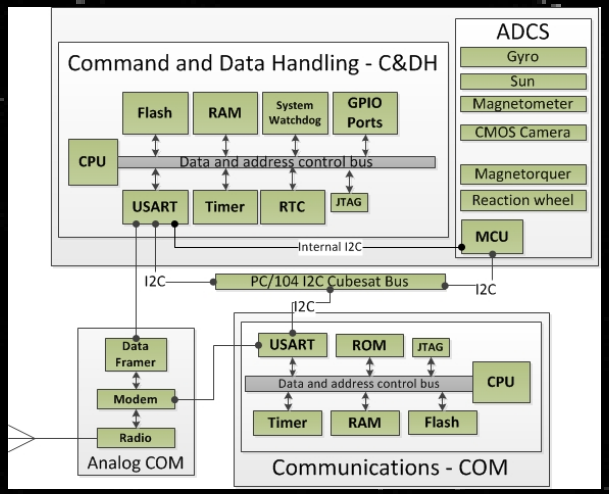
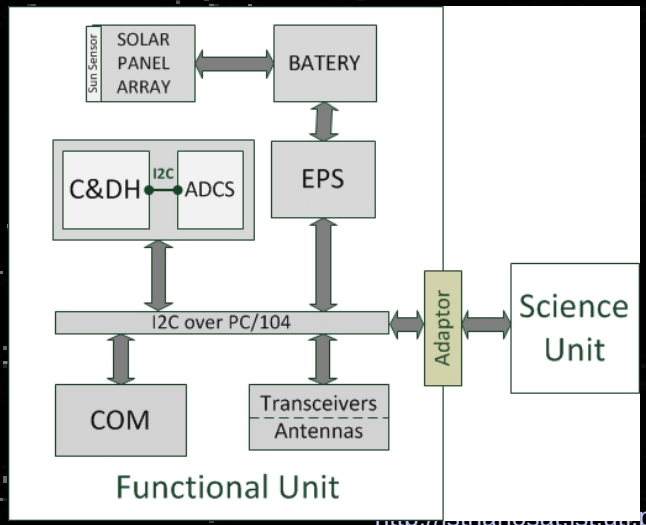
ISTnanosat Project

- First Approach
  - 2U CubeSat (1U Flight Unit+ 1U Scientific experiment)
  - Flight unit - study and test new communication digital protocols which allow an efficient way of:
    - i) Tx/Rx commands; ii) Tx/Rx files; Resilient against very disruptive and asymmetric space-links
  - First module – Heart (COM + CDH)
    - Main achievements: PriSIS (T-CSP+CSP+AX.25)
  - Lessons learnt: 2U too much when funds are short and … there is no mission!





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ISTnanosat Project

- ISTnanosat-1 – the first iteration of the ISTnanosat project
  - Mission:
    - Study of flyby anomaly + space-hardened mixed-signal electronics
    - A visit to Universidad de Vigo brought us the possibility of participating in the Humsat project
  - Structure:
    - For the envisaged mission(s) a 1U Cubesat structure is sufficient
      - typical flight unit + 1 payload board is enough

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ISTnanosat Project

- IST/AMRAD(AMSAT-CT) consortium enlarged (2014) to:
  - CEIIA
    - Good R&D capabilities and large experience in aeronautics industry
    - Strategic partner of Embraer in Portugal
    - Willingness to move into Aerospace arena
  - EDISOFT
    - One of the first Portuguese companies to be involved in Aerospace
    - Large experience with European projects
    - Significant involvement with ESA

  and later …
  - D-Orbit
    - established a protocol with us for developing certain components to be used in nanosats

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ISTnanosat Project

- Such consortium aims at:
  - Enhance the quality of developed systems
  - Strengthens the interaction among partners
    - Involving aerospace professionals, students, faculty and radio amateurs
  - Provide opportunities to subsequent projects
    - Enhancing application areas where we are active or discovering new ones
    - Open space for partnerships with potential users

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ISTNanosat-1
Motivation / Missions

- Motivation and Main Mission:
  - The first and foremost mission of ISTnanosat-1 is an educational one
  - Foster students' enthusiasm for space science and technology
  - Set forth a challenging hands-on approach
    - the need to master the different phases of a space project lifecycle is by no means a minor goal
  - A crucial aspect in the development of this project:
    - designing, implementing and testing in-house all the hardware and software components needed for the spacecraft

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ISTNanosat-1
Motivation / Missions

- Missions :
  - Science unit
    - HUMSAT project
      - Participating in a cubesat constellation aiming to collect data from remote deployed sensors on Earth in a store-and-forward fashion
    - Test the behavior of mixed-signal ICs
      - Study the effects of radiation and thermal variations in space
    - Flyby anomaly
      - Study an unexpected velocity change observed in several spacecraft after their gravitational assist when passing by Earth
  - Flight unit
    - Study new digital communication protocols allowing to efficiently:
      - send and received commands
      - transmit and receive files
      - be resilient against very disruptive and asymmetric space-links

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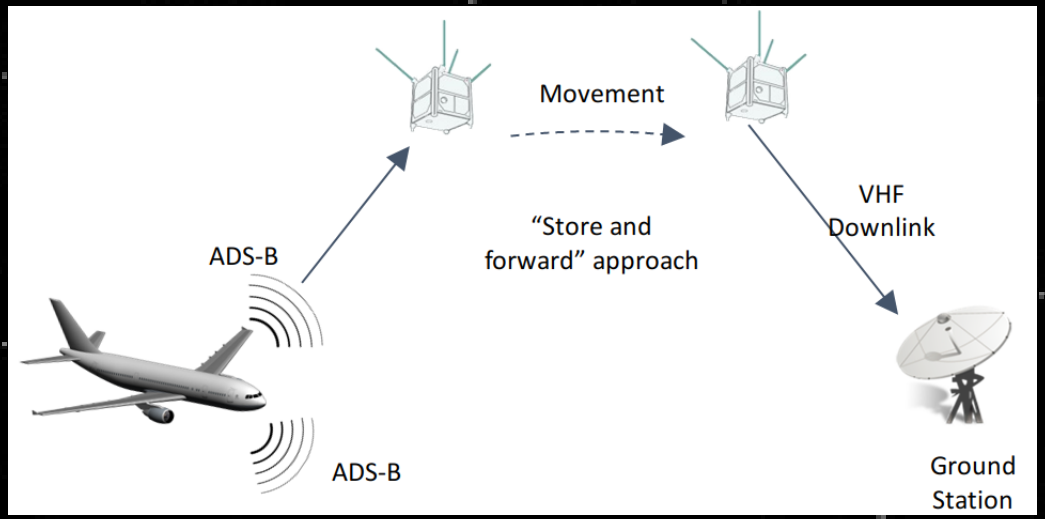
ISTNanosat-1
Missions

- But recently, when preparing submission to FYS2017 …
  - The idea of using this flight to test in orbit the ADS-B technology was brought to us.
  - Hence, this new SB-ADSB mission seeks to:
    - Assess and characterize some performance parameters and operational limitations of such system in a LEO satellite



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Technical details

- Global characteristics
- Architecture
- Functionalities

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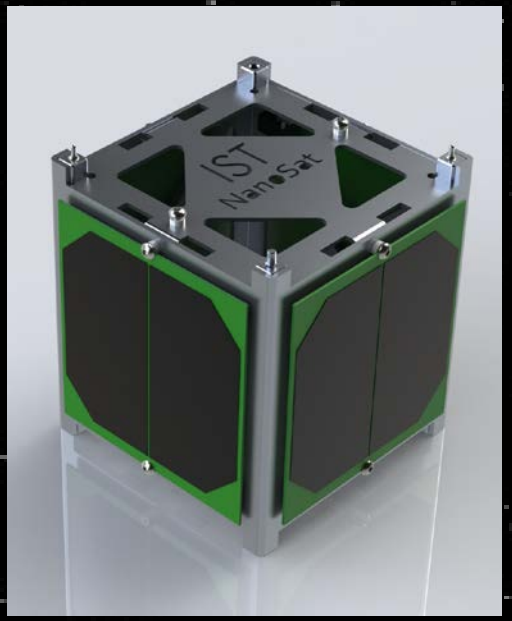
ISTNanosat-1
Global Characteristics

- 1U CubeSat (platform + payload)
- **Subsystems**:
  - OBC = OBDH(On-Board Data Handling) + ADCS (Attitude Determination and Control System)
    - Ultra low power CPU + Gyro, Accel., Magn. GPS
    - Magnetorquers (& Camera?)
  - COM (Communications)
    - Network protocol processing
  - Analogic Communications
    - Multimode modem
    - RF power amplifier
    - Antennas
  - EPS (Electrical Power System)



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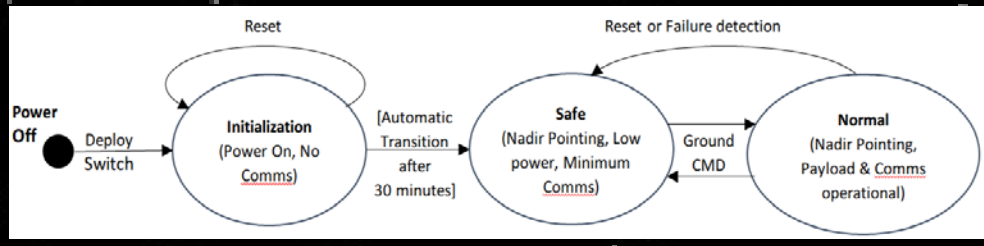
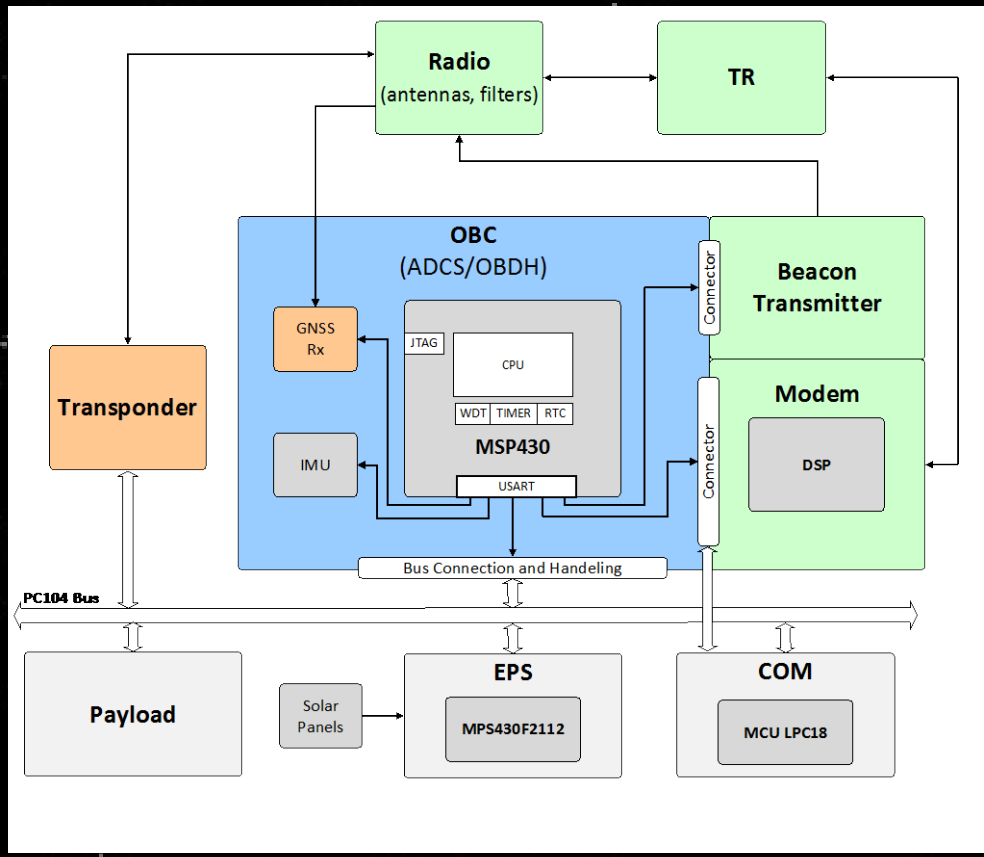
ISTNanosat-1
Architecture

- Hardware
  - Redundant connections
- Two operational profiles:
  - Normal
    - COM - full comm stack + data storage
    - OBDH – housekeeping
    - Payload operational
  - Safe
    - OBDH handles the space-link
    - COM is off
    - Payload offline





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EPS subsystem

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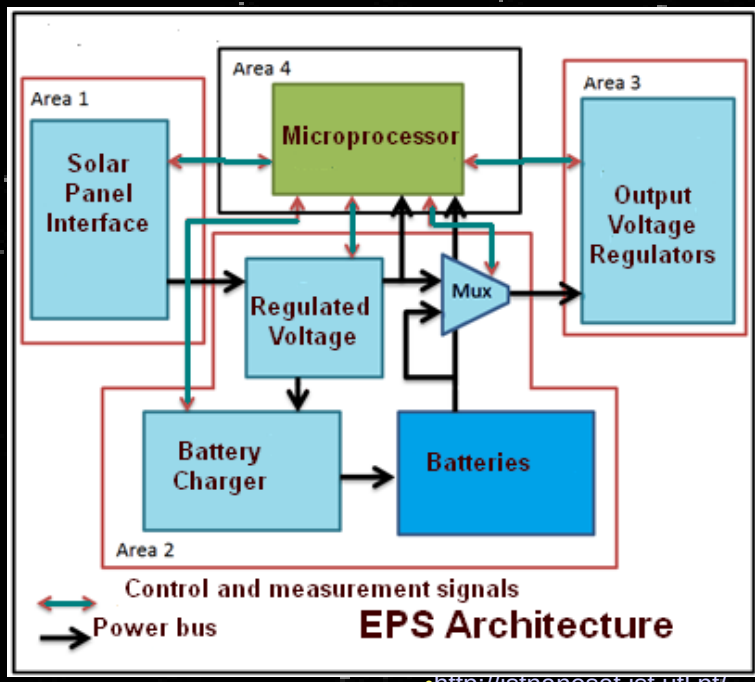
Power Supply
Platform

- Four blocks
  - 5 x Solar panels
    - Using MPPT to maximize energy transfer
  - Batteries (2) + smart charger
  - Output regulators and limiting circuits
  - Controller
    - I & V sensors
    - Communication w/ OBDH
- Can operate in 3 modes:
  - Only w/ solar cells
  - Only w/ Batteries (eclipse)
  - Mixed mode
    - Batteries charged by panels
- Redundant oriented design
- 5W peek power



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COM subsystem

- Base system
- Network functionalities

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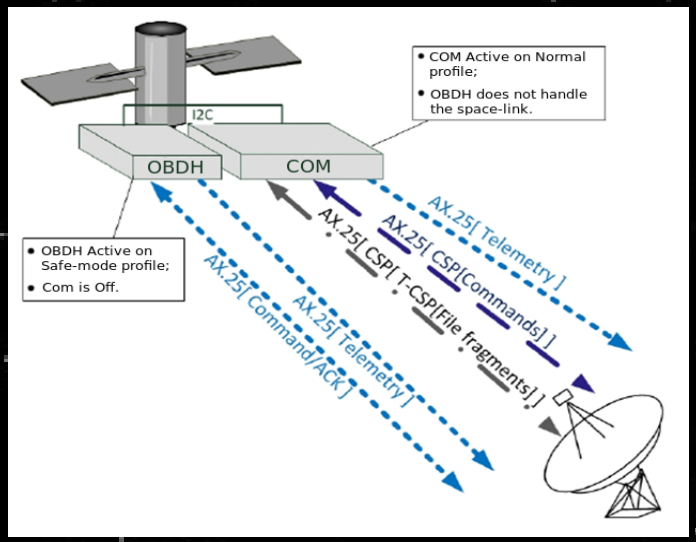
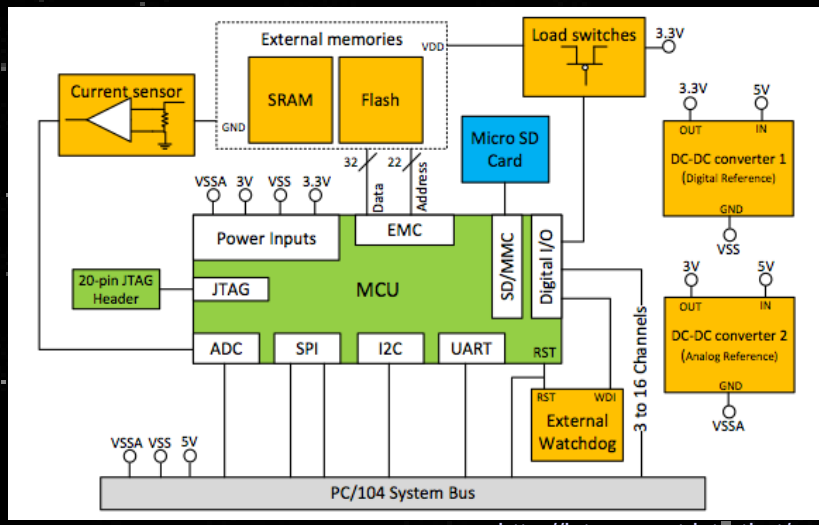
Communications
Platform

- Developed on a NXP LPC1833FET256 board
  - ARM Cortex-M3 core
  - 14 + 1 MByte Flash
  - 16 MByte SRAM
- Free RTOS based
  - Ported AX.25 + CSP to this OS
  - Radio Drivers still to be completed





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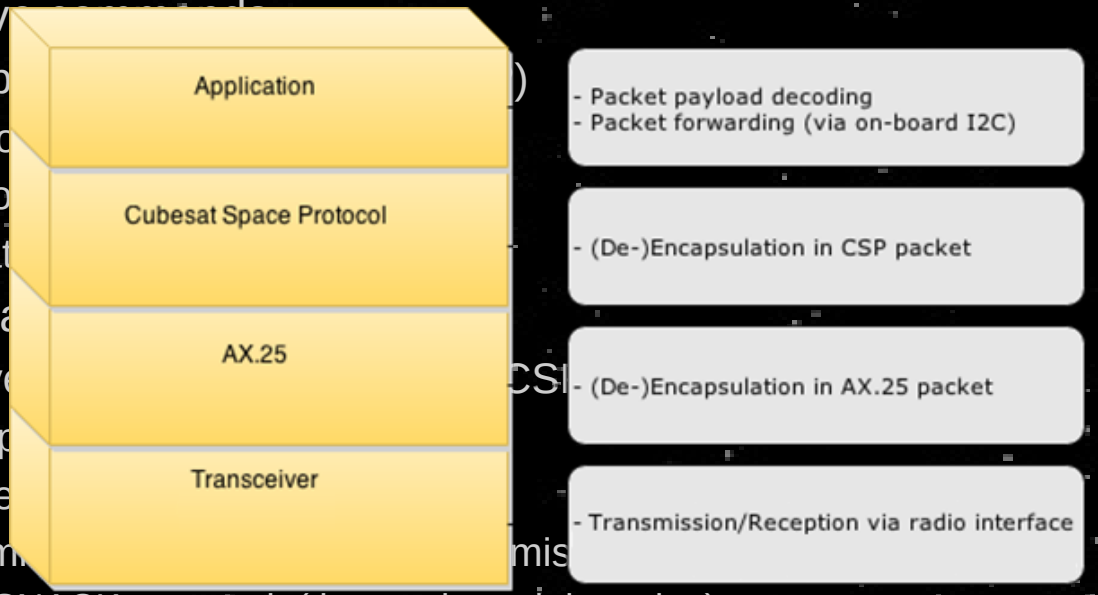
Communications subsystem
Network functionalities (1)

- Three main functionalities:
  - A) Packet telemetry
    - Using AX.25
      - CO Standard format
  - B) Send-and-receiv
    - Using the Cub
      - Layer 3 pro
      - Allow remo
      - Encapsulat
  - C) Send payload da
    - Using the dev
      - Transport p
      - CSP packe
      - Segment m
        - Using SNACK approach (timeout based detection)



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OBC subsystem

- Concept
- Software solution

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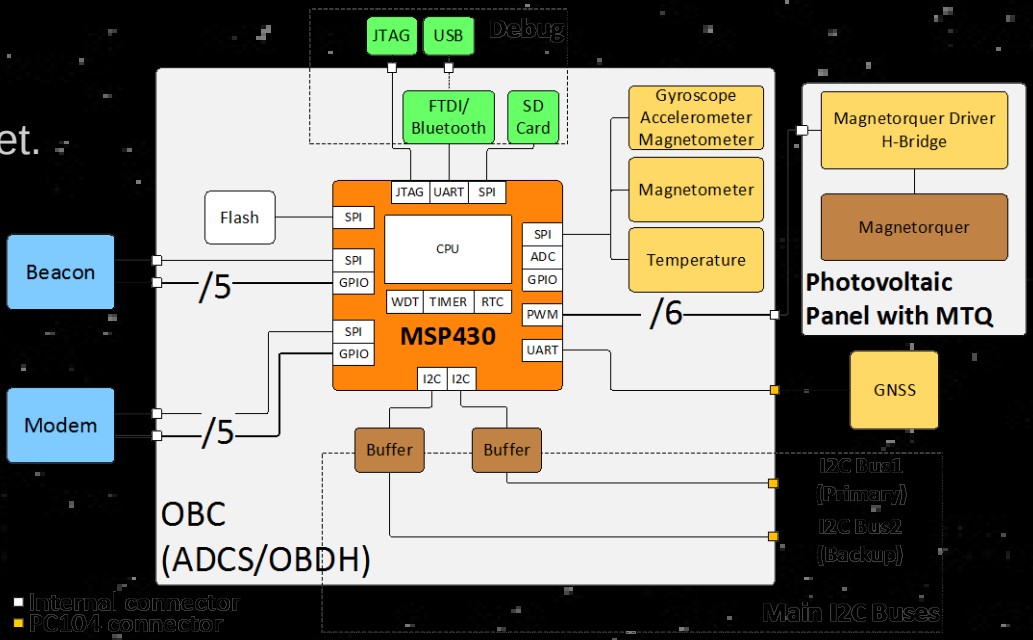
OBDH + ADCS
Platform

- Developed on a TI MSP430F5438A board
  - two rail I²C interface - independent physical hardware drivers
    - redundancy even though one of the I²C buses may be locked because of a defective module.
  - protection circuits that will be turned off by the OBC
    - current drawn exceeds the normal consumption value
- Sensors
  - MPU9250
    - Gyro. + Acc. + Magnet.
  - HMC5983
    - Magnetometer
- Actuators
  - solar panels' board



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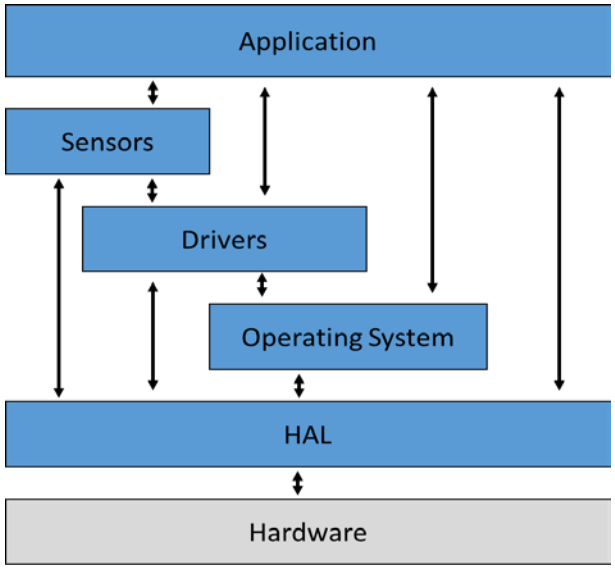
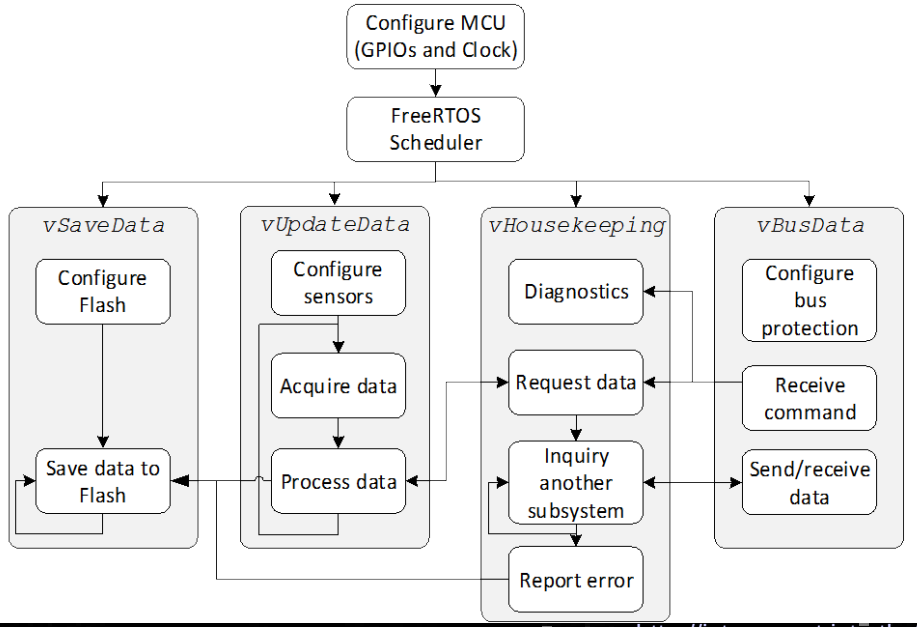
OBDH + ADCS
Software

- FreeRTOS based
  - **vUpdateData**: runs periodically for reading and processing the sensor's data.
  - **vBusData**: task that allows to gather and send/receive information to/from other subsystems.
  - **vHousekeeping**: interprets the commands, perform diagnostics, reports errors and maintains a global view of the state of the other subsystems.
  - **vSaveData**: task that configures the storage system and stores system information in memory.





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Present Status
Fabrication & Testing

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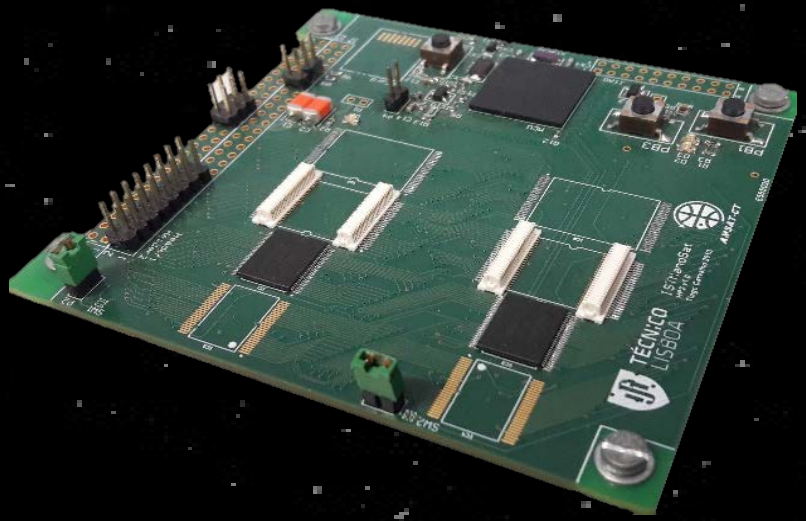

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Conclusions

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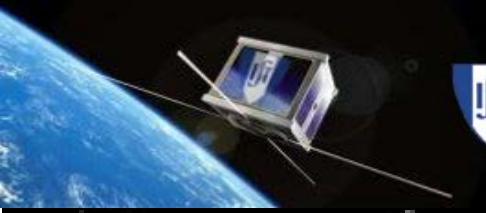

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Conclusions

- ISTNanosat-1
  - AMSAT-CT and IST/ULisbon consortium project
  - Consortium enlarged to other actors
  - Development based mostly on MSc thesis work
  - Submission of:
    - EU project in the context of Humsat idea
    - Proposal to ESA's FYS2017 contest
- Very challenging multidisciplinary project
- Some areas quite difficult to tackle
- New enhancements foreseen for the near future (propulsion?)
- The project should evolve to a IST flagship project
  - A sort of "Projecto FST" for space
  - Involving mainly students from several engineering programmes
  - With two working sites: Tagus and Alameda

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Conclusions

- So … who wants to come aboard??
- Last but not the Least …

… it has been a lot of FUN!

Teaser

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