Deep Space Microsatellite Power System Development ASFAE/2022/021
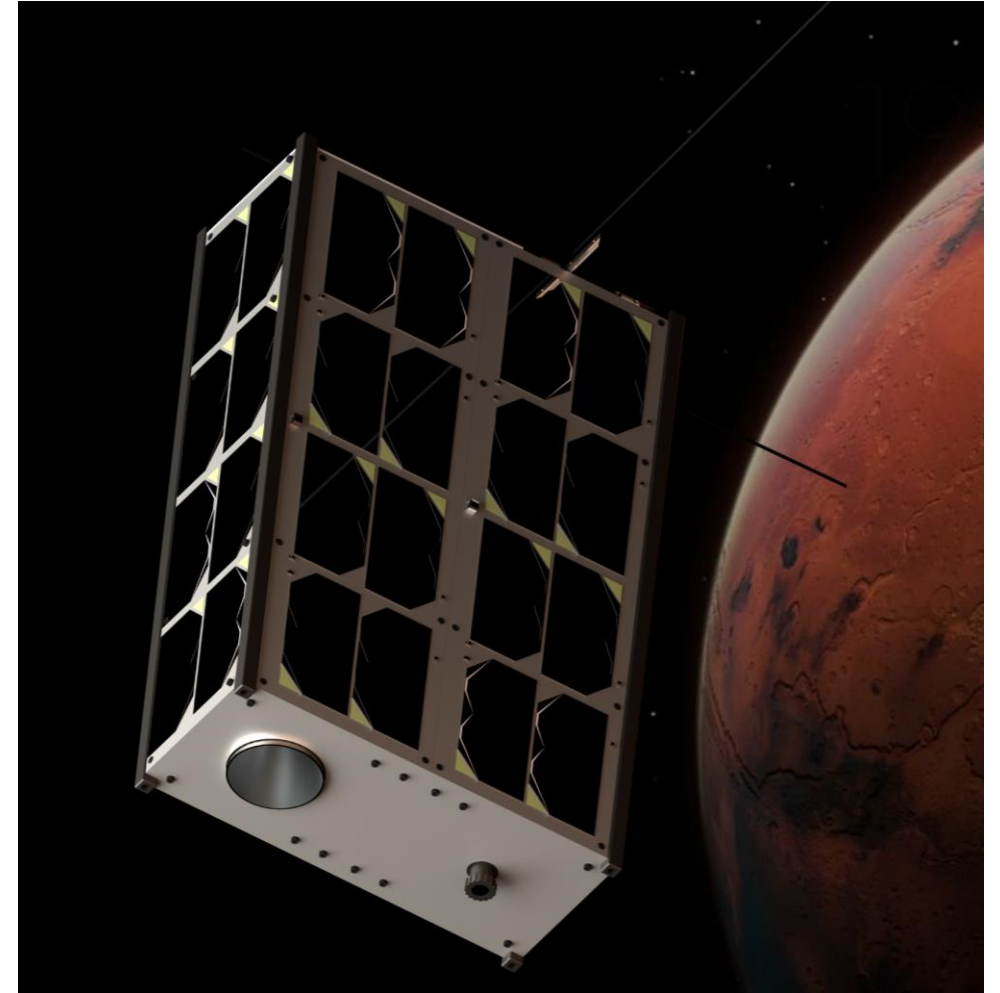
José Manuel Blanes Martínez

Universidad Miguel Hernández de Elche

Marzo 2024, Alicante

Presentation Outline

- Introduction
- Project Goals
- PCDU Proposed Architecture
- Facilities / Equipment Acquired
- Actual Project State and Remaining Tasks
- Questions

Introduction – Project Team

More than 20 years working together in Power Electronics for Space Applications

IPs: José Manuel Blanes Martínez   jmblanes@umh.es
   Ausiàs Garrigós Sirvent   augarsir@umh.es
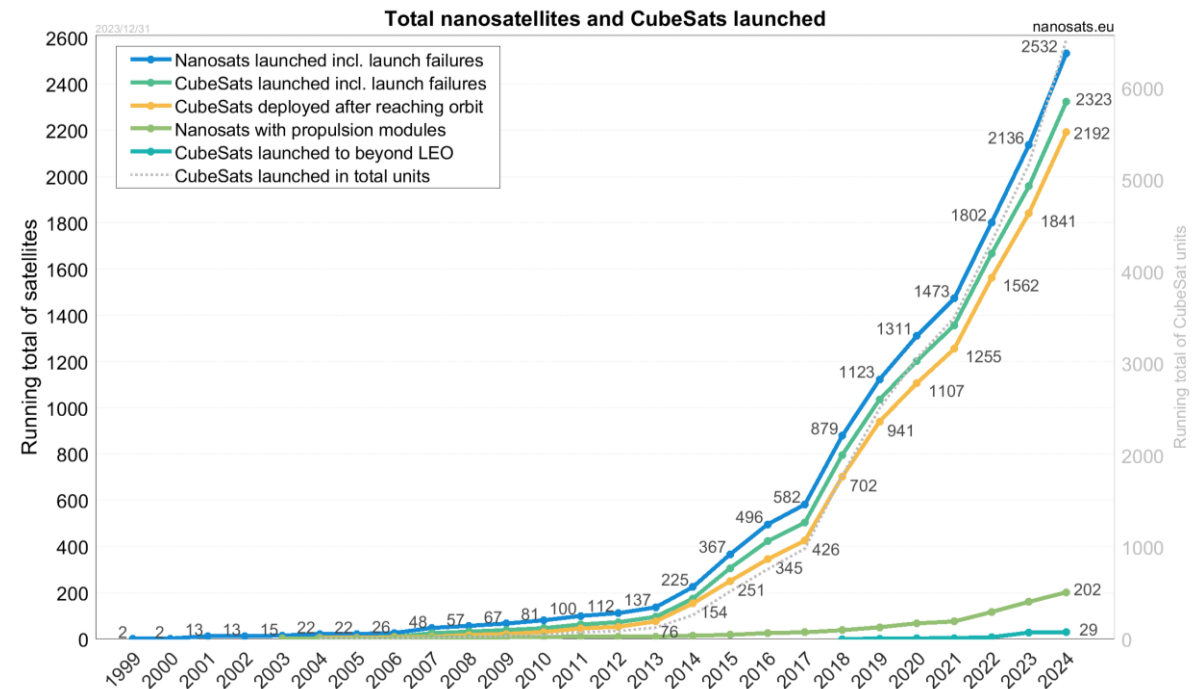
Introduction – Rise of Cubesats

- Traditionally used in the past by universities for educational purposes
- Exponential grow during the last years of Cubesats ("New Space")
- Cost effective solution (Reduced Complexity - COTS components)
- Rapid development timelines

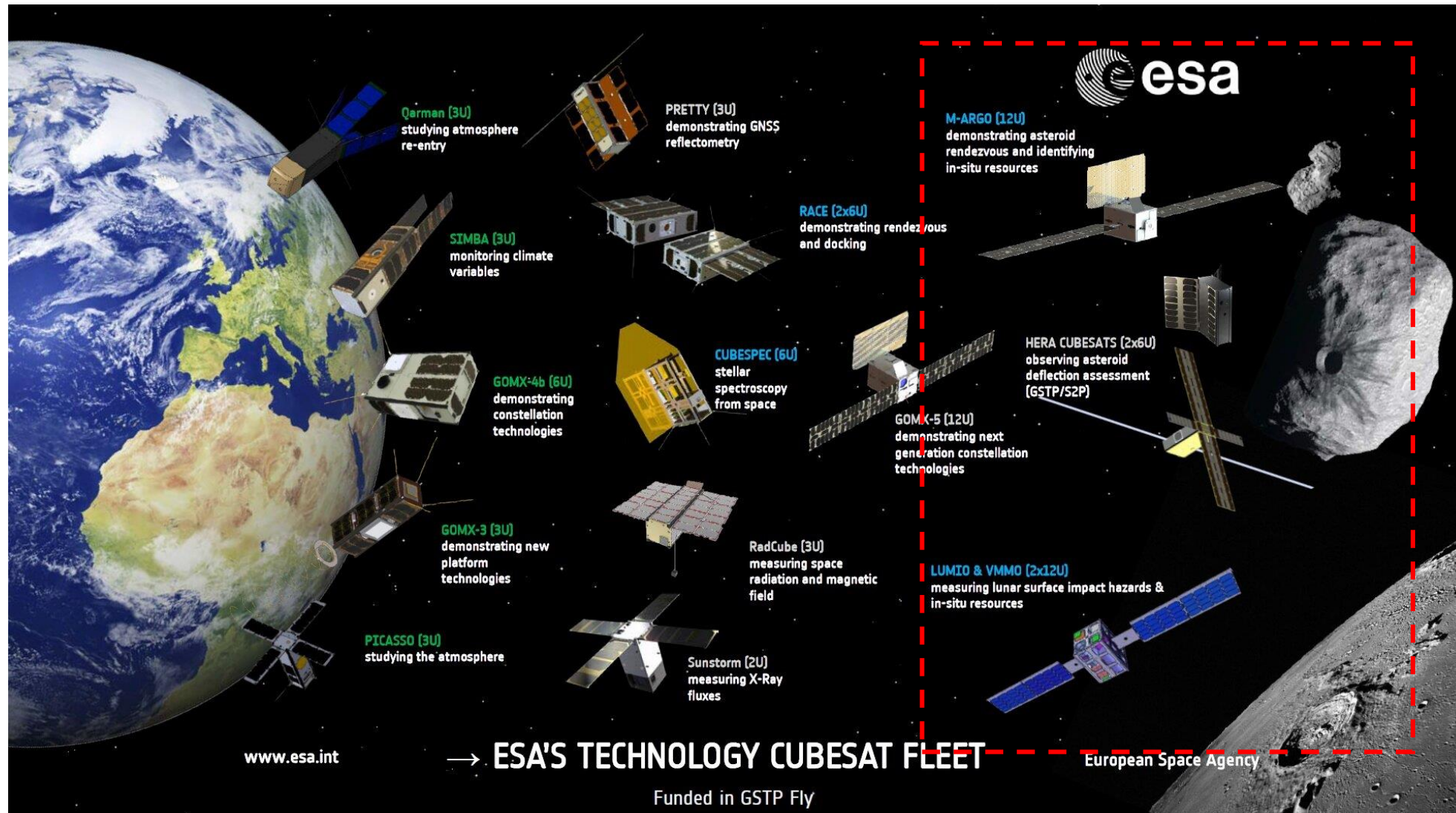- Reduced complexity at the expense of Higher Risks

1U

12U

Total nanosatellites and CubeSats launched
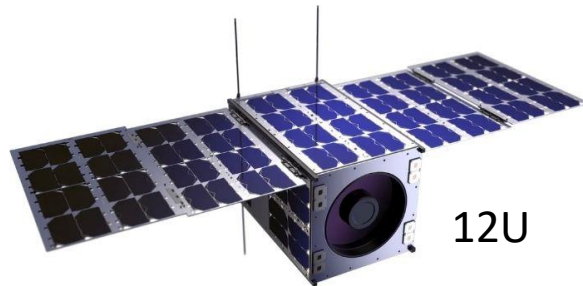
Introduction – Cubesats in Deep Space Missions

Introduction – Cubesats in Artemis I (Deep Space)
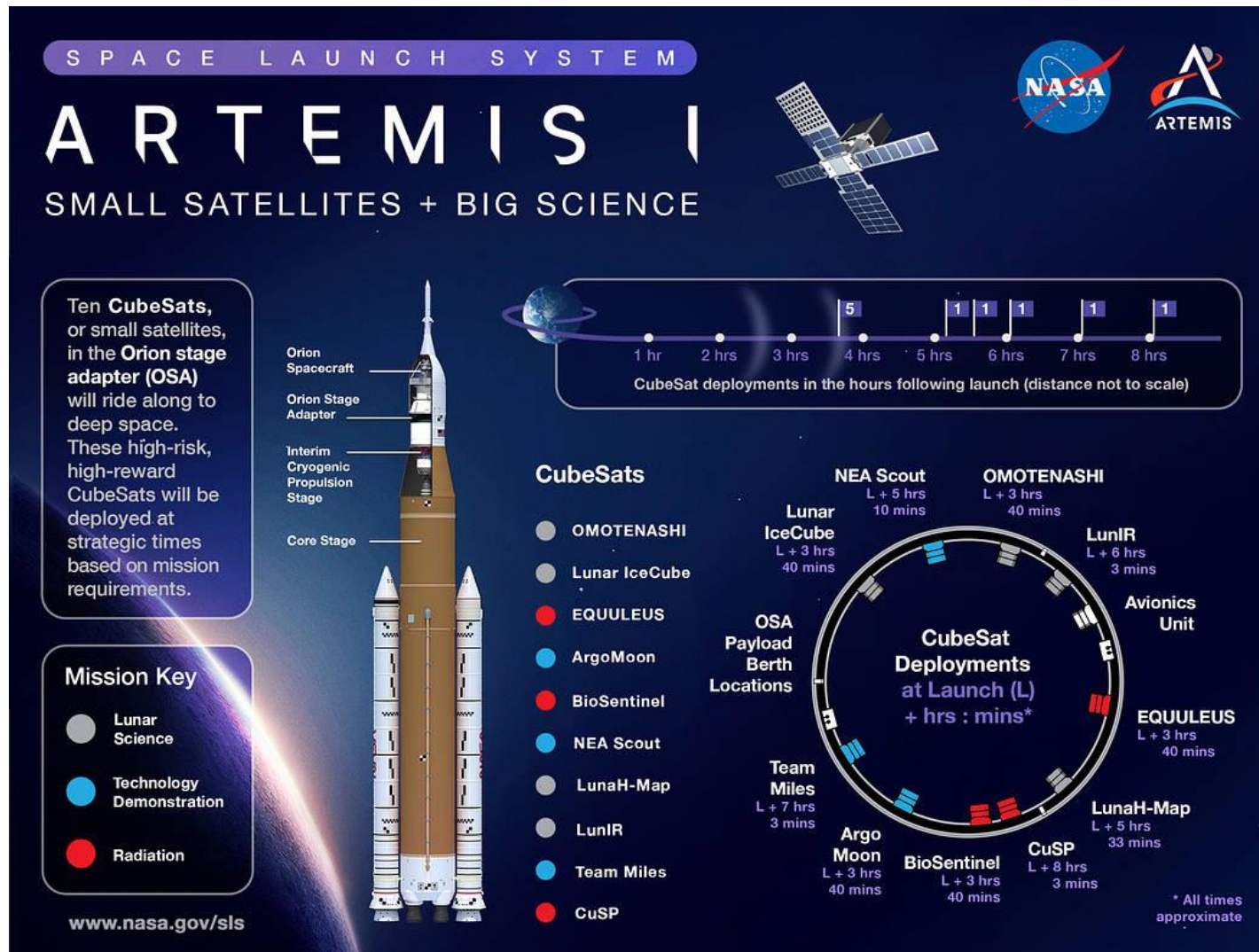
6U Cubesats

BioSentinel
EQUULEUS

Argomoon

LunaHMap
Lunar IceCube
CuSP
LunIR
Omotenashi
**Team Miles**
NEA Scout

Project Goals

- Deep Space Exploration Microsatellite PCDU system development
  - Very low temperature
  - High radiation dose

  - Use of commercial components (COTS)
    - Identify electronic components and battery cells
    - "Careful COTS approach"

  - High reliability
    - Protections and Redundancy for critical functions
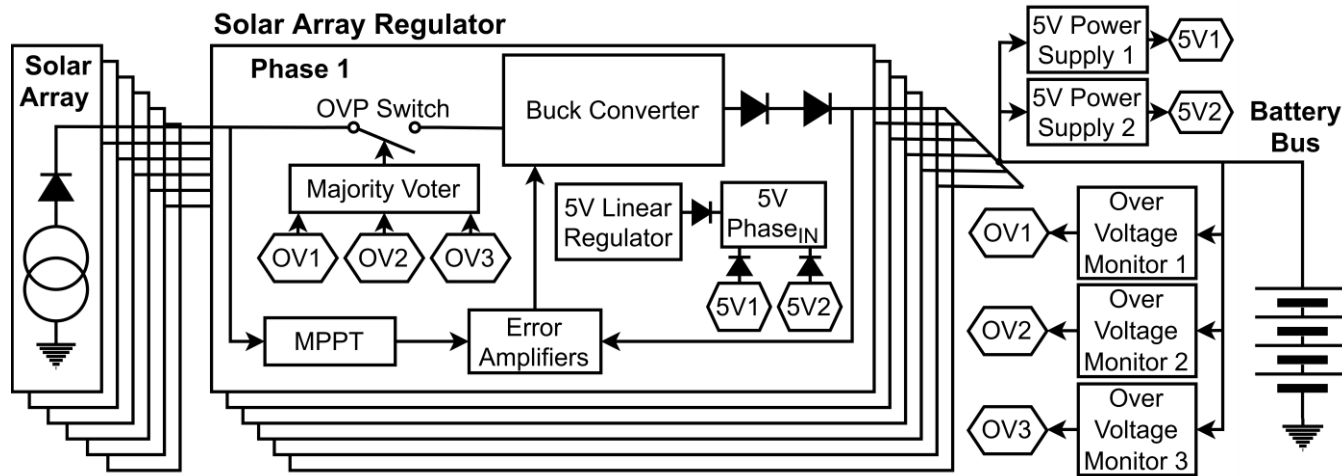
- Validation System development

# PCDU Proposed Architecture - 6U

- Block diagram
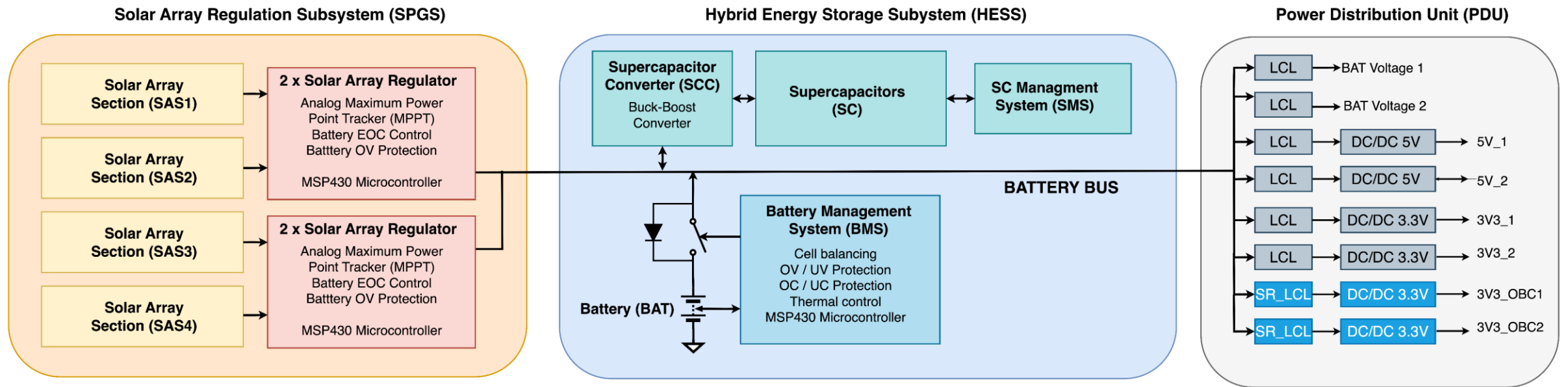
# PCDU Architecture – Solar Array Regulator (SAR)

C. Torres, J. M. Blanes, A. Garrigós, D. Marroquí and J. A. Carrasco, **"High-Reliability Solar Array Regulator for Deep Space Exploration Micro-Satellites"** in IEEE Access, vol. 11, pp. 94138-94147, 2023

One SAR failure without propagation can be assumed (25% power lost)

- COTS: Extended temperature range automotive qualified components
- Analog MPPT
- LT3845 (RH3845)
- Double control loop
- μController only for Telemetry
- Redundancy and Protections
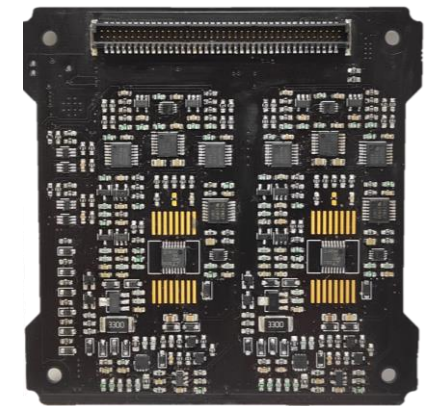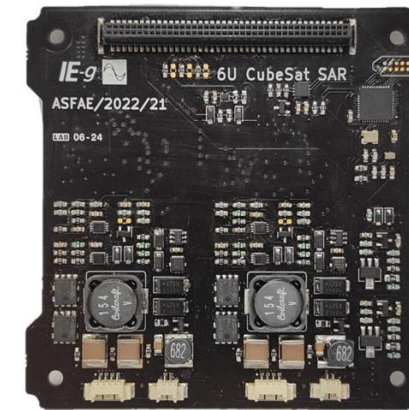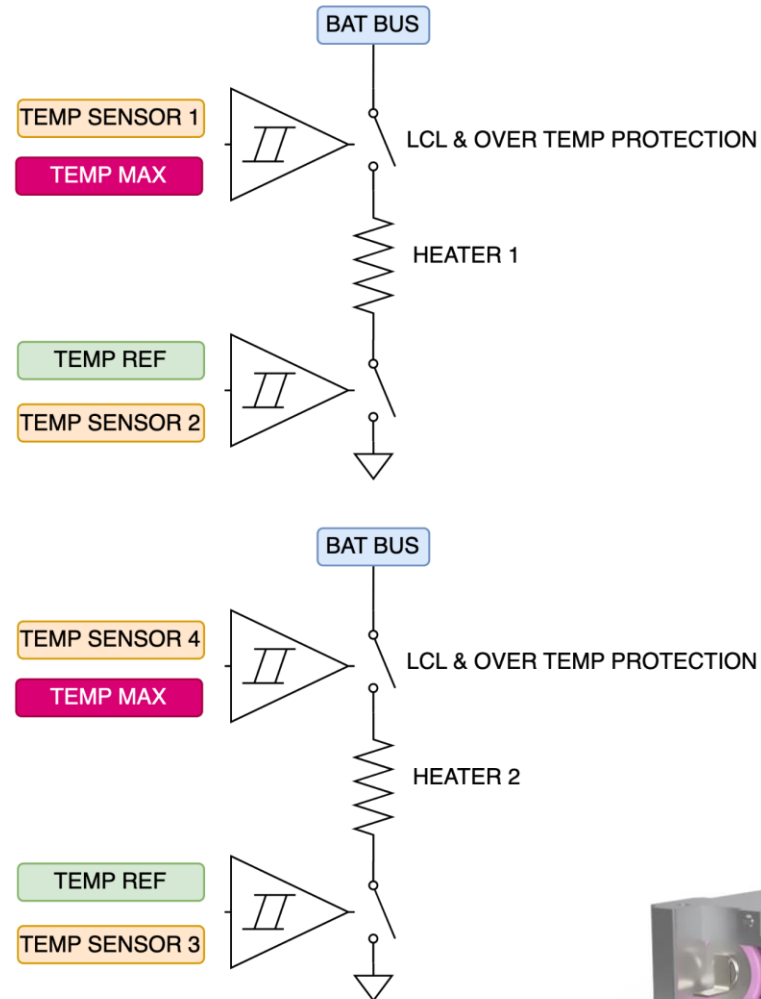
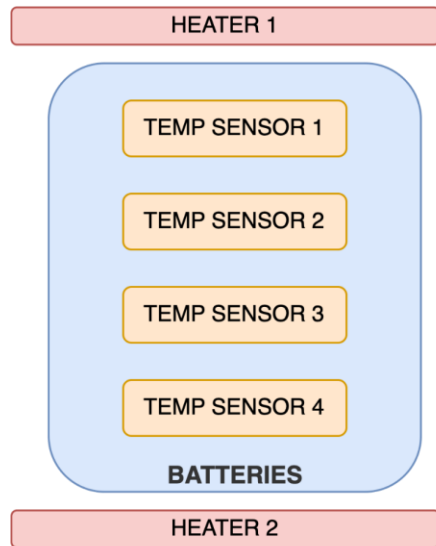# PCDU Architecture – Battery Management System (BMS)
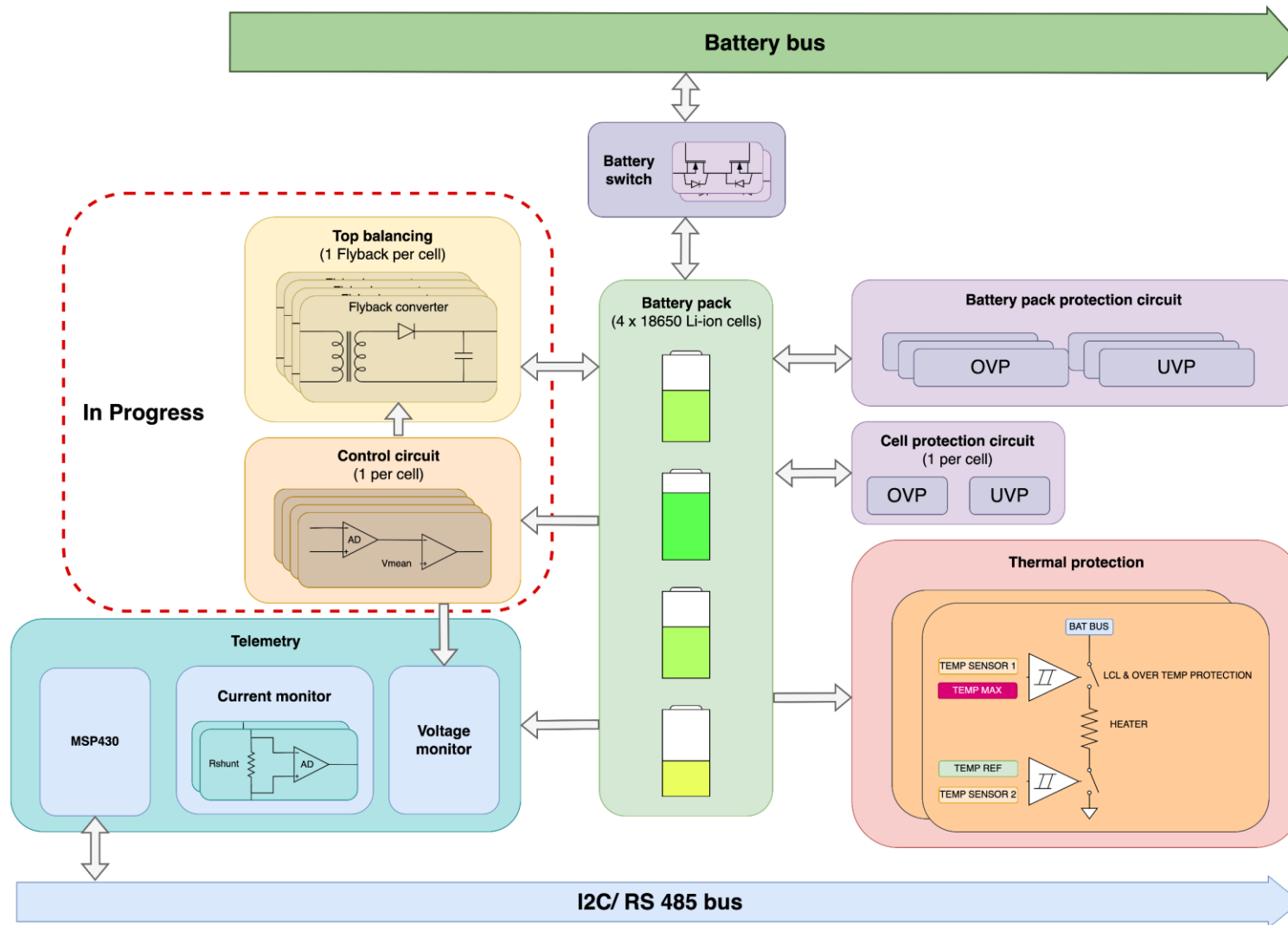
- Battery and Cells OVP / UVP
- Cell voltage equalizar
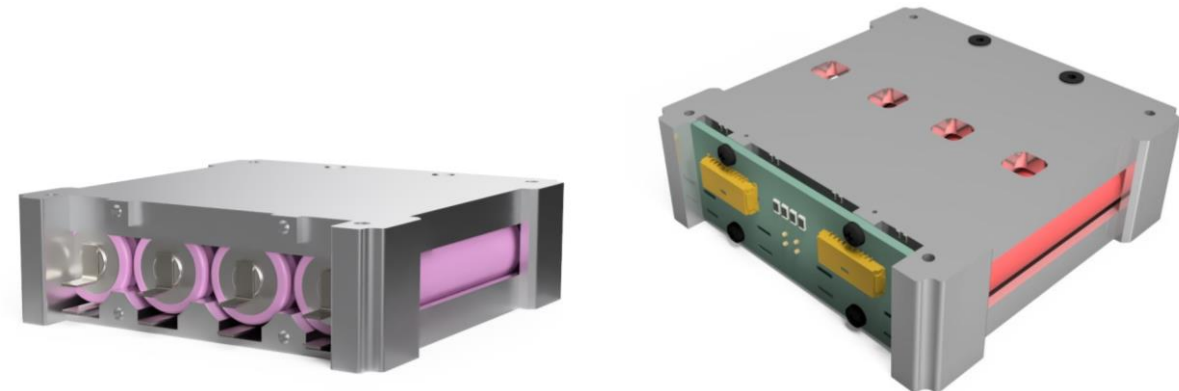- Thermal control (Heaters)
- µController only for Telemetry

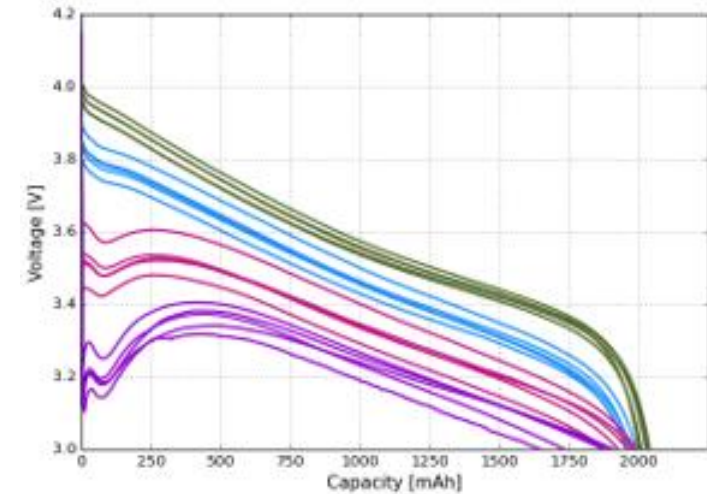# PCDU Architecture - Heaters

- Critical element
- Redundancy
- 4 Temperature Sensors
- Over Temperature Protection

PCDU Architecture – Power Distribution Unit (PDU)

- Vbat, 5V, 3.3V
- Redundancy in all the distributed voltages
- OC and UV protections (LCL)
- OBC dedicated redundant supply lines
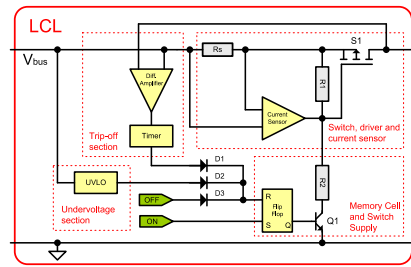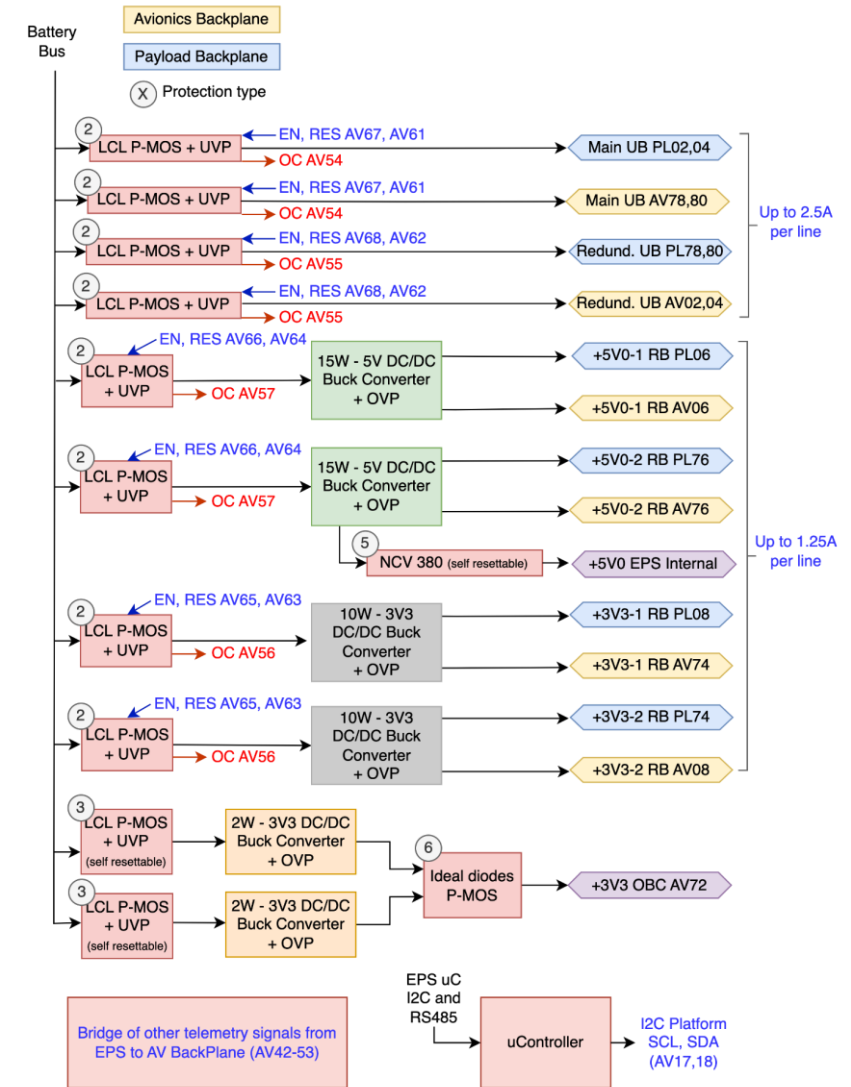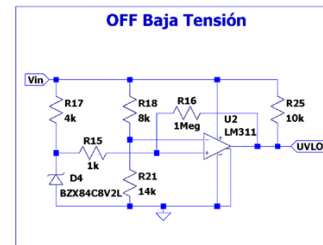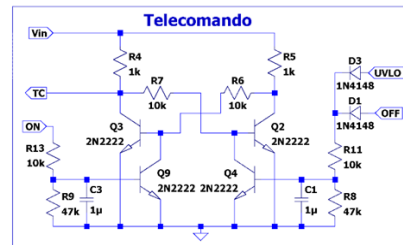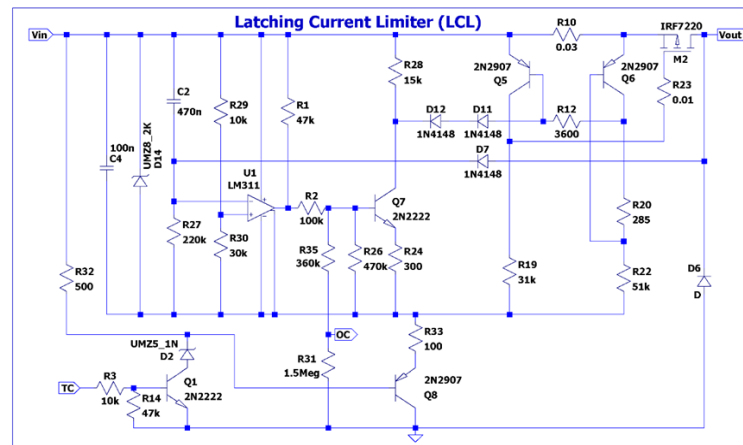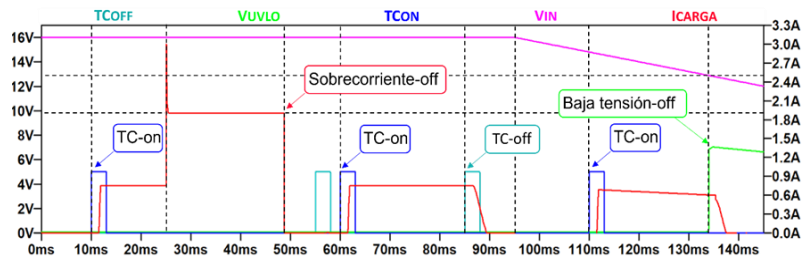- DC/DC LT3845 Controller
- µController only for Telemetry

Figure 5-1: LCL generic block diagram

ECSS-E-HB-20-20A

PCDU Architecture – Hybrid Energy Storage Subsystem (HESS)

Hybrid ESS can offer additional benefits, particularly with respect to high current capability at lower temperatures, along with greater cycle life.
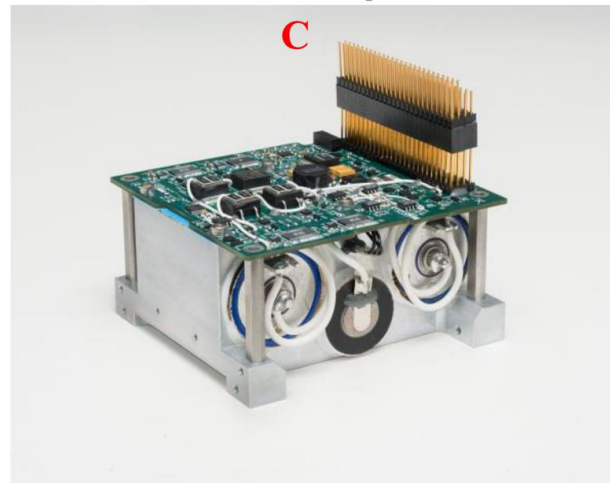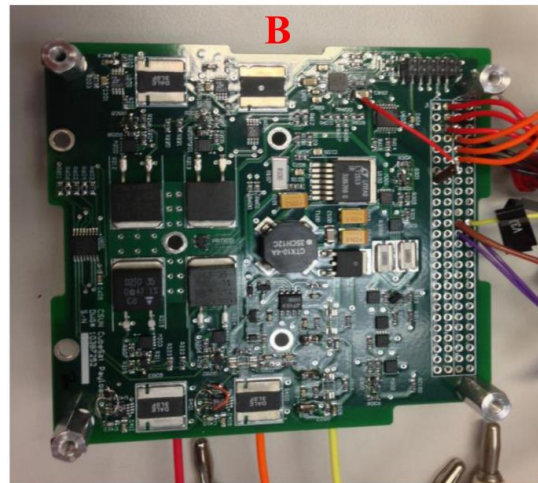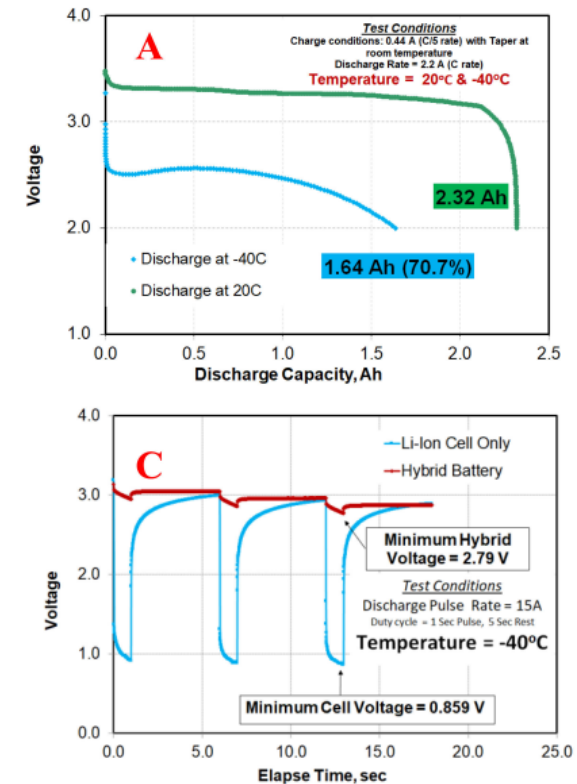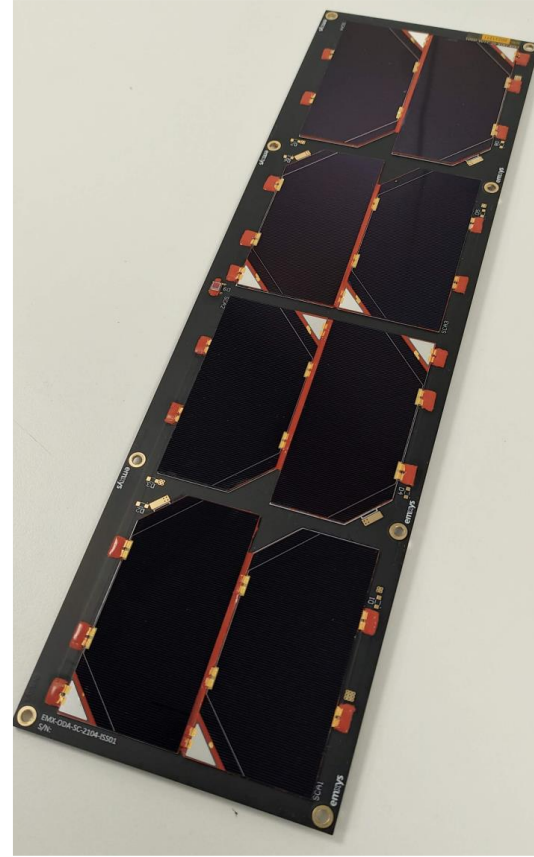

Figure 4.
A) Functional block diagram of payload electronics board. B) Prototype engineering model of JPL's payload electronics board. C) Integrated hybrid ESS, following thermal vacuum testing.
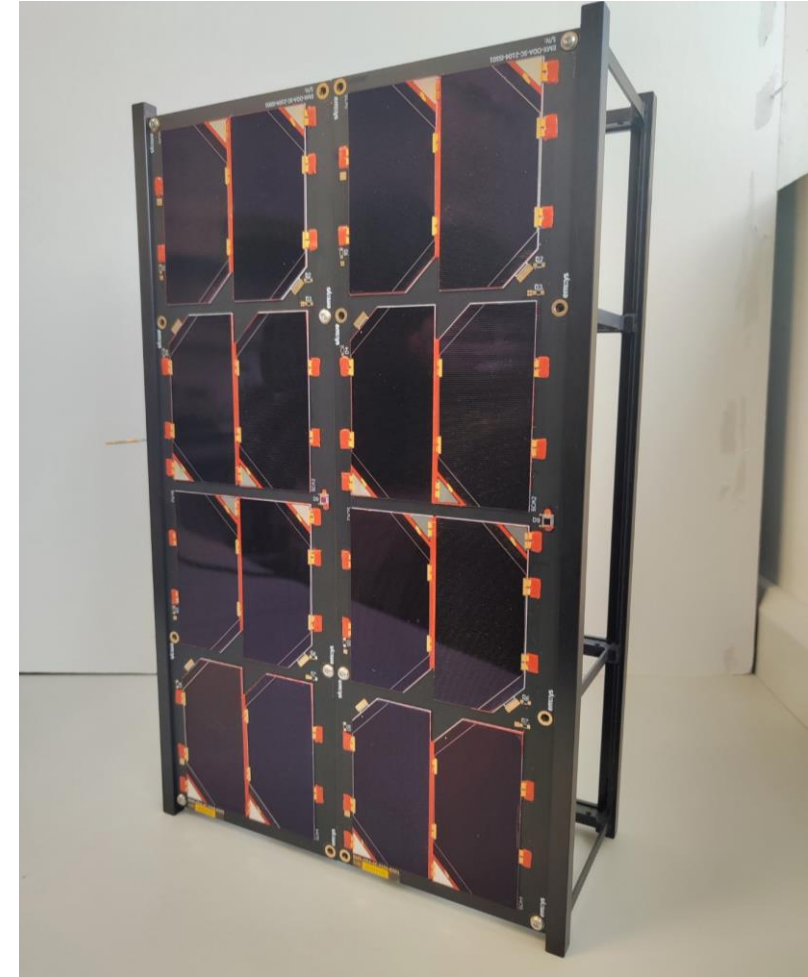
Solar Panels + Structure (6u + 4x8S1P)

6U Cubesat Structure - EMXYS
CubeSat Design Specification Rev. 14.1

8S1P – EMXYS
Cesi CTJ30-SCA

Structure + 2x8S1P

Facilities – Battery Characterization System

Climatic Chamber
CCI (Serial number: P12803)

BCM PCB
COOLuSAT_BCM-v1-PCP

5 x 4-wire connection

Pt100

5 x Pt100
5 x Vcell
5 x Icell

Digital Multimeter
Agilent 34401A

DAQ
Agilent 34970A

Bidirectional Power Supply
1 x ITECH M-3412
4 x ITECH M-3612

RS232

GPIB

USB

GPIB to USB
Agilent 82357B

USB

USB

USB

PC
BCM program (Python)
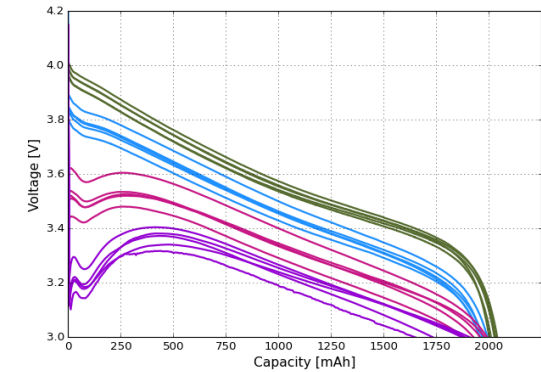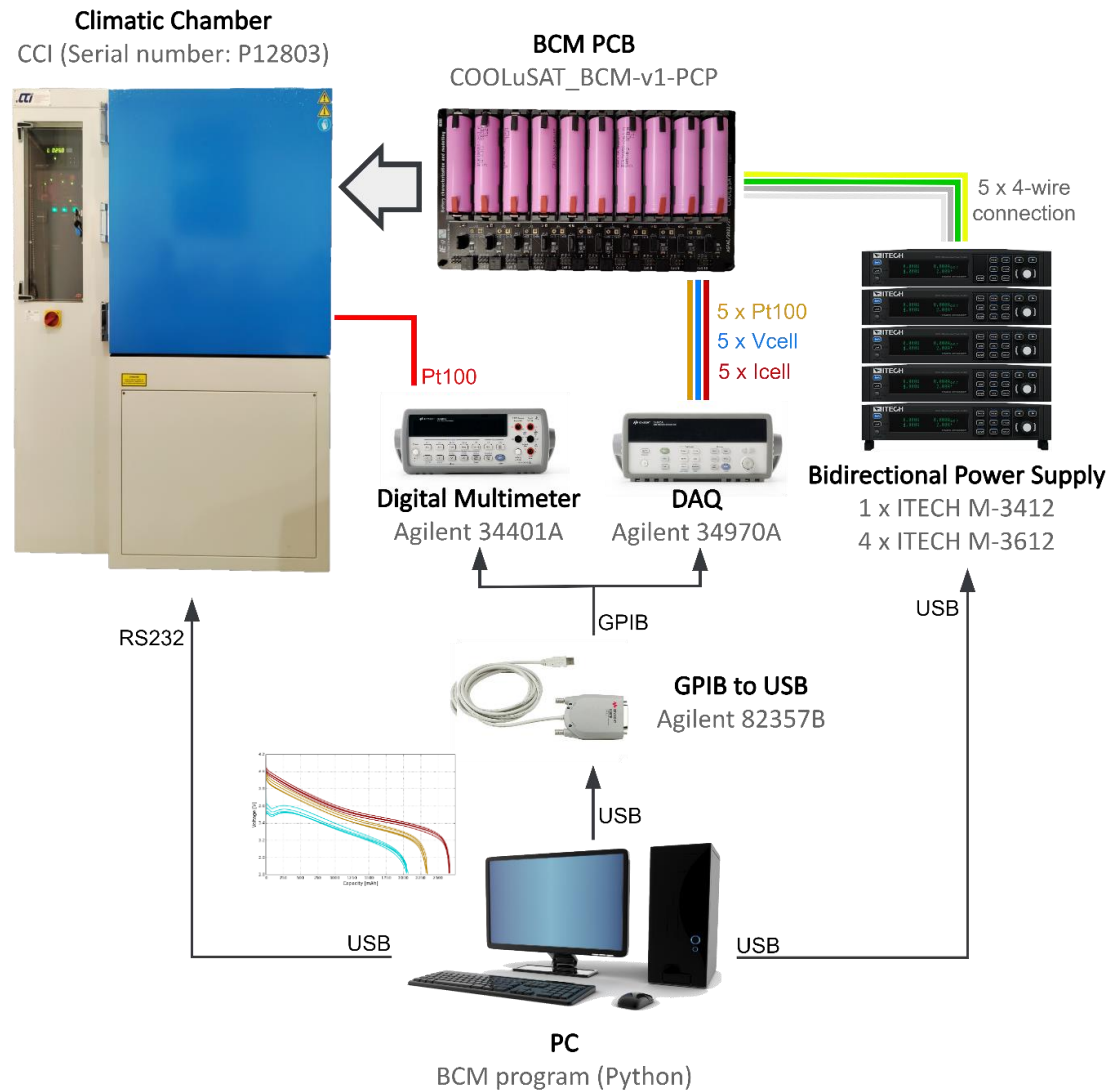
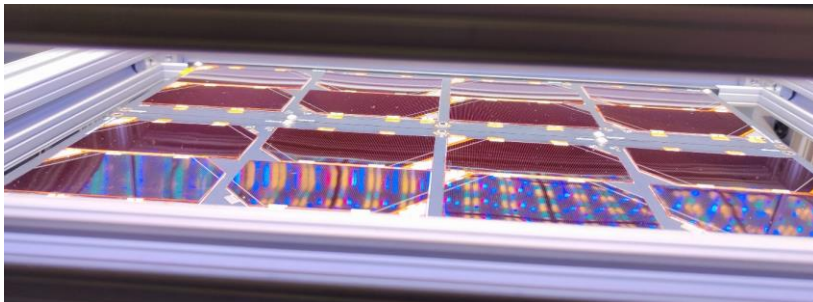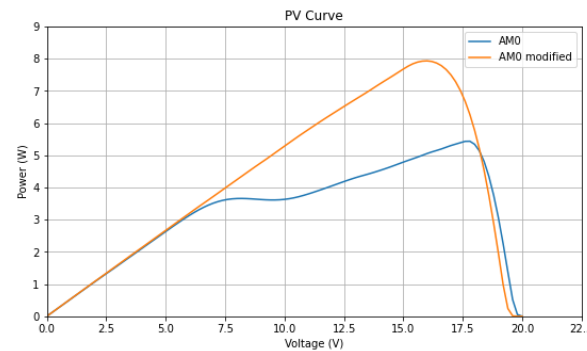**12 different battery cells characterized**

Facilities – Sun Simulator

G2V SUNBRICK

       LED LARGE AREA SOLAR SIMULATOR 20x80 cm2

       32 Channels

SMU KEITHLEY 2461

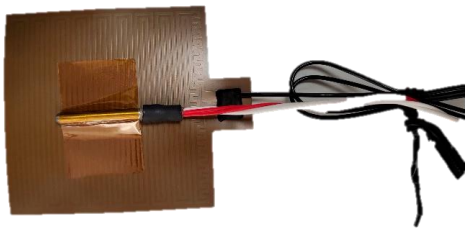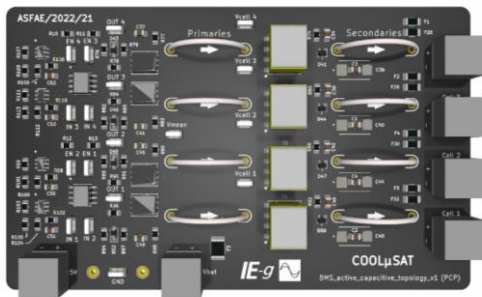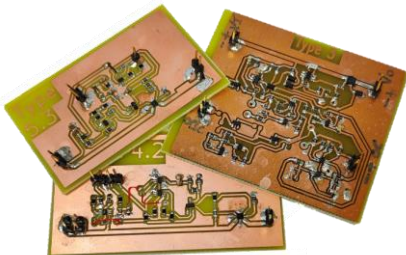# Tasks Ongoing

Summary

✓ SAR Implementation - Completed

➢ BMS Implementation – Heaters – Ongoing

➢ PDU Implementation – Ongoing

❖ HESS Implementation - Remaining

✓ Battery Charge/Discharge Tests – Completed

➢ SuperCapacitors Tests – Ongoing

❖ Battery Spectroscopy Impedance Tests - Remaining

❖ PCDU Full Integration and Tests- Remaning
  ❖ Functional Tests
  ❖ Temperature
  ❖ Radiation
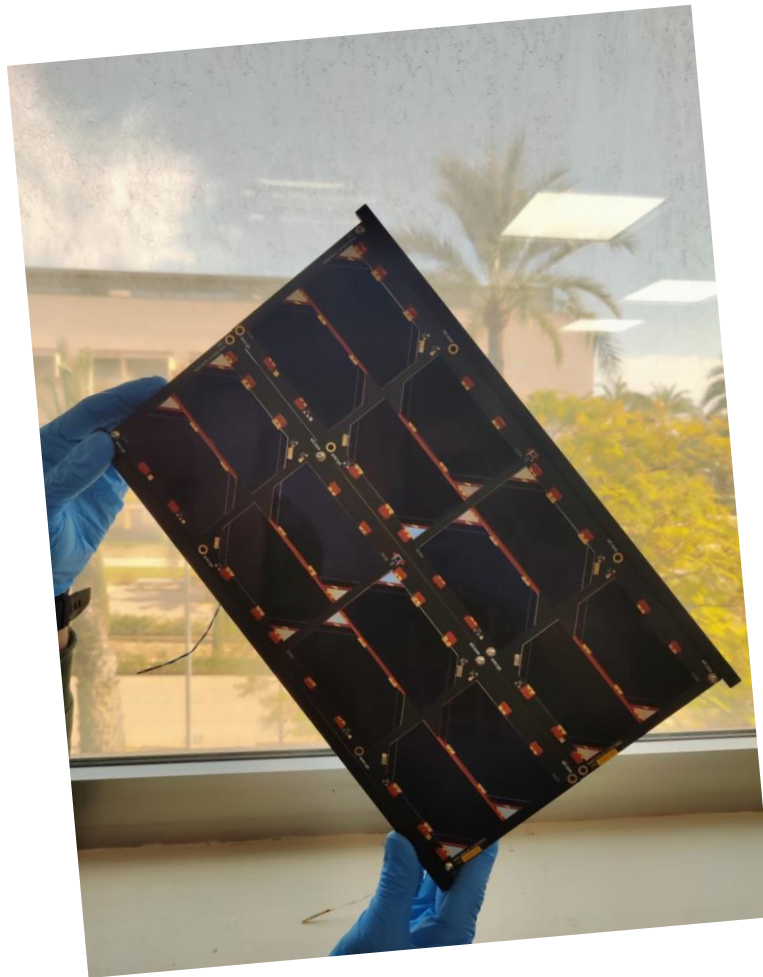
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