VHF Omni Directional Radio Range Satellite

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Summary

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The Team

The Numbers

- 8 undergraduated students
- 5 Professors
- €100.000,00 budget

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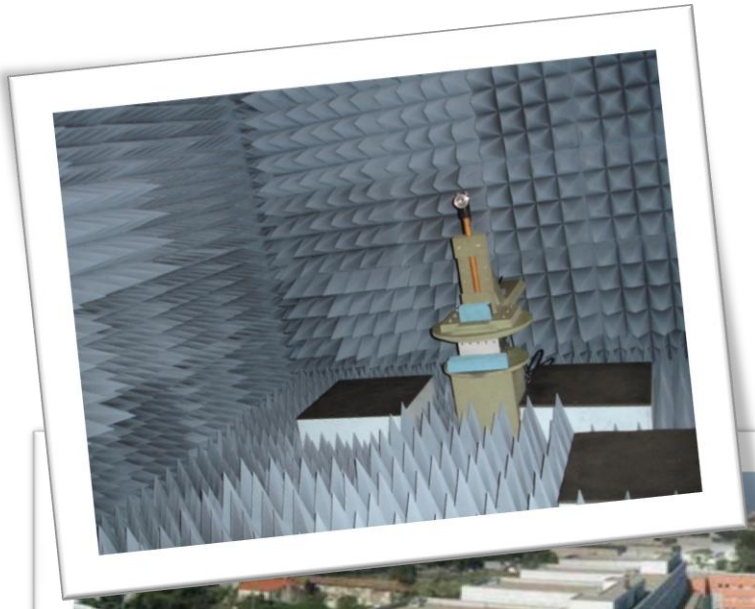
Facilities



Faculty of Engineering, University of Porto

- Anechoic chamber
- Electronics Laboratories
- Ground Station

Mission Goals

- Measuring the space vehicle attitude on a ground station from transmitted signals
- Reentry
  - Adjust reentry point
  - Survive reentry
  - Recovery

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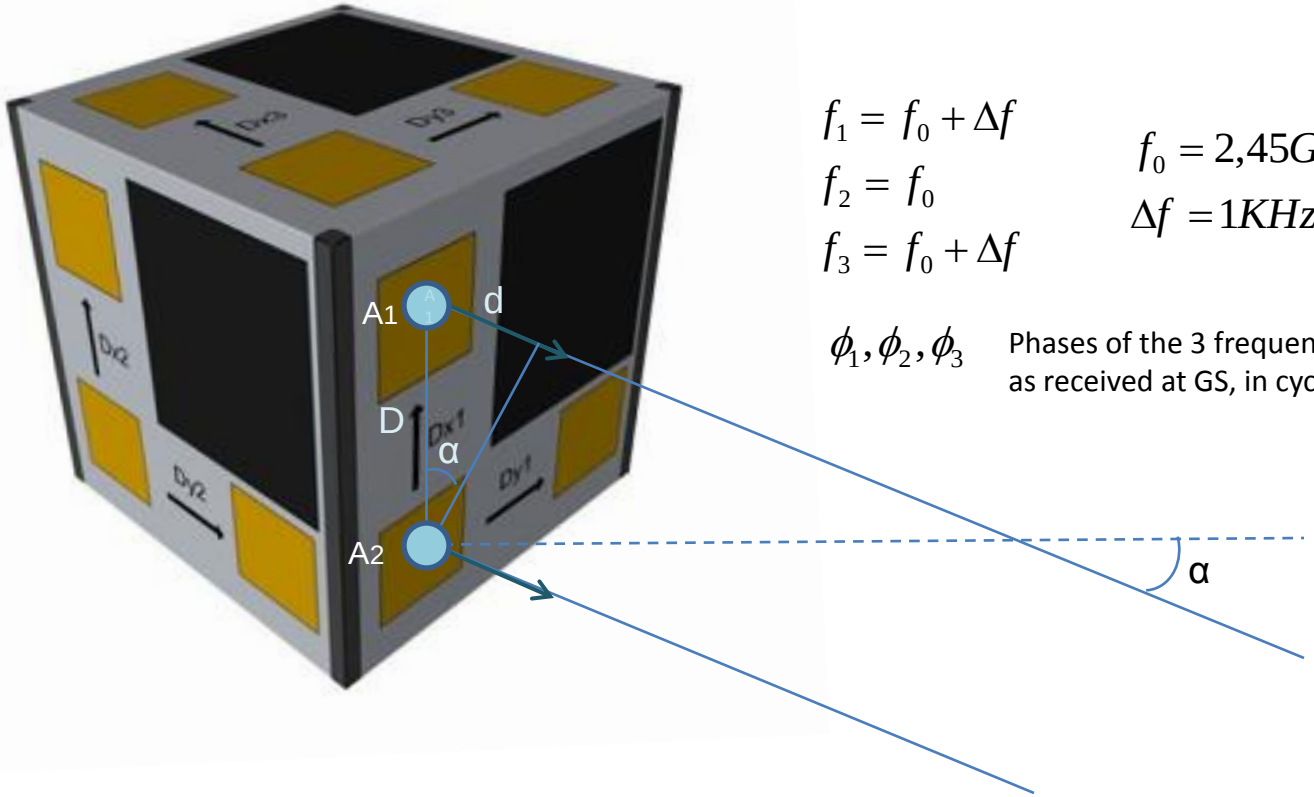
Measuring Attitude



$$f_1 = f_0 + \Delta f$$
$$f_2 = f_0$$
$$f_3 = f_0 + \Delta f$$

$$f_0 = 2{,}45GHz$$
$$\Delta f = 1KHz$$

ϕ_1, ϕ_2, ϕ_3 Phases of the 3 frequencies as received at GS, in cycles

$$(\phi_1 - \phi_2) - (\phi_2 - \phi_3) = -\frac{d}{\lambda} = -\frac{Dsen(\alpha)}{\lambda}$$

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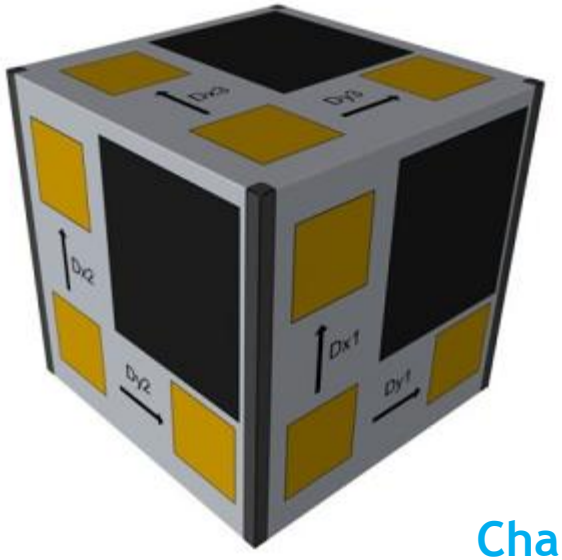
Transmiting Antennas

- 3 patch antennas per face for attitude determination
- Alternate transmitted signals between faces and between pair of antennas in the same face
- Instantaneous measurements allows to capture two angles of attitude
- Evolution in time provides full attitude and rotation information
- Ephemeris and telemetry modulated in other signals transmitted through these antennas

Navigation

- Navigation: single GPS receiver
- Omni-directional antenna: an array antenna obtained from individual patch antennas in each face
- Beacon: VHF or UHF to allow for initial tracking of the CubeSat in the sky

The VORSat



- 10 x 10 x 10 cm
- Per face:
  - 3 antennas
  - 1 GPS antenna
  - 1 beacon
- Solar panels in all faces

Challenge:

Combine antennas and solar panels

in the small area of the faces.

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Solar Panels + Antennas

- Combination of solar panels with antennas in order to maximize the exposure area and energy provided.
- Patch antenna embedded in one of the solar cells layer during its production.

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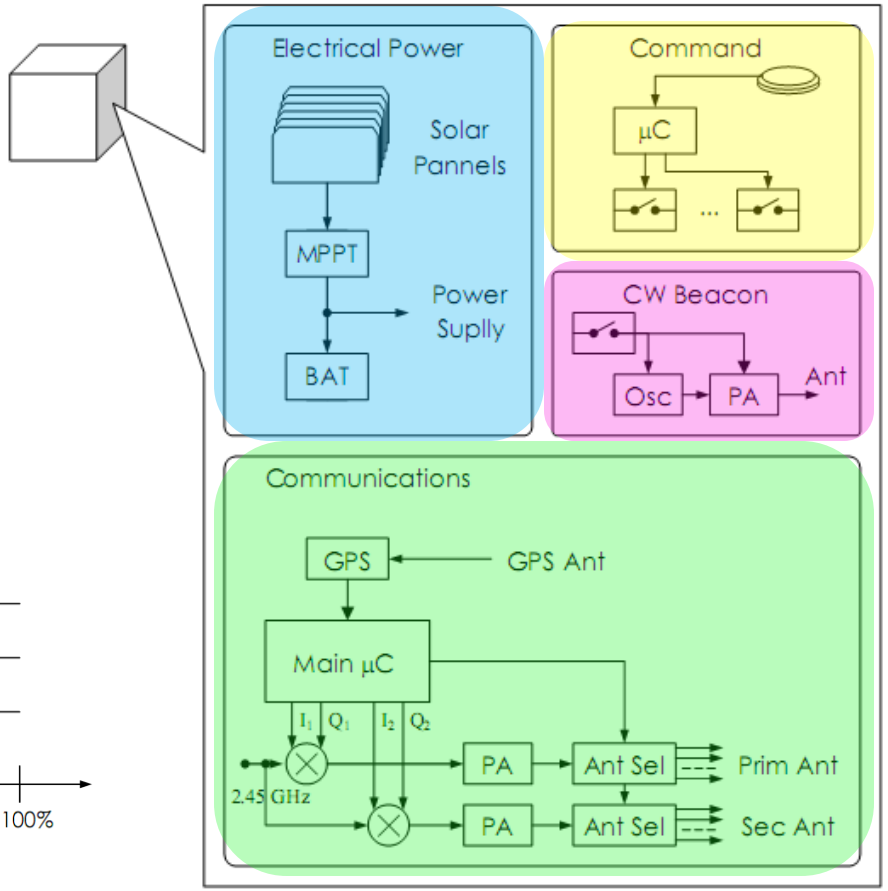
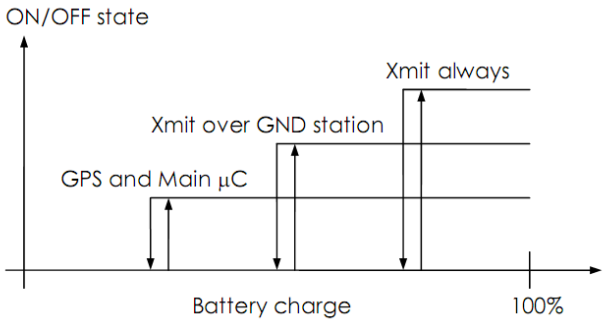
Hardware





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Structure & Material

- Composite made with carbon fibers
- Estimated weight – 265g (lower than Aluminium)
- New processing technique

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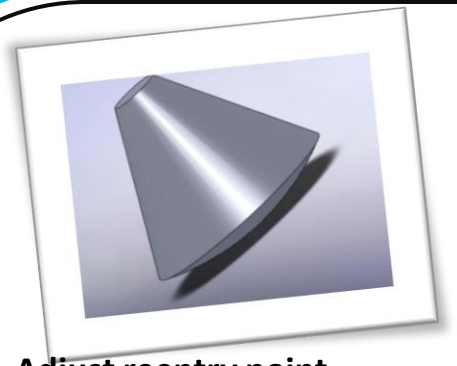
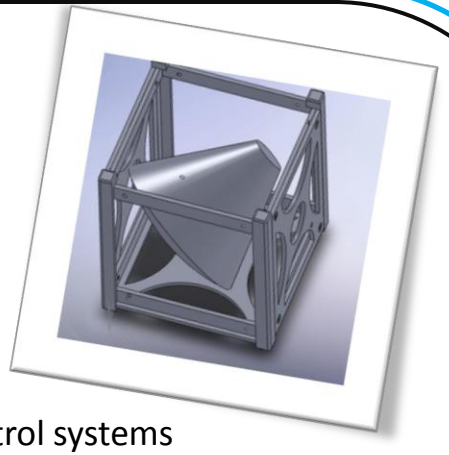
Reentry





1. Adjust reentry point

- Stabilize VORSat attitude using passive or active attitude control systems
- Use passive systems to increase drag at critical altitude to select expected landing site OR use propulsion to adjust the reentry point

2. Entry, Descent, Landing (EDL)

- A capsule ejects from the main structure
- Main structure burns in the atmosphere
- The capsule survives to the reentry (maximum dynamic pressure, high temperatures)
- The capsule land/splashdown in a pre-determined area

3. Recovery

- The capsule is able to survive a considerable amount of time in hard environmental conditions
- Sporadic transmission of sonar pings to allow for eventual recovery or if possible using also satellite transmission

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Current Work

- Tests in the anechoic chamber revealed that our system has an error of just 1 degree, although we haven't tested it with atmospheric perturbations which aren't significant for such close frequencies and are expected to be small.
- Calculations revealed that if we interfere with the VORSat attitude at 200-250Km, increasing its drag coefficient from 1.8 to 2.0, we are able to anticipate its fall up to 15 orbits (1 day), enabling us to determine where we want it to land: North Atlantic.
- During the slow down phase, below 100 Km and above 40 Km, accelerations of up to 8 Gs and a power dissipation of 300 KW will generate a maximum dynamic pressure in the reentry capsule structure that must be designed to survive such dynamic and energetic loads

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Tens uma ideia?
IDERA