
# *CubeSat Mission Concepts and Preliminary Design at UniNA : from education to research*

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# Background – Aerospace Systems at UNINA

- Despite its long-term heritage in the field of analysis and design of space missions and payload

## UNMANNED AERIAL SYSTEMS

- Advanced avionics and payloads for UAS
- Autonomous take off and landing systems
- Detect and avoid architectures and algorithms
- Autonomous GNC for UAS and re-entry vehicles

## SPACE SYSTEMS

- GNC and AOCS advanced techniques and Technologies
- Space mission design based on small and micro platforms
- Space Situational Awareness/Space Surveillance and Tracking
- Advanced Aerocapture systems for planetary exploration

## REMOTE SENSING AND SYNTHETIC APERTURE RADAR

- Bistatic and distributed SAR by formation flying satellites
- Algorithms and techniques for marine and maritime SAR application
- AI techniques and solutions for image analysis

*…the team does not have a long tradition in CubeSats program, either educational or for research*

# Outline

- FORmation flying of CubEsat assemblies for remote sensing (FORCE)
- CubeSats Student Projects

# FORCE

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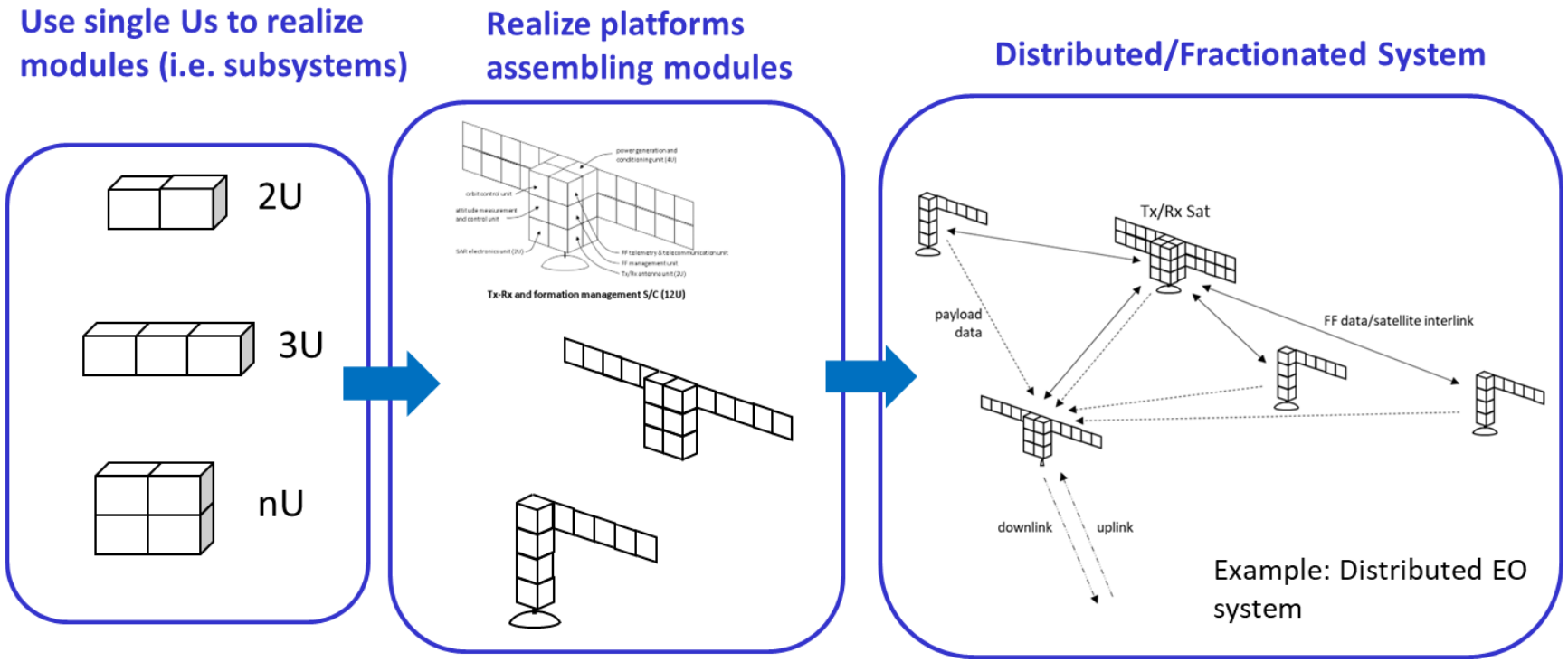
- Main goal is the design of **Modular CubeSat-based platforms** to implement missions exploiting modularity and formation flying, e.g. in-orbit servicing, active debris removal, remote sensing
- Each platform has a modular design: it is an Assembly of CubeSat-based modules



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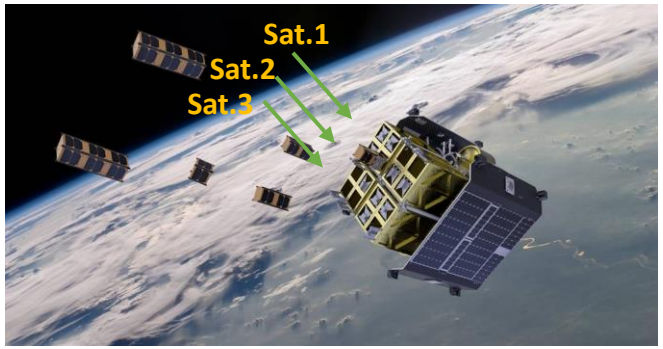
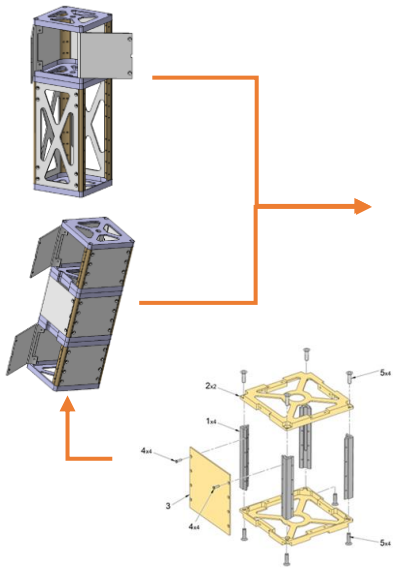
- Project involved the development of several Module Breadboard/Prototypes (TRL 4)
  - ***Antenna Module*** (developed by SMEs: ALI Scarl, SRS, LeadTech)
  - *Propulsion Module* (developed in cooperation by University and SRS)
  - ***Relative Navigation Module*** (developed in cooperation by University and LeadTech)
  - *OBDH Module* (developed by SMEs: TSD and SRS)

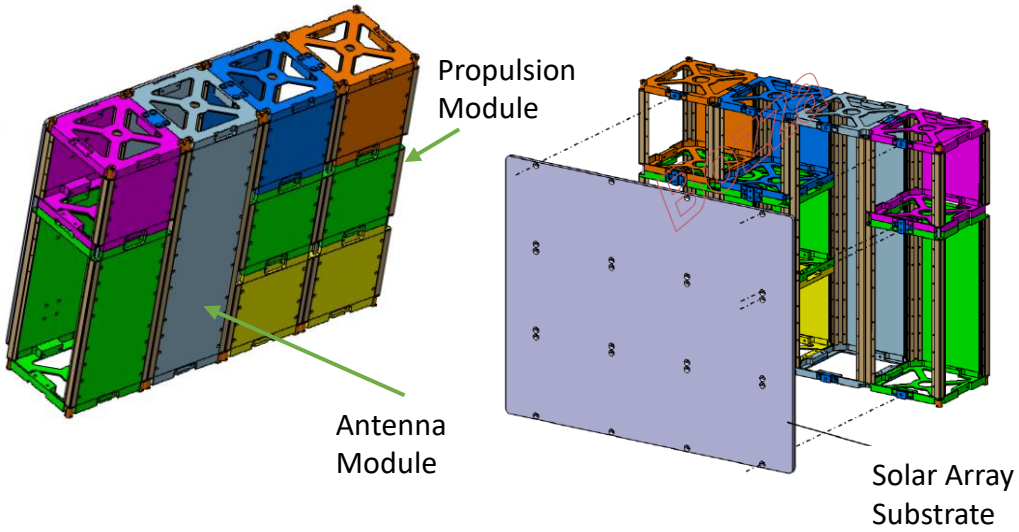
# Force Platform Layout

| Subsystem/Module | Mass (kg) | Average Power (W) | Volume (U) |
|---|---|---|---|
| STR/TCS | 3.25 | 13 | - |
| EPS Module | 1.5 | 1.3 | 1 |
| ADCS Module | 1.5 | 15 | 1 |
| OBDH/TT&C Module | 1 | 11.4 | 1 |
| SAR Antenna Module + SAR Payload | 3.2+1.3 | 7.5 | 3+2 |
| Propulsion Module | 4 | 6.5 | 4 |
| **Total** | **16** | **55** | **12 U** |




Courtesy of D-Orbit

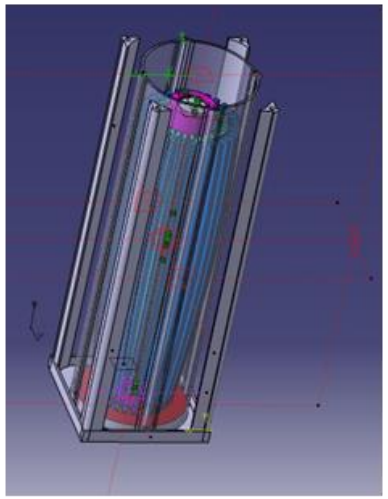





Each platform is an assembly of modules

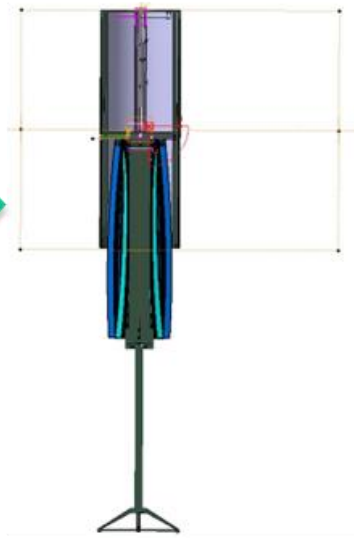
Layout compatible with ION Satellite Carrier (operated by D-Orbit) providing both cluster orbit and satellite separation (in case of a cluster)

# Antenna Module

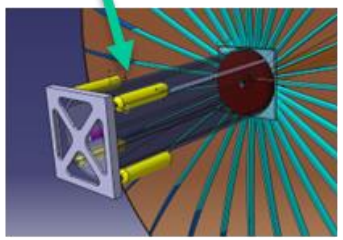


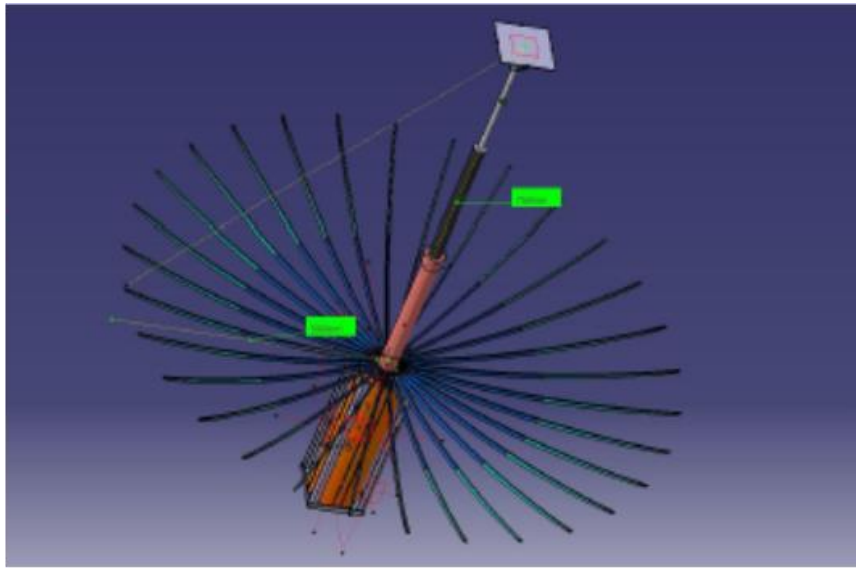
Antenna folded in the 3U module (extraction in 3 steps)

Release of gas-spring locking mechanism and extraction of the feed first stage



Extraction of antenna hub by activation of gas cartridges





Activation of a spring mechanism for ribs extension, and extension of feed second stage by pneumatic extraction of the gas spring housing

Antenna main parameters

| | |
|---|---|
| Frequency | 9.6 HGz – X Band |
| Incidence angle | 20°-40° |
| Band | ≥ 80 MHz |

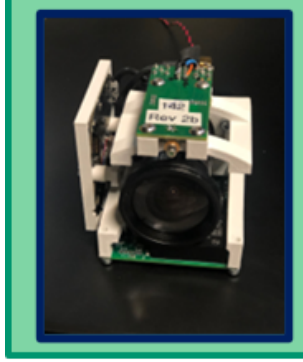
| | |
|---|---|
| Ant. Radius | 0.5 m |
| Ant. Focal length (Lf) | 0.75 m |
| Ant. Gain | 37.5 dBi (MO1)<br>30.9 dBi (MO2) |
| Feed size (L x W) | 192 x 29.4 mm |

**Antenna is a 1-m parabolic reflector weighting around 3 kg**

*(Antenna designed by Unina, Deployment system developed by ALI, SRS, LeadTech)*

# Relative Navigation Module

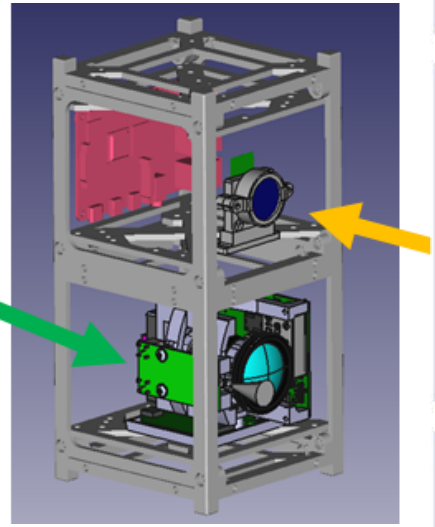
- This module is designed for close proximity operations and in-orbit servicing
  - a **miniaturized Laser Range Finder** (LRF), based on direct TOF principle, is used for both ranging and markers illumination
  - a **monocular camera** collects images of reflecting markers placed on the external surface of a target platform



Laser Range Finder:

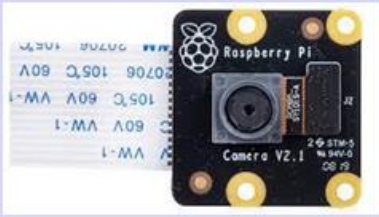
- Range measures
- Illumination

70.6 mm x 66 mm x 76.4 mm



- QuickSwitch QS-905 laser (905 nm, 2.5ns, 10KHz rep. rate)
- Hamamatsu Photonics MPPC
- Fish-eye collecting lens system (20° x 20° FOV)
- Control electronics

**Raspberry Camera Module V2 NoIR**




**Overall size: 34 mm x 25 mm x 8.4 mm**
**Connection Ribbon to Raspberry Pi 4**

**IR Pass-Band Filter L905-25**

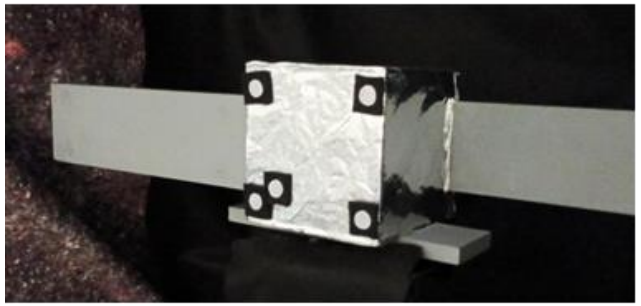

**Overall Size: Φ25.4 mm x 6.3 mm**
**Slot for filter arrangement**

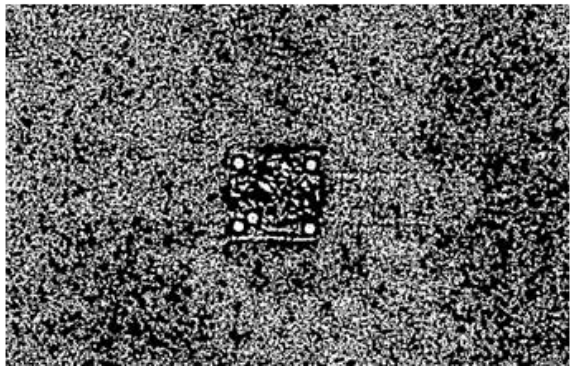
**Raspberry Pi 4 Model B**

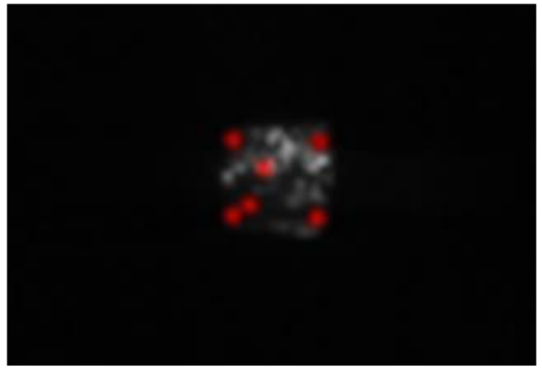
**Overall Size: 88 mm x 58.5 mm x 16 mm**
**Interfaces: USB, HDMI, Ethernet,**

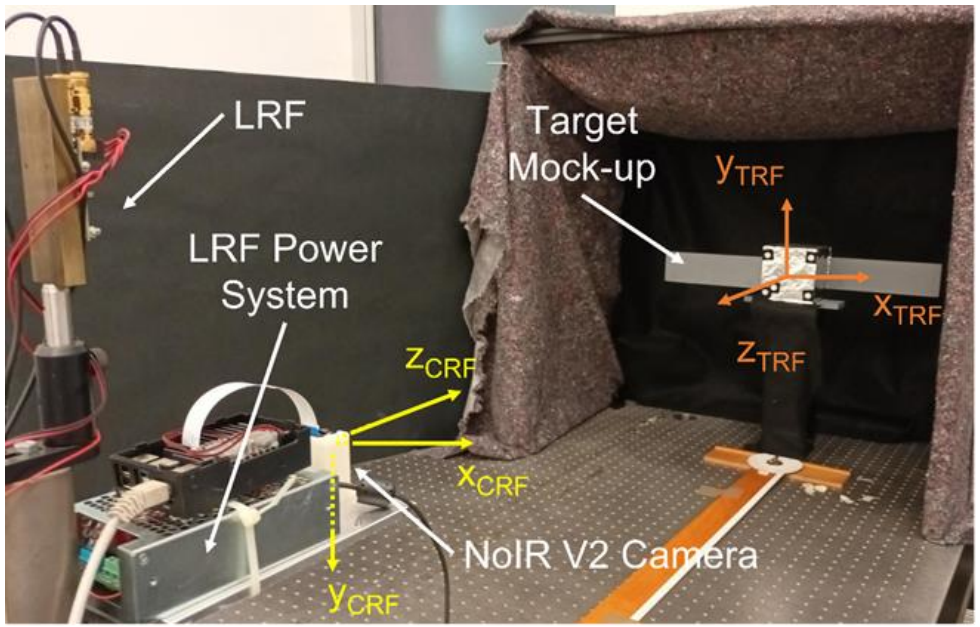
# Relative Navigation Module

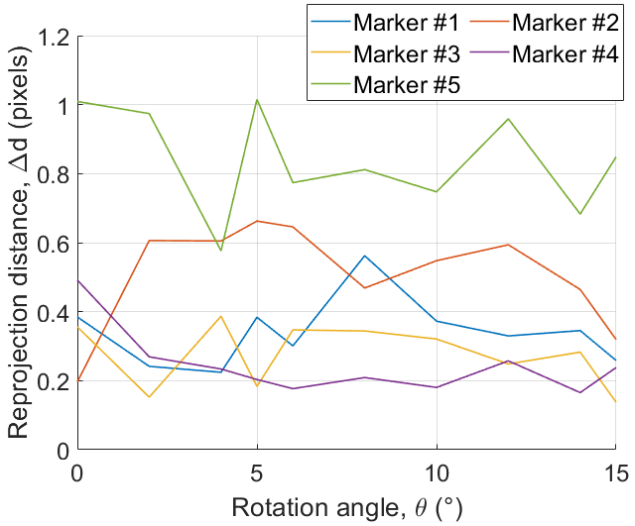
***Satellite mock-up*** ***Image Processing (Filtering, Thresholding…)*** ***Outliers' rejection (size, circularity…..)***










- test bench being developed at the GNC laboratory of the University
- circular markers made of polycarbonate prisms selected
- about 1.2 m camera Camera/Mock-up distance
- pose determination performance evaluated by looking at the reprojection error, that is always of sub-pixel order

# CubeSats Student Projects

- Students of Space Systems course – 1° year of Master Degree
  - 9 teams of 10-12 students
  - Only one requirement: max 3U cubesat
  - Very different topics
  - Inspired at «fly your satellite» program of ESA (report and presentation)

# CubeSats Student Projects


Mission Name: LiSD – Lidar for Small Debris
Mission Description: Demonstration of **LiDAR** scanning technology for small debris cataloging in Low Earth Orbit for space situation awareness application.


Mission Name: SunflowerSat
Mission Description: SunflowerSat's mission is a technology demonstration of a compact 2-DOF Sun-tracking **deployable system** to orient a Solar Array to increase the power output for implementation in future CubeSat missions. The mechanism is integrated in a 0.5U module while the rest of the subsystems are contained in 1.5U.


Mission Name: C.L.O.D.
Mission Description: Technology mission for 2U relay CubeSat to demonstrate the feasibility of **optical communication through a UHF** crosslink and optical downlink of telemetry data.

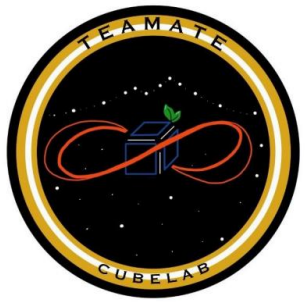
# CubeSats Student Projects

Mission Name:  DynamoSat
Mission description: Technology demonstration mission exploiting the **tumbling motion** of satellite to collect other amounts of energy for platform power means and testing the properties of an experimental material (metglas). The development of a cheap/sustainable technology that provides power to the satellite without requiring special conditions is something needed for the future.

Mission Name: SOCARRAT I
Mission description: 2U cubesat with the goal of developing a satellite for compressing optical camera's data with AI, in order to improve downlink efficiency for future surveillance applications

Mission Name: HyperCube
Mission description: The mission is a technology demonstration of vessels detection, realized using an hyperspectral camera mounted on a 2U CubeSat.

# CubeSats Student Projects




Mission name: Cubelab
Mission description: Conducting biological and materials experiments in an unconventional environment with a high level of radiation to simulate the conditions of a journey to Mars.


Mission name: Efesto
Mission description: The aim of the mission is to test a new application of SMA technology in particular for ADR by a 2U cubesat.


Mission name: HeartSat
Mission description: Demonstration of CubeSat technology for monitoring vital signs and position data during calamitous events for the purpose of locating and assisting people by rescue organizations

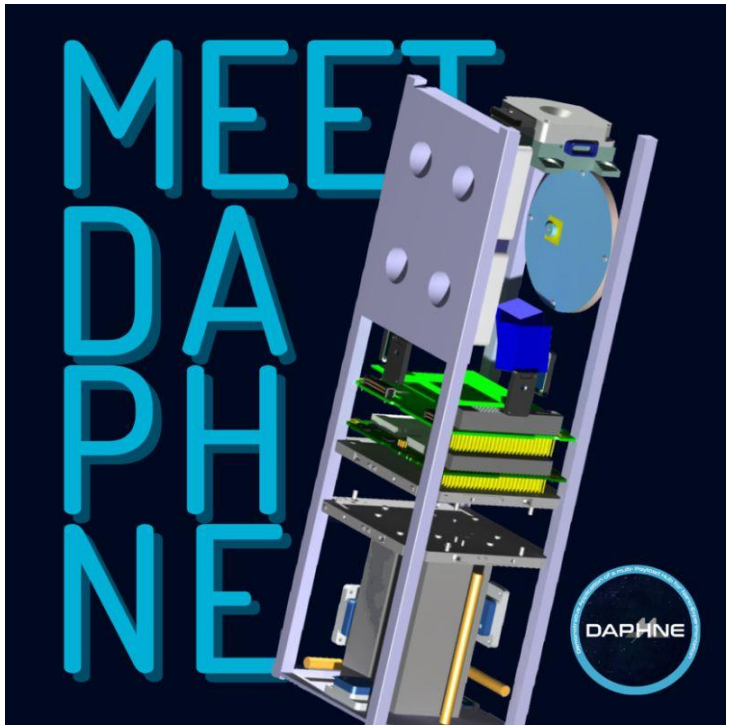
# DAPHNE is a 3U Multimission CubeSat

*Per astra ad laurum* ✨

**In-Orbit Demonstration:**
Innovative technologies for shielding from radiative environment

**Internet of Things**
Low-cost distributed Ground Segment

**Ions characterisation**
Characterisation of atomic oxygen
in a VLEO orbit




*Thank you for your attention!*

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