HERCCULES

Heat-transfer and Environment Radiative and Convective Characterization in a University Laboratory for Experimentation in the Stratosphere

STRAST

POLITÉCNICA

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REXUS/BEXUS

The REXUS/BEXUS programme allows students from universities and higher education colleges across Europe to carry out scientific and technological experiments on research rockets and balloons. Each year, two rockets and two balloons are launched, carrying up to 20 experiments designed and built by student teams.

The REXUS/BEXUS programme is realised under a bilateral Agency Agreement between the German Aerospace Center (DLR) and the Swedish National Space Agency (SNSA). The Swedish share of the payload has been made available to students from other European countries through a collaboration with the European Space Agency (ESA). EuroLaunch, a cooperation between the Esrange Space Center of SSC and the Mobile Rocket Base (MORABA) of DLR, is responsible for the campaign management and operations of the launch vehicles. Experts from DLR, SSC, ZARM and ESA provide technical support to the student teams throughout the project. REXUS and BEXUS are launched from SSC, Esrange Space Center in northern Sweden.

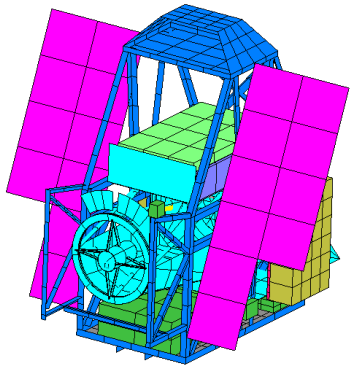
IDR-STRAST

The **Instituto Universitario de Microgravedad "Ignacio da Riva" (IDR)** is a research institute from the **Universidad Politécnica de Madrid (UPM)** with experience in anemometry, aerodynamics and Space Systems development. IDR is also responsible for teaching the Space Systems Master degree of UPM. It has already participated in several stratospheric balloon missions (SUNRISE I, II and III) as well as space missions such as Solar Orbiter, ExoMars, Ariel etc.

STRAST (Real-Time Systems and Architecture of Telematic Services) is a group from the **UPM** specialized in electronics and computing.

These two institutes have been working together for a long time. A good proof of it is the successful launch of the UPMSat-2 microsatellite in 2020, which was design by both groups and tested in the IDR facilities.

Our proposal to BEXUS



SUNRISE III at MPS.

Balloon flight applications are continuously improving. Characterizing the thermal behaviour of these platforms not only during the floating phase but also during the ascent phase is essential to fulfil the requirements.

Convection and the **thermal environment characterization** increase uncertainty in the thermal analysis.

HERCCULES aims at improving the thermal analysis and design techniques of this kind of platforms by:

- Validating a new thermal environment characterization methodology based on satellite data.
- Validation of a dynamic model to obtain the relative wind speed based on global wind data.
- Establishing a criteria for considering convective heat transfer during the ascent and float phase.

Objectives

Convective heat transfer quantification on heated flat plates during the flight.

Thermal radiation environment characterization to compare with CERES data.

Relative wind speed measuring on external surfaces to quantify forced convection.

Nadir sensor test for space system's attitude determination.

Technical Motivation

Participation in stratospheric missions (SUNRISE)

Student project for a stratospheric experiment (TASEC-Lab)

Multidisciplinary team (IDR - STRAST)

- Space System design (CDF pre-design, thermal, structural, mechanical, SW…)
- Aerodynamic studies.
- Space System testing (thermal vacuum, vibrations…)
- Anemometry calibration.

Working team

Project Manager

David González Bárcena

Payload

Daniel Alfonso Corcuera

Juan Bermejo Ballesteros

Secondary payload

Marina Merchán Bravo

Technical Support

STRAST

- Prof. Isabel Pérez Grande (Professor in charge).
- Prof. Ángel Sanz-Andrés (Aerodynamics).
- Dr. Lilian Peinado (Thermal Design).
- Prof. Victor Muntean (Fluid Mechanics).
- Prof. Javier Cubas (Attitude Determination).
- Prof. Juan Zamorano (Software).
- Prof. Javier Malo (Electronics).
- Prof. Javier Pérez (Mechanical Design).

Mechanical Subsystem

Blanca Boado Cuartero

Thermal Control Subsystem

Alejandro Fernández Soler

Electrical Power Subsystem

Sergio Marín Coca

On-Board Computer Subsystem

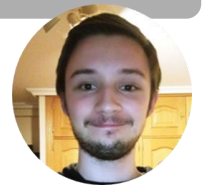
Ángel Grover Pérez

Attitude Determination Subsystem

Ángel Porras Hermoso

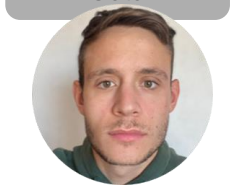
Electronics Subsystem

Juan Manuel Redondo



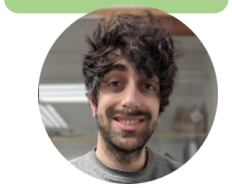
Communication Subsystem

Javier Garrido Sola

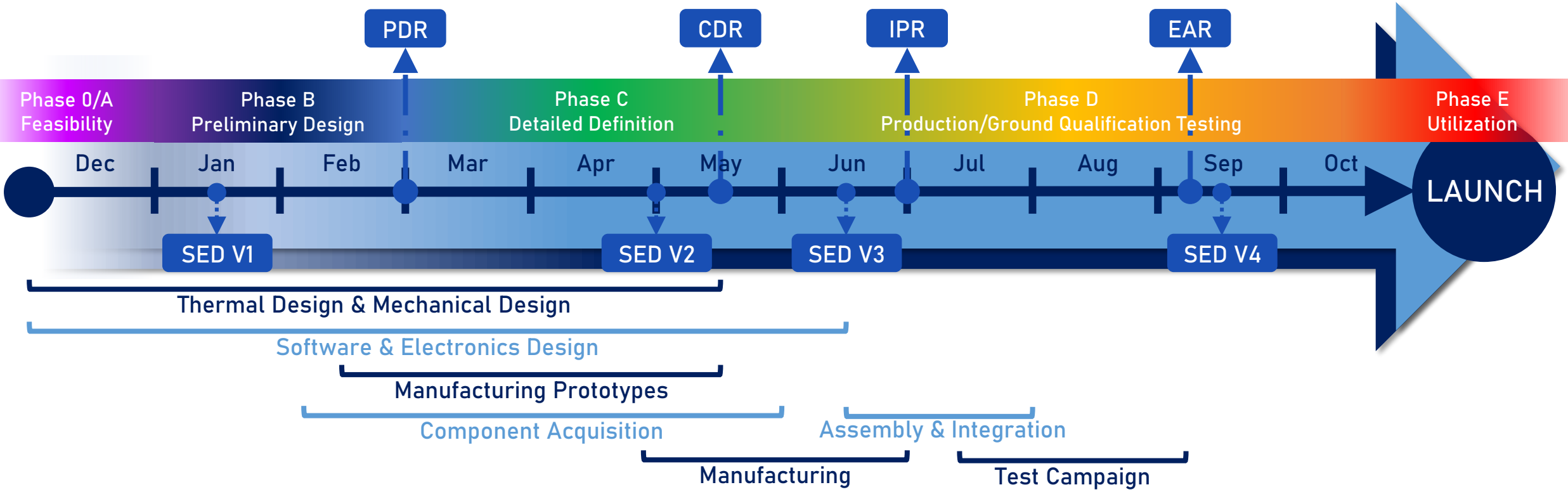


AIT and Outreach plan

Jose Miguel Álvarez Romero



Project Planning



Outreach Plan

The aim of these part is to attract young engineers and show them the characteristics and importance of ballooning in the aerospace sector.

The project will be firstly published in a dedicated website with all collaborators and sponsors.

Experience elaborating videos and media to disseminate information though a non-specialized sector.

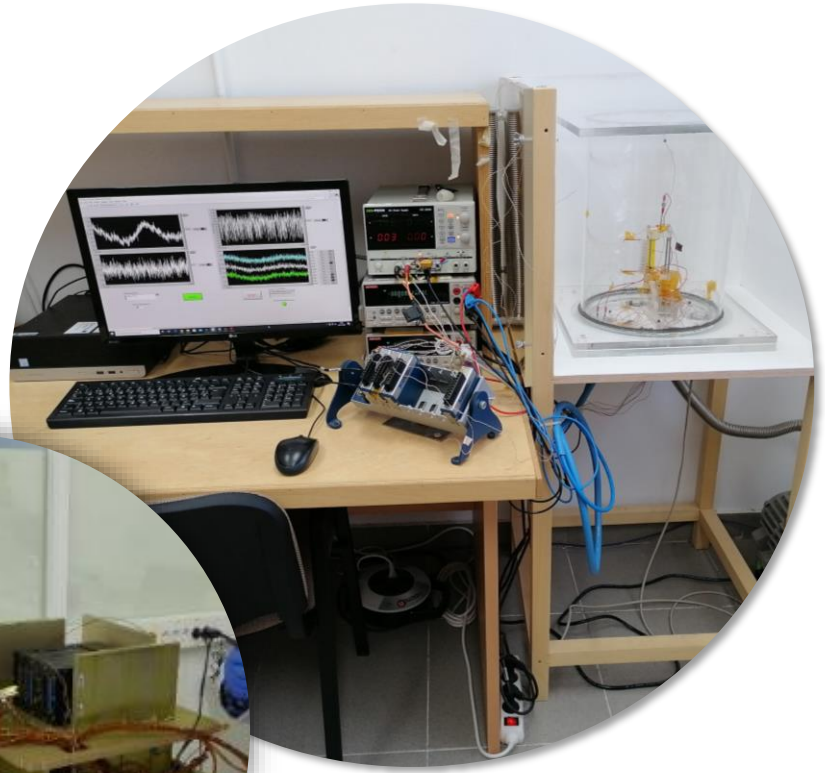
IDR's Social media will be following the project development.

The HERCCULES Project and the BEXUS campaign results will be published in scientific journals as well as presented in several conferences.

The possibility to inform about this project will be offered to newspapers, radio and television.

Available Facilities

Clean Room, Thermal Vacuum Chamber & Wind Tunnel



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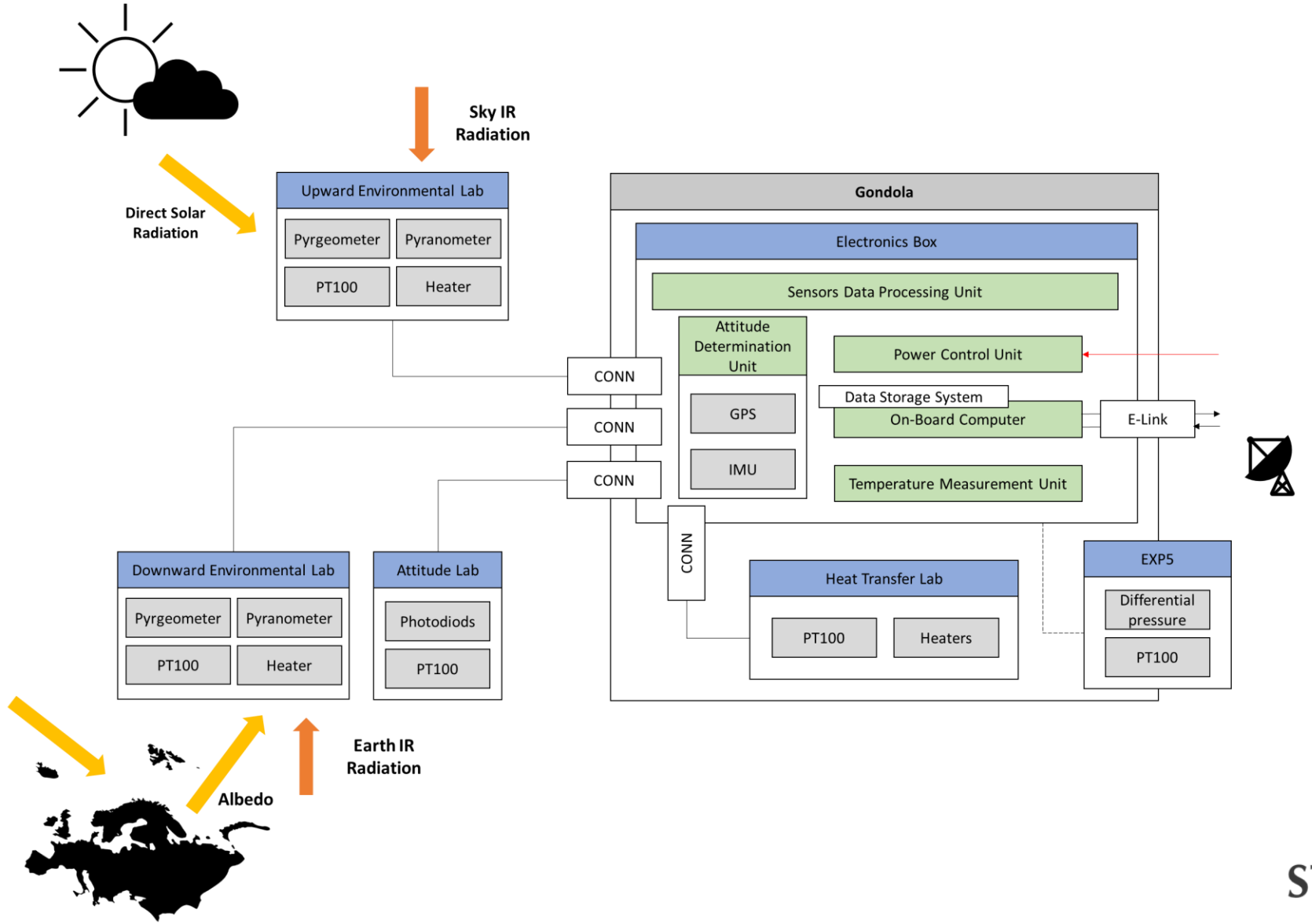
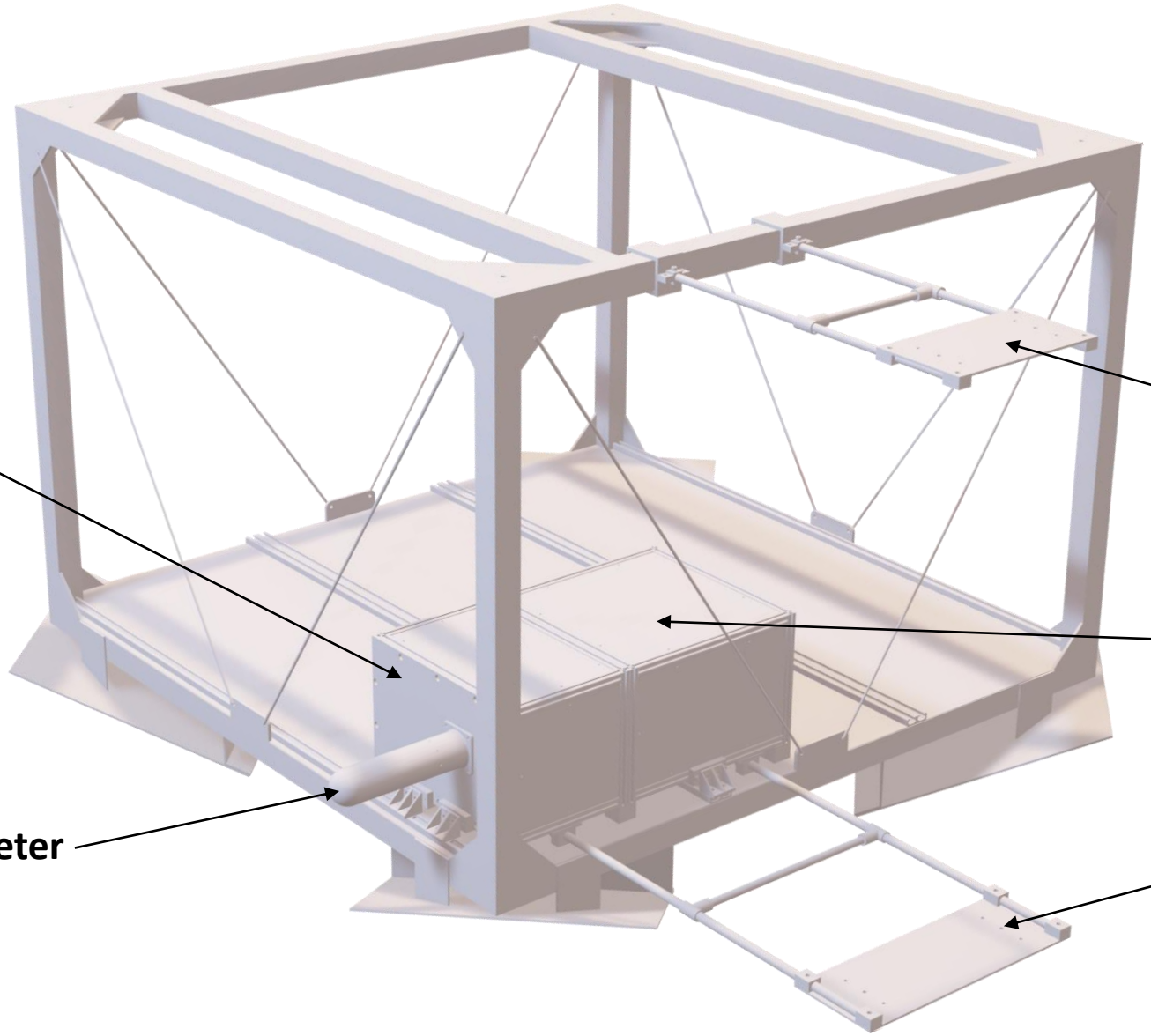
Structure & Equipment



Structure & Equipment



Heat Transfer Lab

Free convection estimation in different configurations

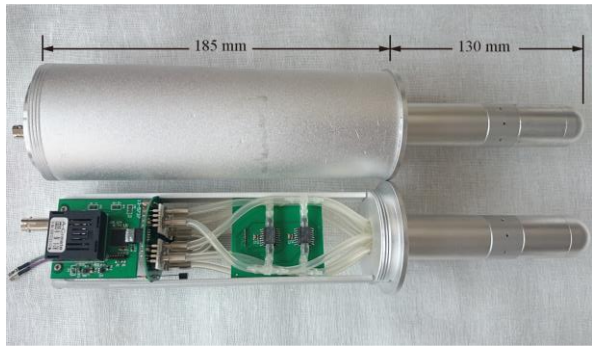
EXP1 - Horizontal heated plate

EXP2 - Vertical heated plate

EXP3 - Radiator + thermal strap

EXP4 - Multiple gapped vertical plates

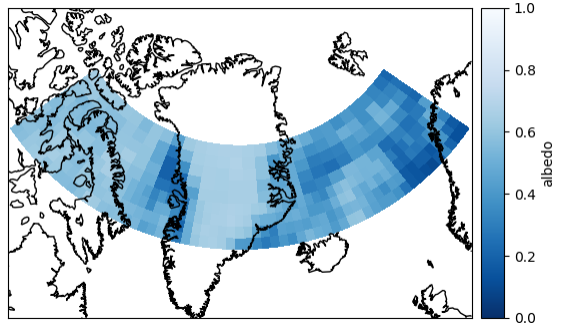
EXP5 - Relative wind speed measurement

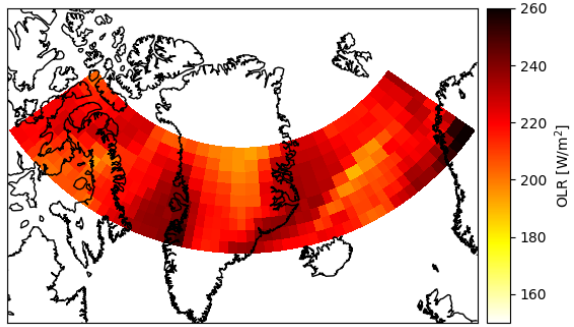


C. Liu, L. Du and Z. Zhao, **A directional cylindrical anemometer with four sets of differential pressure sensors.** Review of scientific instrumentation, 2016.

Environmental Lab

Characterization of the thermal environment





Comparison with CERES and ECMWF data for thermal environment characterization

CERES

ECMWF

- Based on COTS
- Albedo
- Outgoing Longwave Radiation
- Direct Solar Radiation
- Sky Infrared radiation
- Air temperature and pressure

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Attitude Lab

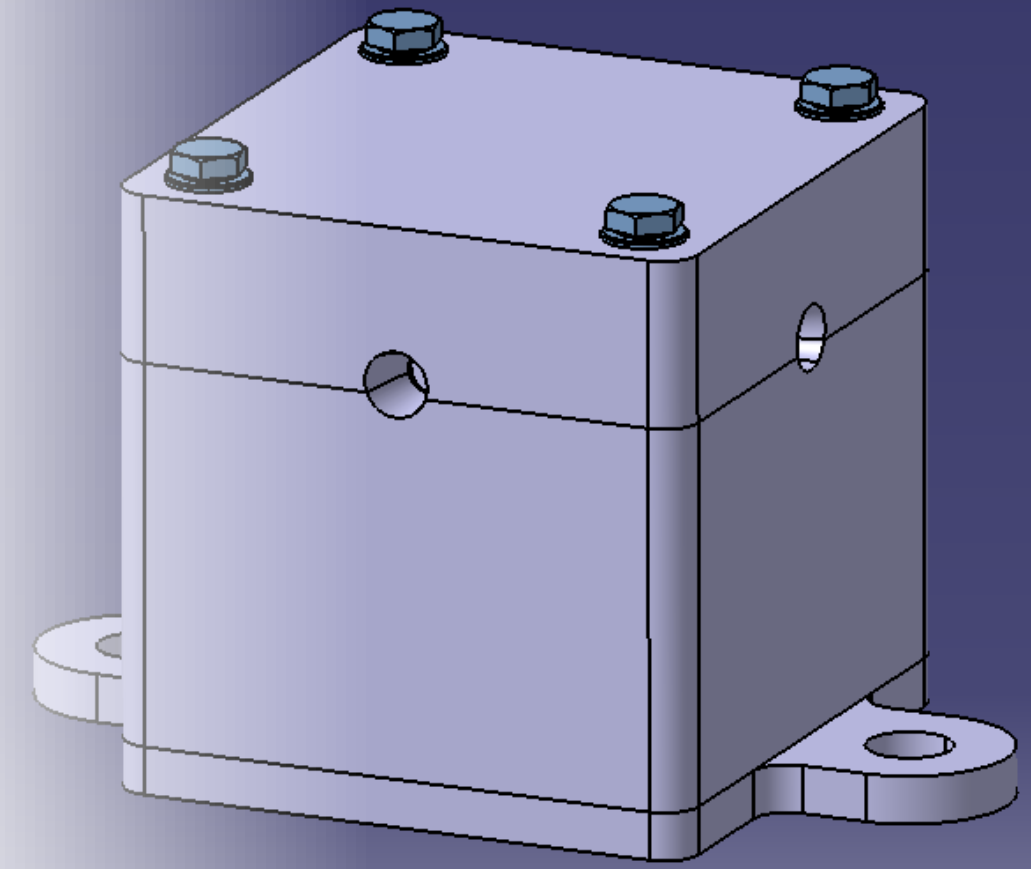
Nadir Sensor Design

Goal: to test and validate a new design of a Nadir sensor based on IR photodiodes and adapted for stratospheric altitudes.

After the flight, the nadir sensor measurements will be compared against the estimated nadir direction.

A pre-design has been already done and the IR photodiodes have been bought.

Based on COTS



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On-Board Computer

RPi Compute Module 3+ single board computer as the OBC:

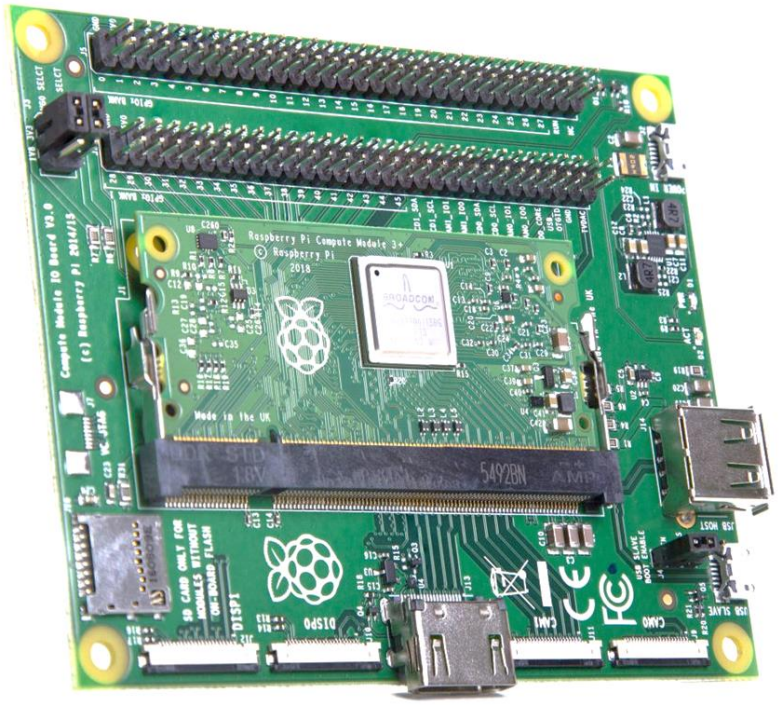
48x GPIO pin header that support digital protocols such as I²C, SPI, UART.

Broadcom BCM2837B0, Arm Cortex-A53 @ 1.25 GHz (Quad-core).

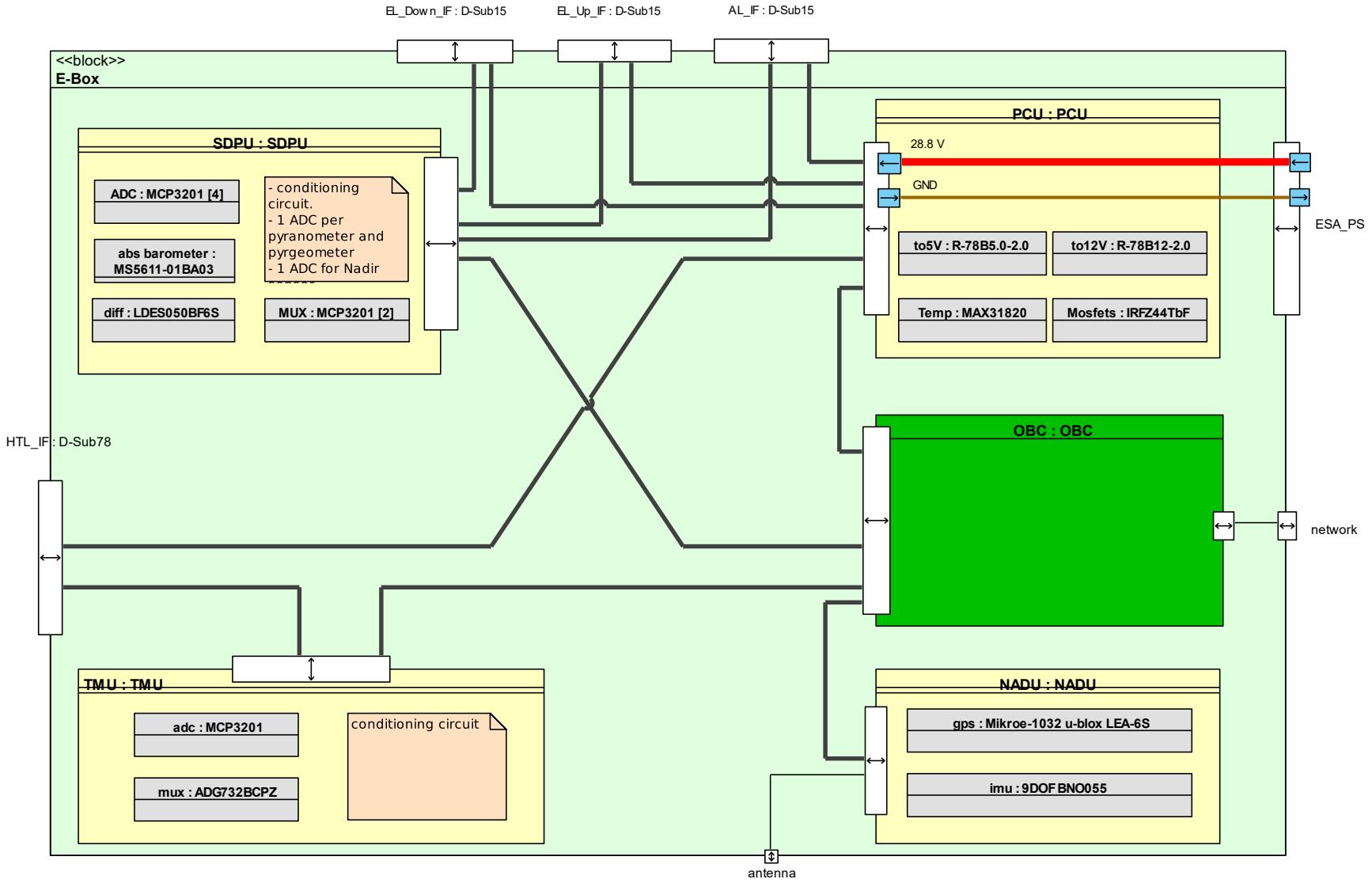
1 GB SDRAM LPDDR2.

Micro SD card available for data storage; eMMC flash is also available.

Ethernet adapter will be needed to communicate with E-Link.



Electronics



COTS Equipment

Collaboration or sponsorship

The total cost budget of the experiment is 120000 € regarding materials, sensors, manufacturing, testing, manpower, travelling, outreach, etc.

We are looking for:

- PCBs manufacturer.
- Electronics supplier.
- Financial support.

We would appreciate any kind of collaboration or sponsorship. All institutions and companies participating in HERCCULES would be published in the website, social media, public events, etc.

More information:

https://rexusbexus.net/

https://blogs.upm.es/herccules/

http://www.idr.upm.es/index.php/es/

Contact:

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david.gonzalez@upm.es

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