



# LASP

HEX20

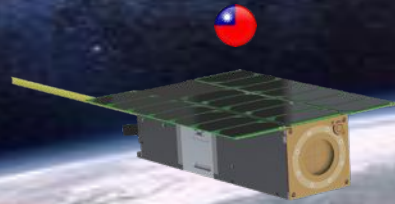
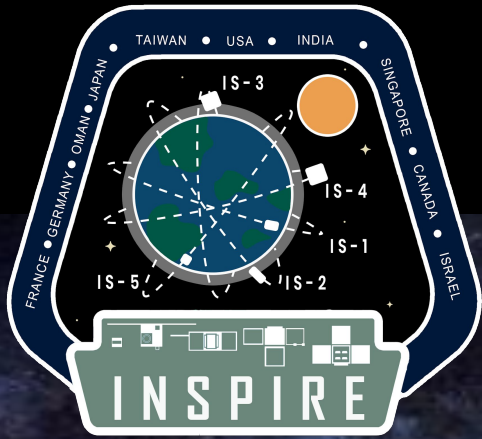
## The COSPAR-1 Mission: Advancing Space Science through Capacity Building

Amal Chandran, LASP SmallSat Chief Engineer

Carlos Gabriel, COSPAR Capacity Building Chair



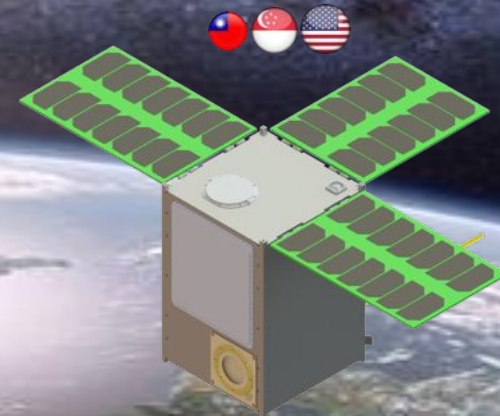
# The INSPIRE Small Sat Program at LASP



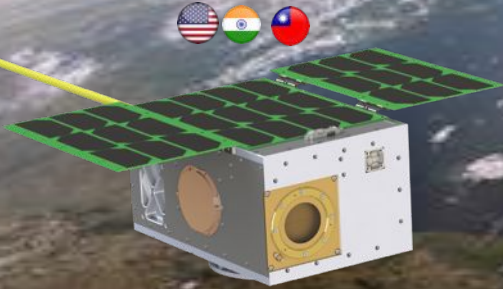
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INSPIRESat-4



INSPIRESat-6



INSPIRESat-1



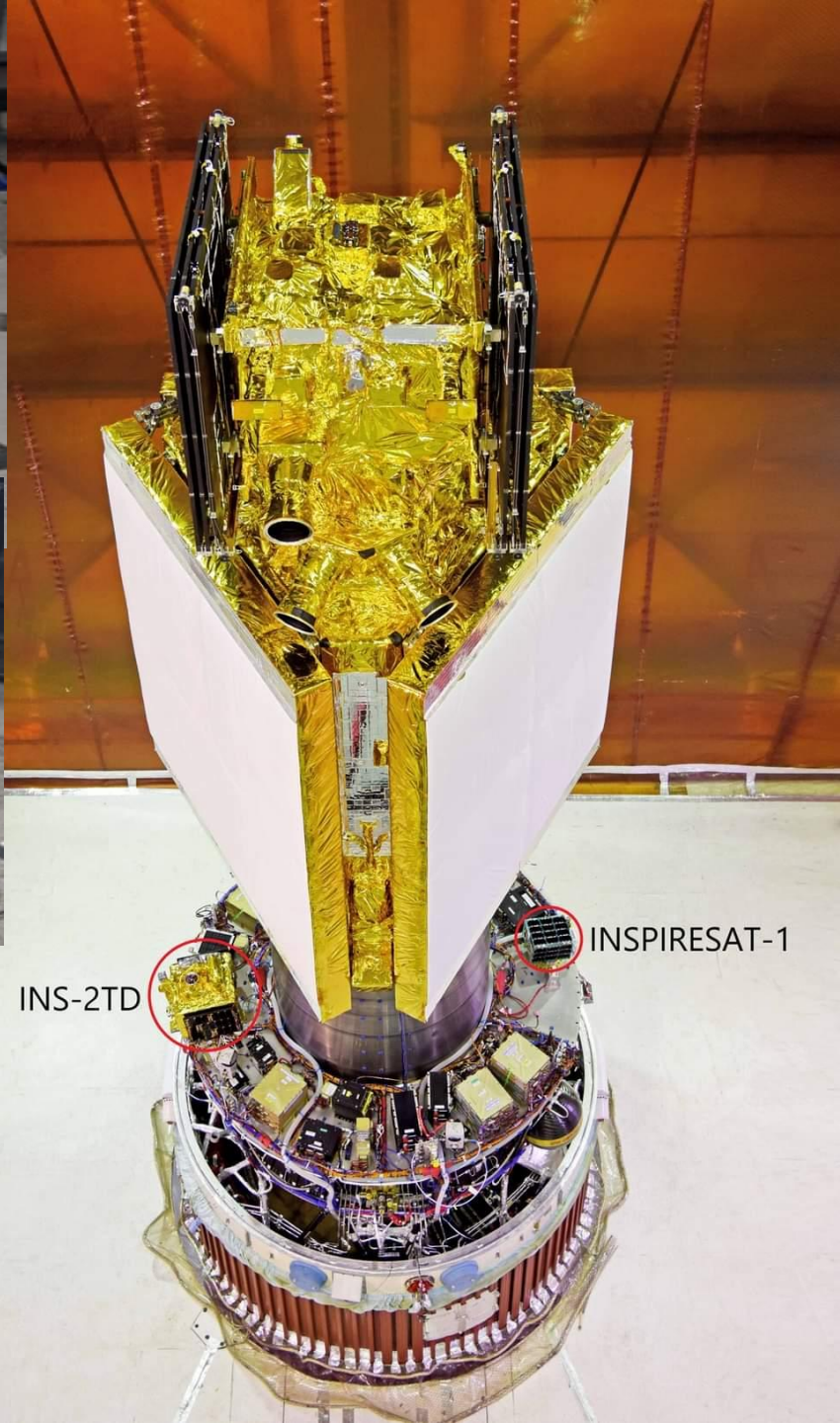
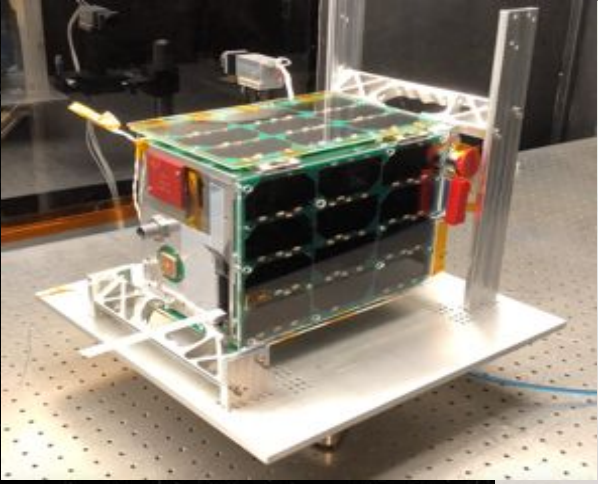
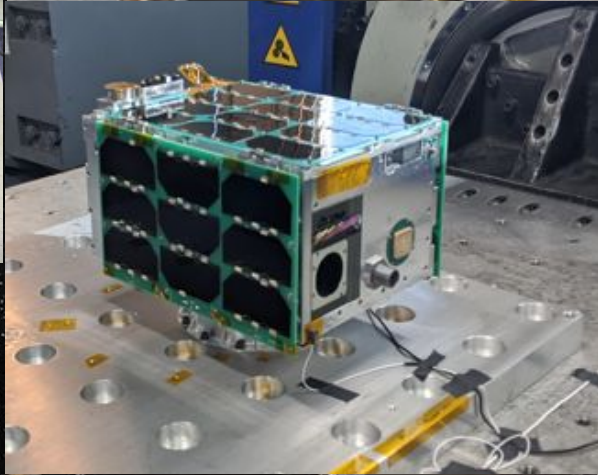
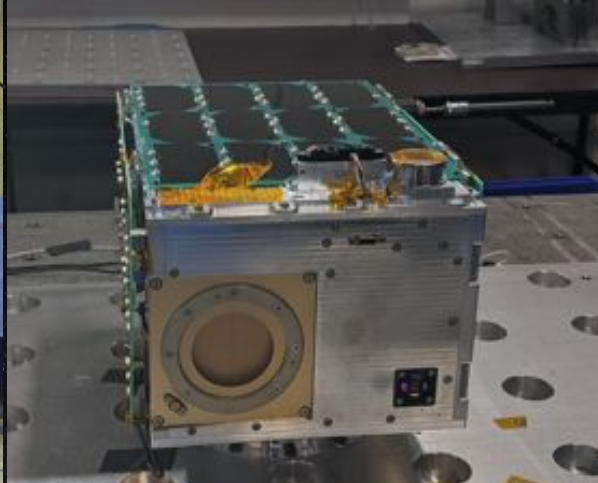
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# COSPAR-INSPIRE Tie up

- At the 2019 COSPAR symposium in Herzliya, the idea of tying up INSPIRE with COSPAR was discussed.
- COSPAR has a capacity building initiative which is limited to satellite science data analysis. The INSPIRE tie-up would bring satellite hardware element to their capacity building efforts.
- A COSPAR task group for a constellation of small satellites (now a panel) was formed with Dan Baker as Chair and Amal C as vice chair.
- COSPAR to work as a facilitator (and science enabler) to enable constellations utilizing member states efforts for objectives such as space weather observations, climate change measurements etc.
- The COSPAR-INSPIRE tie-up and summer programs started in 2024 for the COSPAR-1 mission.

# COSPAR designated Center of Excellence for SmallSats/CubeSats

The INSPIRE-COSPAR plan for capacity building and international collaboration includes:

- ❑ **Connect a regional CubeSat center of excellence with an emerging nation for Capacity Building**
- ❑ LASP small sat group was identified as a center of excellence for CubeSats and National Institute of Engineering in Lima, Peru was identified as a partner institute for capacity building.
- ❑ A summer program focused on the teaching of best practices and processes for cubesat and smallsat missions that includes hands on student participation in space science mission development.
- ❑ Professional support and mentoring for design, management, hardware development, launch, mission operations and data systems.
- ❑ Defined processes for sustaining and expanding the capacity building capabilities over multiple build cycles and partnership engagements.

A 10-week summer program, hosted at LASP, is modeled after successful efforts on INSPIRE and initially consists of 14 selected students from current INSPIRE partners and 5 COSPAR selected students from Uni Peru. The students are working on the COSPAR-1 3U mission.

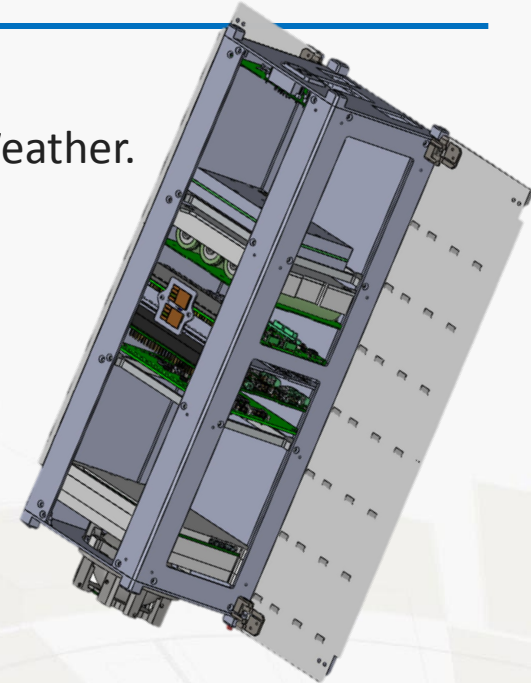
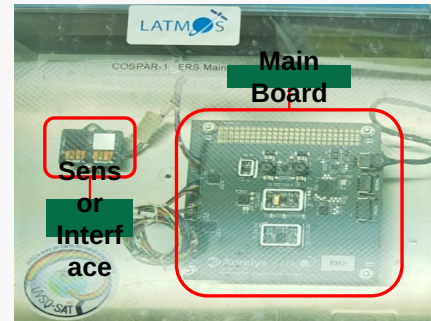
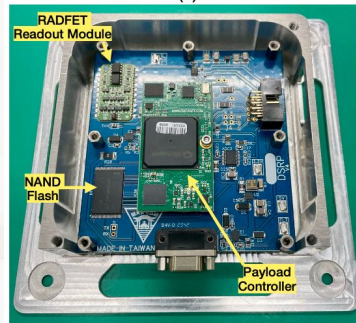
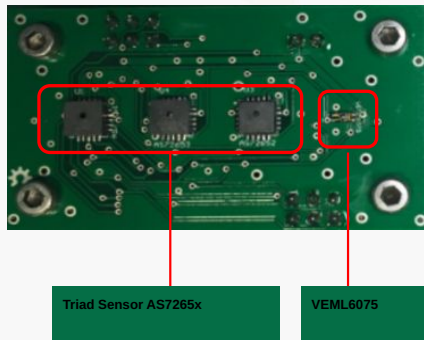
The students are mentored and supported by full time engineering professionals at LASP SmallSat group with the curriculum covering all aspects of spacecraft design, engineering, testing and operations.

**The main objective is to create a sustainable program that partners can use to generate funding within their own countries in the long term.**

# INSPIRE-COSPAR Pilot Program for Capacity Building – COSPAR-1

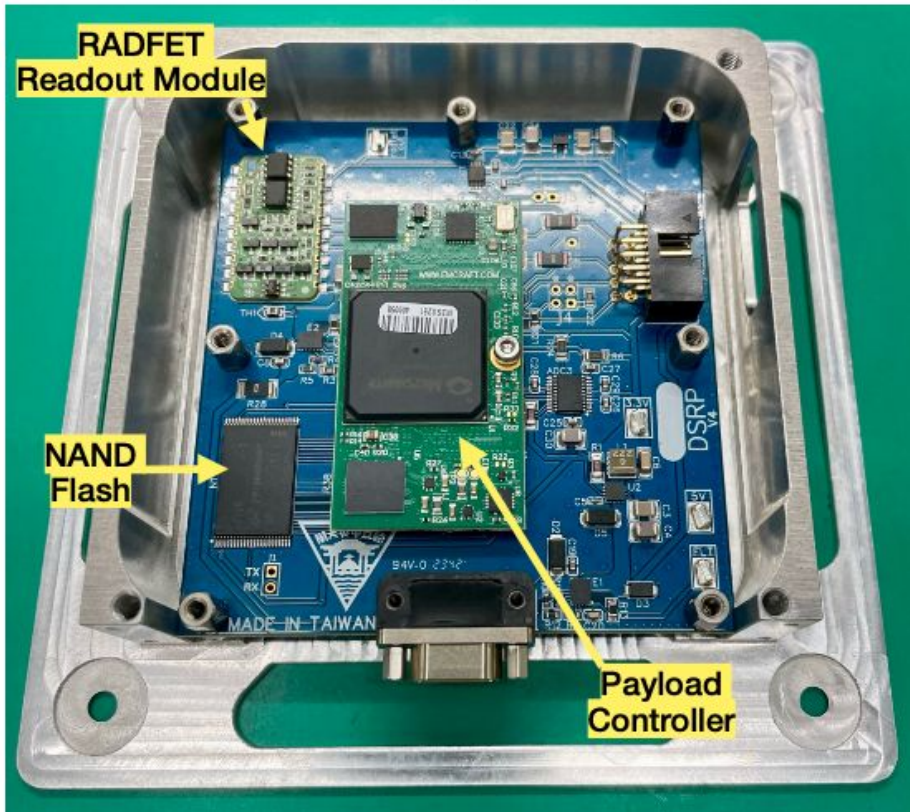
## COSPAR-1 – 3U Spacecraft

- ❑ COSPAR PCSS driven international Industry-Academia collaboration effort in sub-group 1: Space Weather.
- ❑ Spacecraft contributed by HEX20 and launch contributed by Skyroot India.
- ❑ LASP built Solar Spectral Sensor payload; **Measure Incoming Solar Radiation**
- ❑ LATMOS France built Earth long-wave radiation detector; **Measure Outgoing Long Wave Radiation**
- ❑ NCU Taiwan built Dosimeter; **Measure Total Ionizing Dose in LEO environment**



HEX20

# Payload 1: Compact Radiation Probe



CRP is derived from NCU's Deep Space Radiation Probe (DSRP) flying onboard ispace M2 Lunar lander.

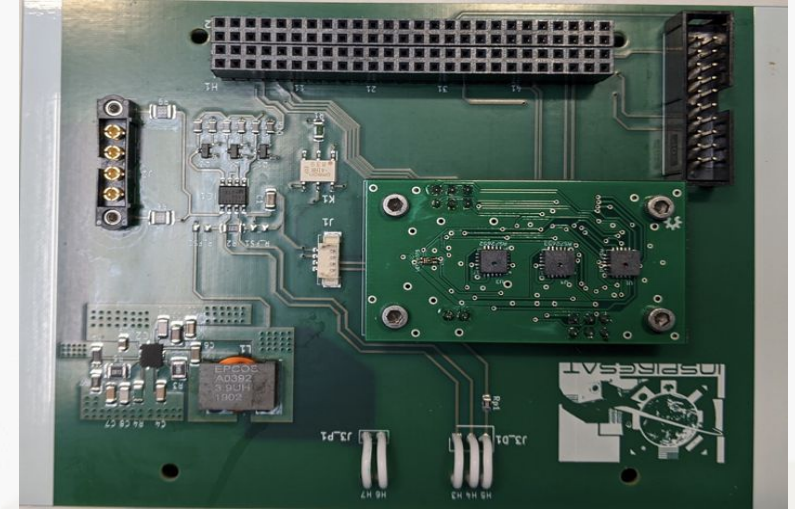
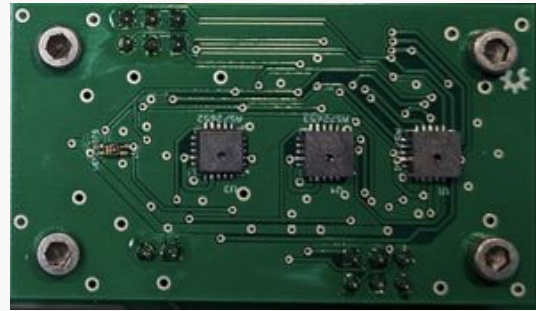
**Purpose:** Ionizing radiation dosimeter payload and Single Event Upset (SEU) counter.

**Sensor:** RADFET radiation dosimeter, Nand flash

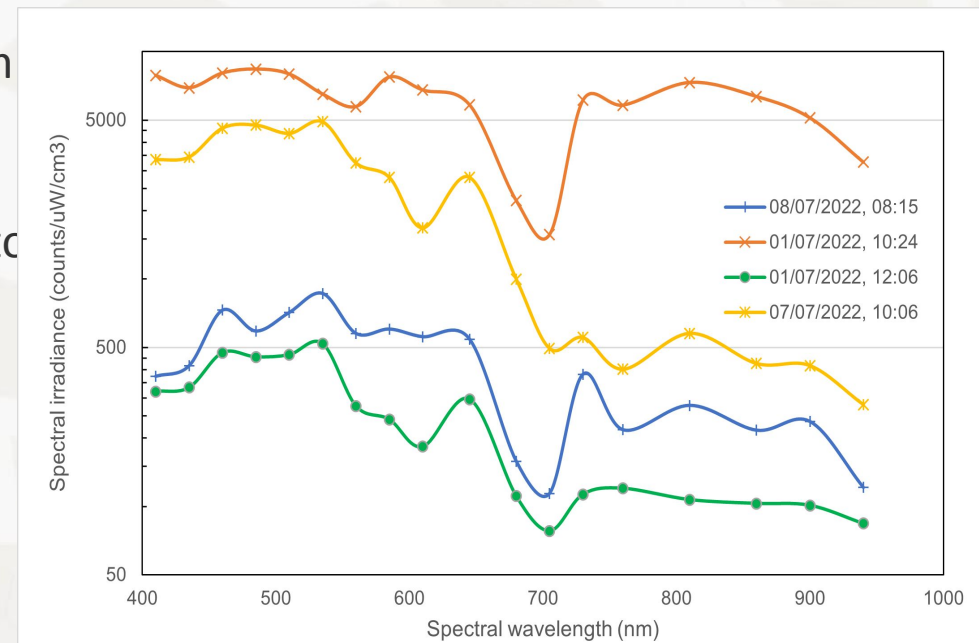
**Controller:** SmartFusion2 SOM (System-On-Module)

**Memory:** Nand Flash (MT29F128G08AJAAWP-ITZ:A TR)

# Payload 2: Solar Spectral Sensor



- SparkFun Triad Spectroscopy Sensor is made up of three sensors; the AS72651, the AS72652, and the AS72653 and can detect the light from 410nm (UV) to 940nm (IR).
- 18 individual light frequencies can be measured with precision down to  $28.6 \text{ nW/cm}^2$  and accuracy of  $\pm 12\%$ .
- Sensors have been calibrated at NIST.
- Flight heritage on SDO rocket calibration flights and SCOOB-I satellite



# Payload 3: Earth Radiation Sensor

The LATMOS payload of the COSPAR-1 (ERS for Earth Radiative Sensors) satellite has been designed to meet scientific requirements for measuring key components of the Earth's Radiation Budget (ERB).

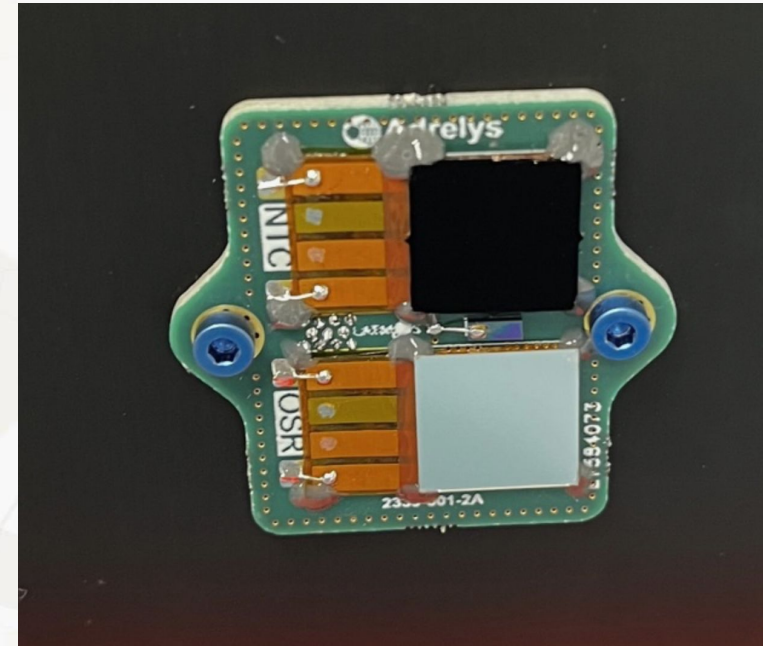
The ERS payload capabilities are specified as follows:

## Outgoing Shortwave Radiation (OSR) Requirements:

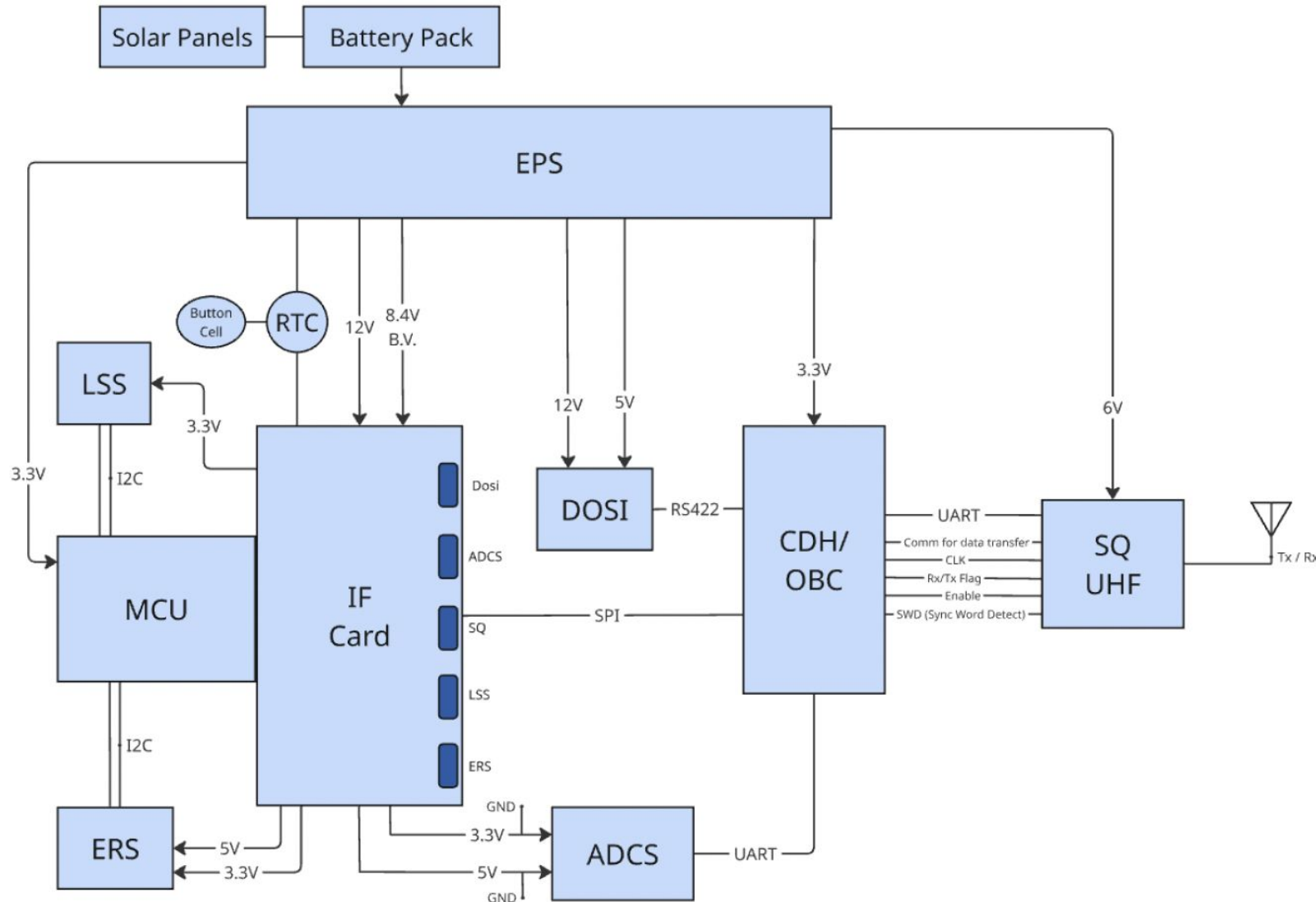
- **Absolute Accuracy:** The ERS is required to maintain an absolute accuracy of  $\pm 5.00 \text{ W m}^{-2}$  for OSR measurements.
- **Stability Per Year:** The satellite must ensure a stability of  $\pm 1.00 \text{ W m}^{-2}$  per year in OSR data, allowing for the reliable detection of gradual changes in radiation reflected by Earth.
- **Spatial Resolution:** It features a spatial resolution of 2500 km, enabling comprehensive coverage and data collection over extensive geographic areas.

## Outgoing Longwave Radiation (OLR) Requirements:

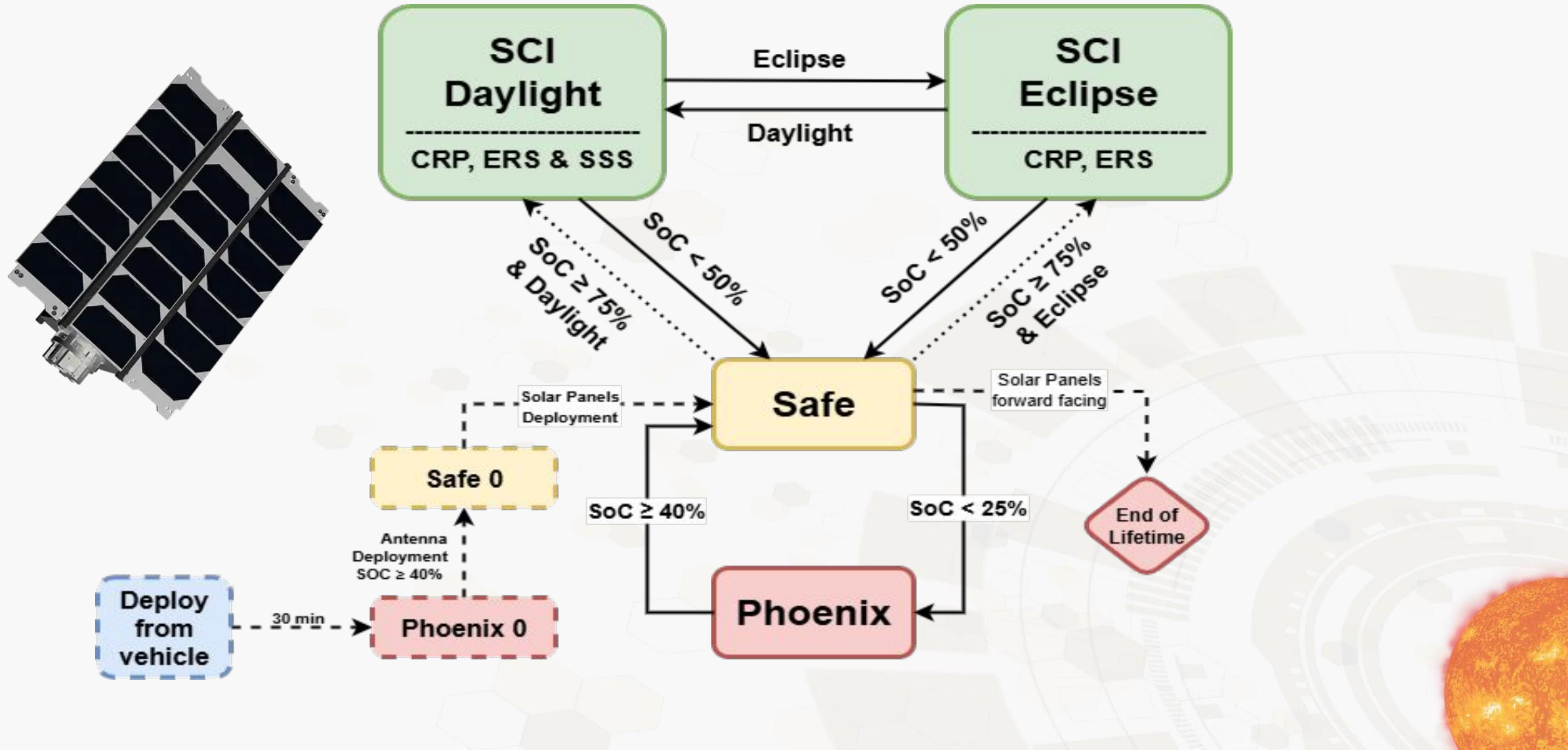
- **Absolute Accuracy:** For OLR, the satellite is expected to achieve an absolute accuracy of  $\pm 5.00 \text{ W m}^{-2}$ .
- **Stability Per Year:** The annual stability of OLR measurements must be maintained at  $\pm 1.00 \text{ W m}^{-2}$ .
- **Spatial Resolution:** The OLR measurements share the same spatial resolution as OSR, set at 2500 km.



# COSPAR-1 Functional Block Diagram



# COSPAR-1 Conops



# COSPAR 1: Data and Power Budget

## 1 Day Data Size, for UHF, 530 km SSO

	Data Rate (Bytes / sec)	1 Day Duty Cycle (%)	Operating Time (sec)	Total Data Size (KB)
CRP-HouseKeeping	1.57	100.00	86400	132.19
CRP-Science Data	0.53	100.00	86400	45.00
ERS (Latmos)	1.50	100.00	86400	126.56
SSS	1.87	68.45	59140	107.81
ADCS				
<b>Total Science Data</b>				411.56
<b>Downlink</b>	1200.00	1.32	1140	1335.94
<b>Margin (%)</b>				224.61



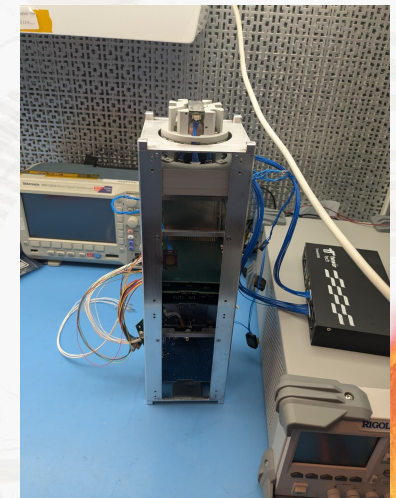
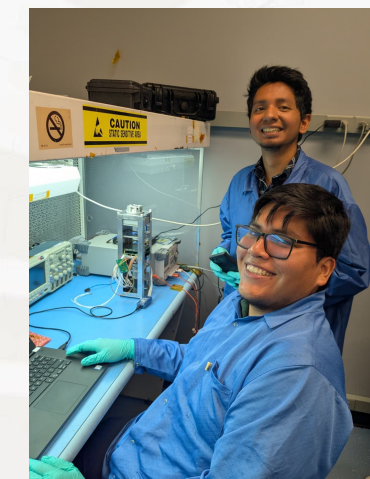
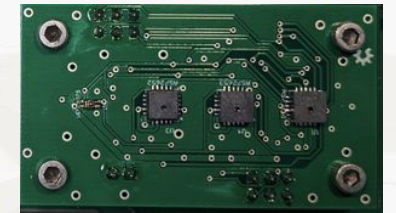
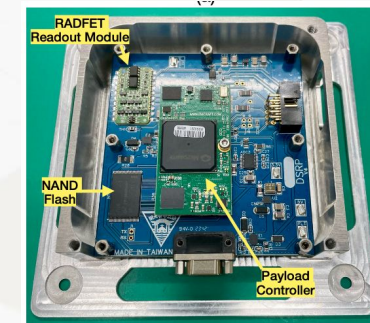
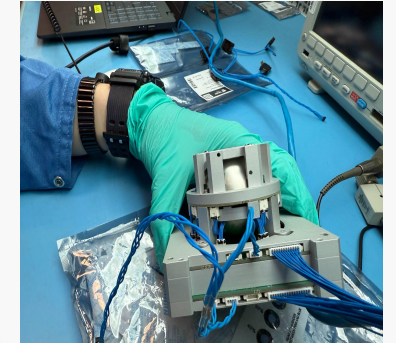
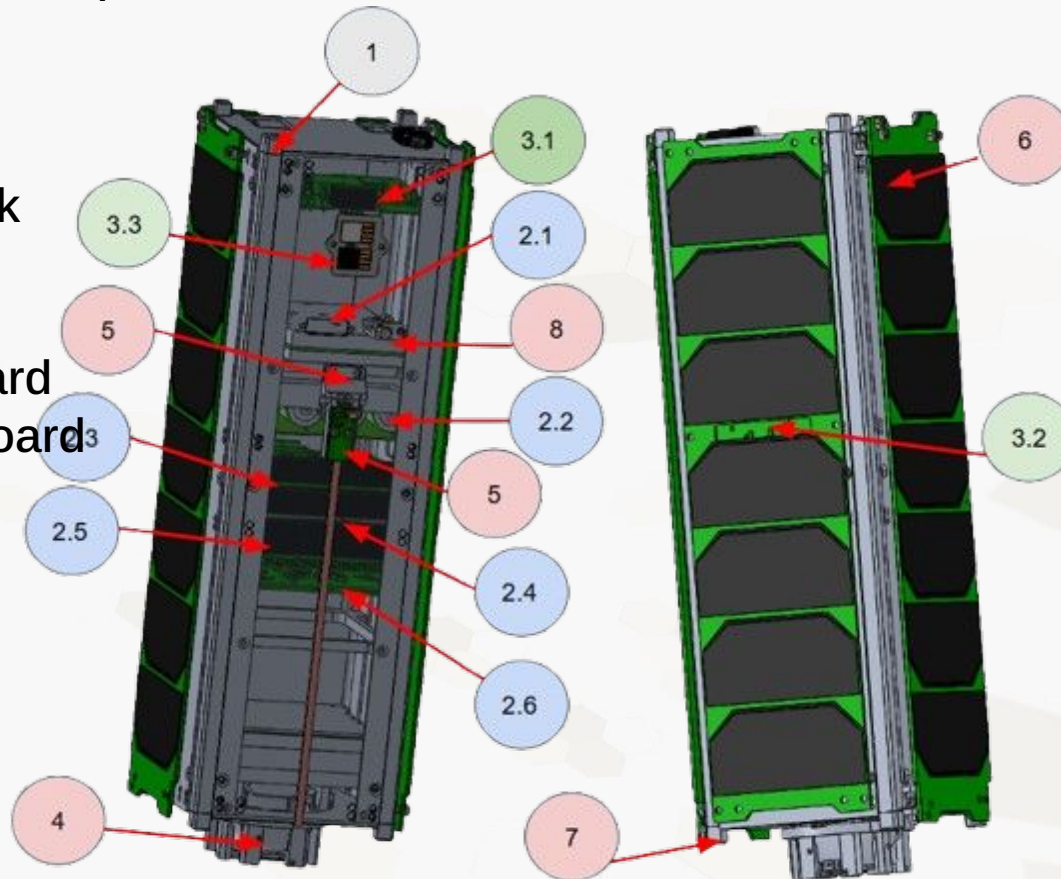
CRP	47 bytes/30sec	HouseKeeping
	32 bytes/60sec	Science Data
ERS (Latmos)	45 bytes/30sec	
SSS	56 bytes/30sec	
Downlink	9600 bps = 1200 bytes/sec	

2025.06.04 NOMINAL V4.0							
Subsystem	EMERGENCY				NOMINAL		Watt
	Phoenix 0	Safe 0	Phoenix	Safe	Sci_Daylight	Sci_Eclipse	
CDH	1	1	1	1	1	1	0.60
EPS	1	1	1	1	1	1	0.60
ADCS	0	1	0	70.39%	70.39%		4.21
UHF (Tx)	3.33%	3.33%	3.33%	13.50%	13.50%		0.88
UHF (Rx)	96.67%	96.67%	96.67%	86.50%	86.50%		0.13
CRP	0	0	0	0	100.00%		0.40
SSS	0	0	0	0	70.39%		0.35
ERS	0	0	0	0	100.00%		0.50
Battery heater	0	0	0	0	8.05%		0.242
SolarPanels	11.73%	11.73%	11.73%	70.39%	70.39%		15.56
Consumption (W)	-1.56	-1.98	-1.56	-3.78	-8.00		-10.40
Generation (W)	2.59	2.59	2.59	15.56	15.56		15.56
Total	1.03	0.61	1.03	11.77	7.55		5.15
Margin	39.77%	23.57%	39.77%	75.67%	48.56%		33.13%

# COSPAR-1 Spacecraft

- The Spacecraft Components:

1. Structure:
2. Stack:
  - 2.1. TRX-U
  - 2.2. Battery Pack
  - 2.3. EPS
  - 2.4. CDH
  - 2.5. Interface Card
  - 2.6. ERS Mainboard
3. Payload
  - 3.1. CRP
  - 3.2. SSS
  - 3.3. ERS
4. ADCS
5. Antenna
6. Solar Panels
7. Pin Deployer
8. RBF



# Team Breakdown – Summer 2025

Team Breakdown								
PM	SE	ME	EE	FSW	Thermal	ADCS	Comms	Ground Systems
<b>Shatha Abueljebain</b>	Jacy Yiyu Chang	Abdullah Alkazemi	Shatha Abueljebain	Abdullah Alkazemi	<b>Raul Figueroa</b>	<b>Shatha Abueljebain</b>	<b>Jacy Yiyu Chang</b>	Anfal Allenqawi
Rayshawn Holscher	Abdullah Alkazemi	<b>Martin Rospigliosi</b>	Magaly Luna	Dylan Blevins	Martin Rospigliosi	Ali Alazmi	Rayshawn Holscher	Roberto Future
<b>Raul Figueroa</b>	Ali Alazmi	Brandi Thomas	Ali Alazmi	<b>Roberto Future</b>		Dylan Blevins	Gabriel Flores	<b>Salvador Romero</b>
Jackson TzuWei Hung	<b>Roberto Future</b>	Shatha Abueljebain	<b>Gabriel Flores</b>	<b>YiHsuan (Monday)</b>		YiHsuan (Monday)	Dylan Blevins	Magaly Luna
	Morgan Stuckey	Kennedy Miller	Salma Almunayes	Sin Yu (Cindy)		Kennedy Miller	<b>Brandi Thomas</b>	Raul Figueroa
	Salma Almunayes	Morgan Stuckey	Jackson TzuWei Hung	Anfal Allenqawi		Morgan Stuckey	YiHsuan (Monday)	Kennedy Miler
	Anfal Allenqawi	Caleb Johnson	Brandi Thomas	Raul Figueroa		Salma Almunayes	Sin Yu (Cindy)	Gabriel Flores
	<b>Jackson TzuWei Hung</b>		Roberto Future	Gabriel Flores		Roberto Future	Roberto Future	Jacy Yiyu Chang
	Salvador Romero		Salvador Romero	Magaly Luna		Jacy Yiyu Chang	Salvador Romero	Caleb Johnson
						Rayshawn Holscher	Caleb Johnson	
Advisors								
<u>Amal Chandran</u>	<u>Jon Mihaly</u>	<u>Spencer Boyajian</u>	<u>Sijo (Hex20)</u>	<u>Gail Tate</u>	<u>Paris Buedel</u>	<u>Amal Chandran</u>	<u>Jared Cantilina</u>	<u>Scott Gennari</u>
<u>Athira (Hex20)</u>	<u>Evan Bauch</u>	<u>Thomas (Hex20)</u>	<u>Jared Cantilina</u>	<u>Salman (Hex20)</u>		<u>Athira (Hex20)</u>	<u>Salman (Hex20)</u>	
		<u>Salih (Hex20)</u>	<u>Neil White (Hex20)</u>	<u>Prajin (Hex20)</u>		<u>Tensor Tech</u>	<u>Prajin (Hex20)</u>	
				<u>Anant (LASP SSS)</u>			<u>Scott Gennari</u>	
				<u>Emmanuel (ERS)</u>			<u>Evan Bauch</u>	

# Weekly Task List Example

## EE Tasks

DESCRIPTION	Working with	STATUS	PRIORITY	DEADLINE	ASSIGNED TO	NOTES
Flatsat Setup and Checkout		Complete	Low	06/06/25		
Preliminary version of Harness of the IF Card		Complete	Low	06/27/25	Gabriel Flores	
Preliminary version of the procedures for the IF Card		Complete	High	06/27/25	Gabriel Flores	
Update the EPS requirements		In Progress	Medium	06/26/25	Jackson TzuWei Hung	
Make the PIN MAP for the ADCS		Needs Review	Medium	06/26/25	Salma Almunayes	
Make the harness design for the TRX-U module.	Hex20	On Hold	High	06/18/25	Jackson TzuWei Hung	will bring the cables from LASP for testing on June 1
Pin map and end-to-end connector Excel		Complete	Medium	06/13/25	Magaly Luna	
Interface Board Design Review		Complete	Medium	06/17/25	Magaly Luna	
Change the positions of the connectors	Hex20	Complete	Medium	06/10/25	Gabriel Flores	
Change of the positions of the Load SW and VI	Hex20	Complete	Medium	06/16/25	Gabriel Flores	
Make the Harness Document	Gabriel Flores	Complete	Medium	06/27/25	Magaly Luna	
Make the Checkout Document - IF Card		Complete	Medium	06/27/25	Gabriel Flores	
Assembly and manufacturing - IF Card		In Progress	High	07/11/25	Gabriel Flores	

## Mechanical Tasks

DESCRIPTION	STATUS	PRIORITY	DEADLINE	ASSIGNED TO	In cooperation with	NOTES
Provide information about material, mass, center of mass of ADCS	Complete	High	06/12/25	Shatha Kennedy Morgan	ADCS team	Provide data sheet information on ADCS
Create CAD fixture for air-bearing mouning	In Progress	High	06/13/25	Abdullah Martin	Consult Spencer	Reference emails from Spencer Emailed Spencer June 9 for advice for making CAD Awaiting meeting with Spencer and Amal to discuss final design
Full CAD integration (fixture+structure+panels)	Complete	High	06/13/25	Martin Abdullah		
Prepare simplified model for simulations	Complete	High	06/17/25	Martin		
Collect data for Boundary Conditions	Complete	Medium	06/17/25	Morgan Brandi Caleb Kennedy	Consult Spencer, Salih or Thomas	Coordinate with subsystem teams to identify physical constraints and expected launch loads. Use data from ADCS, deployables, Skyroot/Exolaunch requirements.
Simulation: Natural Frequency Analysis	In Progress	High	06/22/25	Martin Abdullah		Based on Skyroot / Exolaunch standards
Simulations: Quasi-static + Sine Vibration	In Progress	High	06/22/25	Martin Abdullah		Validate stack and critical stress areas
Simulations: Random Vibration + Shock	In Progress	High	06/22/25	Martin		

Task	Status	Priority	Assigned to	Notes
Go through the ICD and the Datasheet and all documents in detail	Completed	Low	All members	
Check out document of electrical interfacing and harnesses (pin out map)	Completed	Low	Ali Salma	
Work with EE for the harnessing document	Completed	Medium	Ali Salma	
Document Mechanical Interfacing (center of mass, specifications, assembly)	Completed	Low	Rayshawn Kennedy Morgan	
Document software interface, commands, and Registers	In Progress	High	Dylan Monday	
Modes of operation summary + meet other subsystems about specs	Completed	Low	Shatha	
Write script to plot wheel speed every 10ms (torque, speed), maybe get telemetry at different torque values	In Progress	High	Dylan Shatha	

# Final Environmental Testing

- QUASI-STATIC - FINAL STRUCTURE PARAMETERS**

**Table 6-4: Rideshare Plate Payload Minimum Test Load Factors**

Payload Mass	Axial Load Factor (g) $X_{PL}$	Lateral Load Factor (g) See Table 6-5 for required test axes	
		Circular interfaces, CubeSats and 4-points with footprint ratio $a/b \geq 0.6$	4-point interfaces with footprint ratio $a/b < 0.6$
CubeSat Dispenser	10.0	17.0	N/A

**Factor on the X and Y axis = 17**

**Mass = 2.685 Kg**

**Gravity = 9.81 m/s<sup>2</sup>**

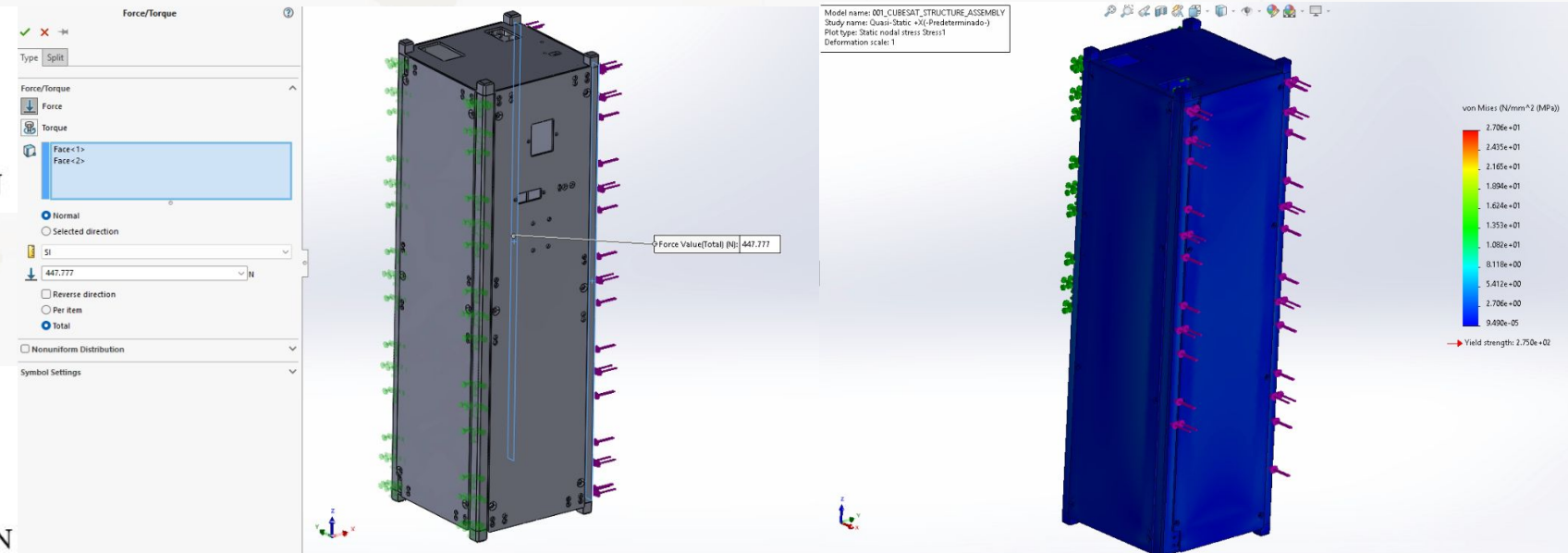
**Force = 17 \* 2.685 \* 9.81 = 477.777 N**

**Factor on the Z axis = 10**

**Mass = 2.685 Kg**

**Gravity = 9.81 m/s<sup>2</sup>**

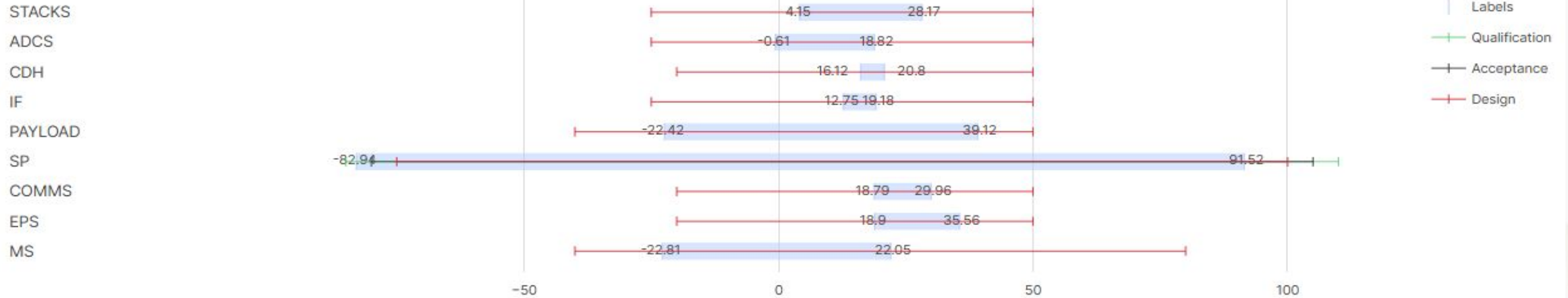
**Force = 10 \* 2.685 \* 9.81 = 263.3985 N**



# Thermal Simulations – Done with Radian Software

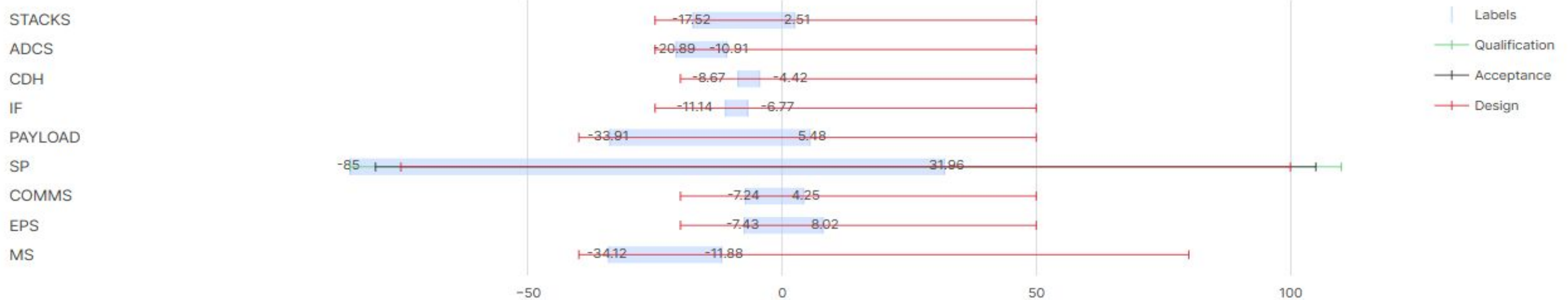
## Hot Case

Temperature (°C)

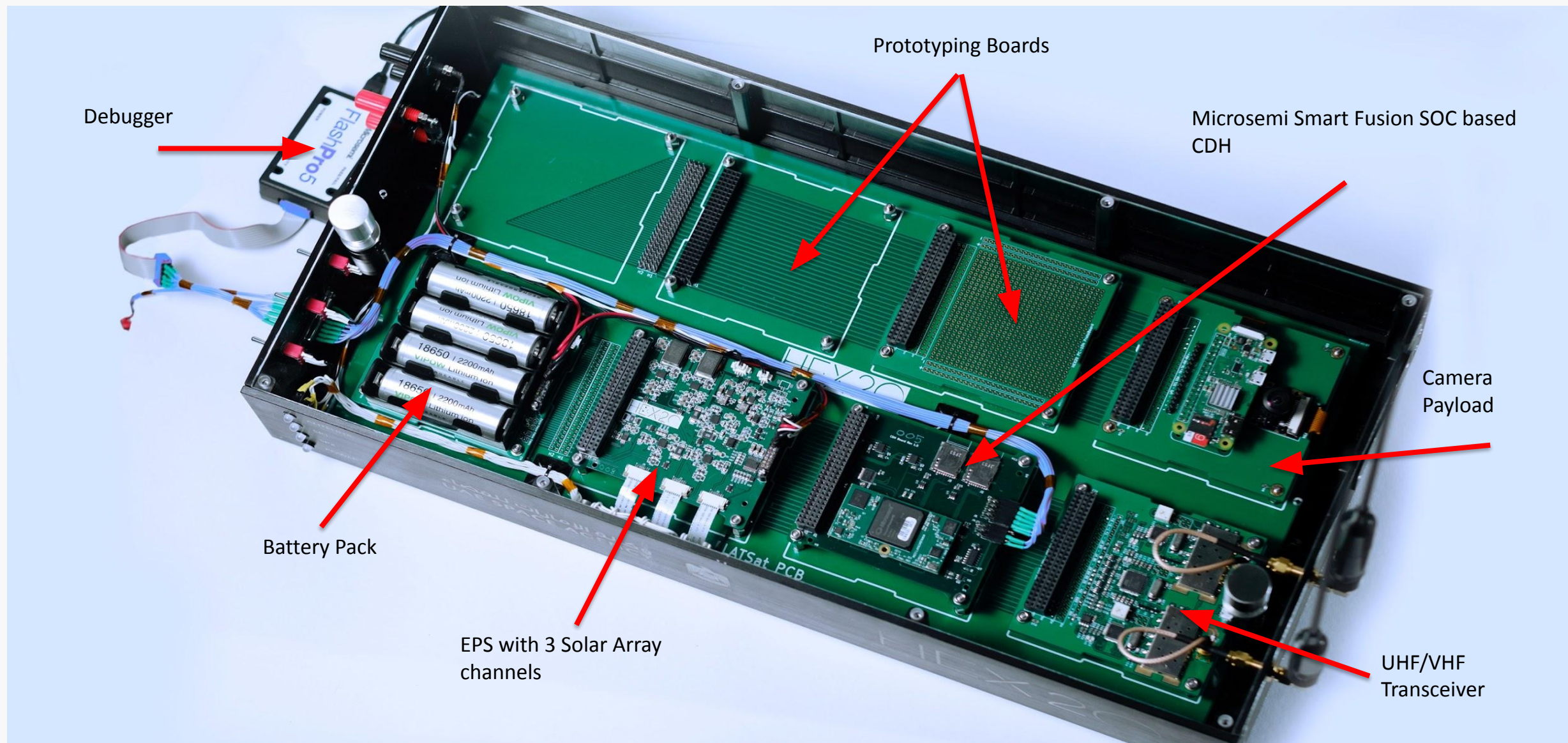


## Cold Case

Temperature (°C)



# 2024 INSPIRE-COSPAR Pilot Program for Capacity Building



Debugger

Prototyping Boards

Microsemi Smart Fusion SOC based  
CDH

Camera  
Payload

Battery Pack

EPS with 3 Solar Array  
channels

UHF/VHF  
Transceiver

# Electrical Testing Procedures Document

1. Objective
2. Scope
3. Requirements
  - 3.1 Materials
  - 3.2 Software
4. Connection diagrams
- 5: Procedures
  - 5.1. Physical connections
  - 5.2. Software Configuration
6. Verification of Operation
7. Security
8. Common Problems and Solutions

Laboratory for Atmospheric and Space Physics  
University of Colorado at Boulder

## Report Procedures Template

Document No. 2025-06-25

Requirement Ref. NA

Action Item Ref. NA

### Approvers List

	Title	Name
Prepared By	[Subsystem] Member	EE Team
Approved By	Project Manager	FSW Team
Approved By	Systems Engineer	
Approved By	Program Lead	

# Electrical Testing

- Report Procedures ERS



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University of Colorado at Boulder

## Report Procedures ERS v1

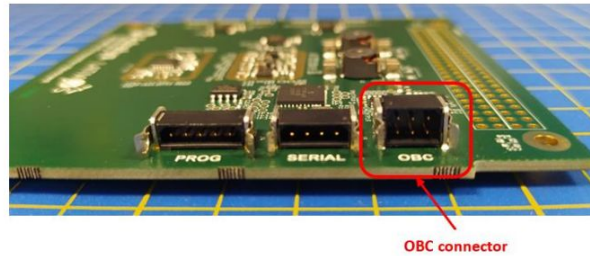
Document No. 2025-07-08

Requirement Ref. NA      Action Item Ref. NA

### Approvers List

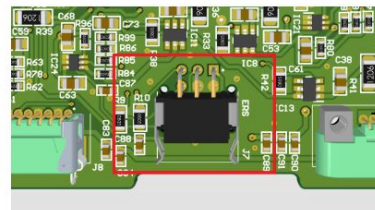
	Title	Name
Prepared By	[Subsystem] Member	Gabriel Flores
Approved By	Project Manager	
Approved By	Systems Engineer	
Approved By	Program Lead	

#### 4. CONNECTION DIAGRAMS



OBC connector

The location of ERS connector in the IF Card is shown in Figure 7:



The harness made has the following pins:

Pin	Name	Short Description
1	ERS_I2C_SDA	Serial Data Line
2	GND	Ground
3	GND	Ground
4	ERS_I2C_SCL	Serial Clock Line
5	ERS_3V3_PWR_OUT	Positive 3.3V supply
6	ERS_3V3_PWR_OUT	Positive 3.3V supply

#### 5: PROCEDURES

##### 5.1. PHYSICAL CONNECTIONS

Step	Test / Task	Expected Result	Client Result
1	Place the IF Card and the ERS payload on the anti-static table mat (ESD mat).	<input type="checkbox"/>	<input type="checkbox"/>
2	Confirm to wear anti-static bracelets (ESD wrist strap).	<input type="checkbox"/>	<input type="checkbox"/>
3	Upload the updated code to the IF Card through the programming connector.	<input type="checkbox"/>	<input type="checkbox"/>
4	Upload the updated code to the CDH module.	<input type="checkbox"/>	<input type="checkbox"/>
5	Carefully insert the Interface Card's and CDH's PC104 connector.	<input type="checkbox"/>	<input type="checkbox"/>
6	Connect the ERS payload to the IF Card using the specified harness.	<input type="checkbox"/>	<input type="checkbox"/>
7	Confirm Power Supply off (light off).	<input type="checkbox"/>	<input type="checkbox"/>



# Electrical Testing

- Report Procedures LSS

Laboratory for Atmospheric and Space Physics  
University of Colorado at Boulder

## Report Procedures LSS v1

Document No. 2025-07-15

Requirement Ref. NA      Action Item Ref. NA

### Approvers List

	Title	Name
Prepared By	[Subsystem] Member	Gabriel Flores
Approved By	Project Manager	
Approved By	Systems Engineer	
Approved By	Program Lead	



Figure 1. LSS Sensor

### 4. CONNECTION DIAGRAMS

The location of LSS connector in the IF Card is shown in Figure 8:

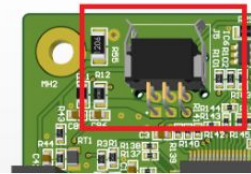


Figure 8. LSS Connector

The harness made has the following pins:

Pin	Name	Short Description
1	LSS_I2C_SDA	Serial Data Line
2	GND	Ground
3	GND	Ground
4	LSS_I2C_SCL	Serial Clock Line
5	LSS_3V3_PWR_OUT	Positive 3.3V supply
6	LSS_3V3_PWR_OUT	Positive 3.3V supply

## 3. REQUIREMENTS

### 3.1 MATERIALS

Below are the materials needed to begin performing connection tests:

	Item	Description	Amount
1	Anti-Static Bracelet	Used to safely discharge static electricity from the body.	1
2	Anti-Static Table Mat	Provides a static-free surface for working with the IF Card.	1
3	Banana Plug	Electrical connector	1 pair
4	Power Supply	Simulates the EPS board with output of 8.4V, current verification.	1
5	LSS Payload	Environmental Remote Sensor module	1
6	Harness (LSS - IF Card)	Harwin M80-8510642	1
7	IF Card	Custom cubesat Interface Board (COSPAR)	1
8	Power Supply	With +3.3V and +5V outputs	1
9	Oscilloscope	For I2C signal integrity	1
10	Multimeter	For voltage and continuity checks	1
11	Logic Analyzer	For verify I2C protocol (Optional)	1
12	Arduino or other	For I2C master testing	1
13	USB to UART adapter	For logging I2C or serial debug	1

# Electrical Testing



## 6: PROCEDURES

### Regulators Testing

- Testing of regulators by varying the battery voltage from 6V to 8.4V, testing the voltage at the output of the regulators (in these cases, a resistor was not used, but was considered for current calculations).

- o Payload 3V3 (IC1):

- Input: 6V – 8.4V
- Output: 3V3/3A
- Test points: TP1 -> TP3

Vbat(Vin)	Vout	Load	A
6	3.284	5	0.6568
7.2	3.285	5	0.657
8.4	3.286	5	0.6572

- o ADCS 3V3 (IC2):

- Input: 6V – 8.4V
- Output: 3V3/3A
- Test points: TP2 -> TP4

Vbat(Vin)	Vout	Load	A
6	2.134	5	0.4268
7.2	2.135	5	0.427
8.4	2.136	5	0.4272

- Load Switches Testing:

We can test the voltage at the output of the following load switches with a slight voltage of 2.1v, either manually in the case of ERS and LSS payloads or through specific pins on the PC104.

- o Enable ERS 5V (IC7)

Vbat(Vin)	Vout	Load	A
6	5.015	10	0.49
7.2	5.002	10	0.4
8.4	4.994	10	0.34

Vbat(Vin)	Vout	Load	A
6	4.654	5	0.92
7.2	4.871	5	0.81
8.4	4.854	5	0.66

## 5. CONNECTIONS

Power connections are made through the PC104, where there are respective pins for each voltage level, in addition to ground connections. There are also pins for opening switches, except for the ERS and LSS payloads, which must be opened from the MCU within the interface through a command from the CDH.

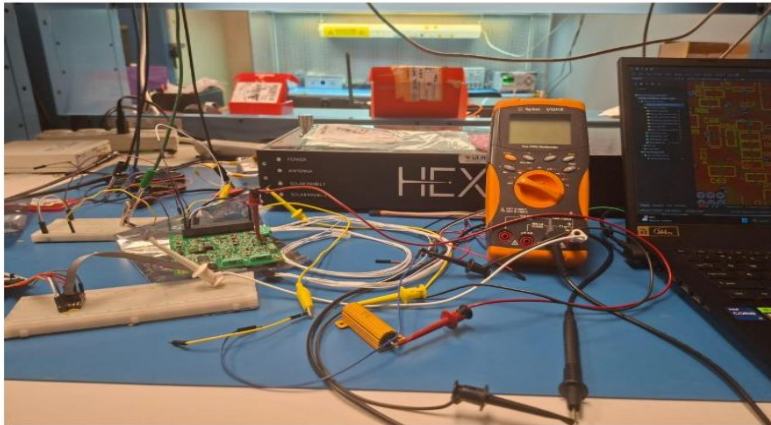
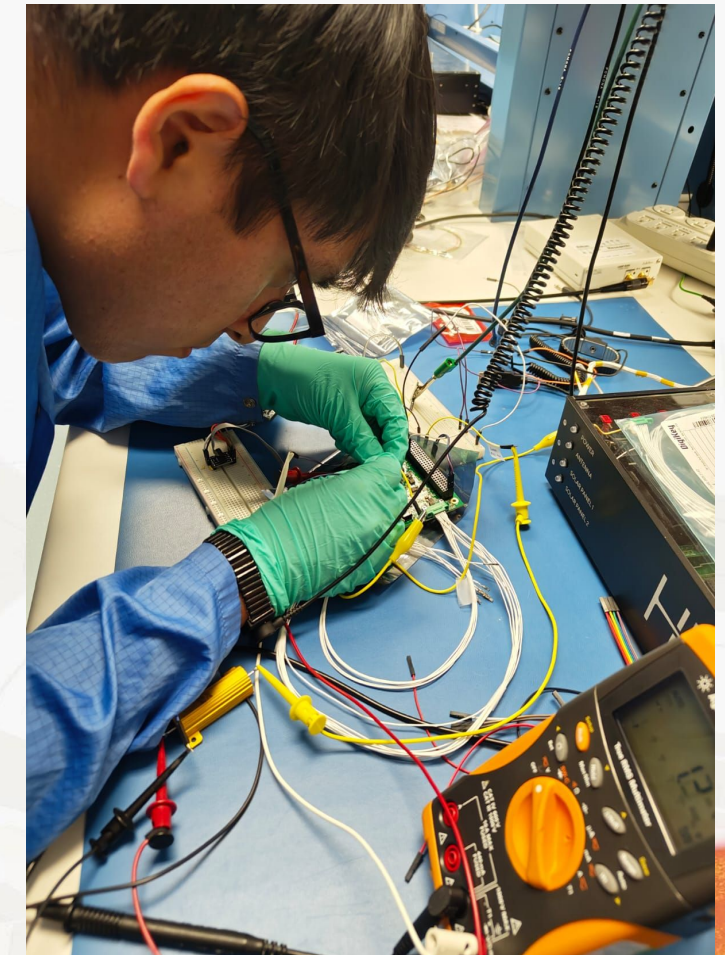


Figure 3. Connections for Electrical Testing of the IF Card

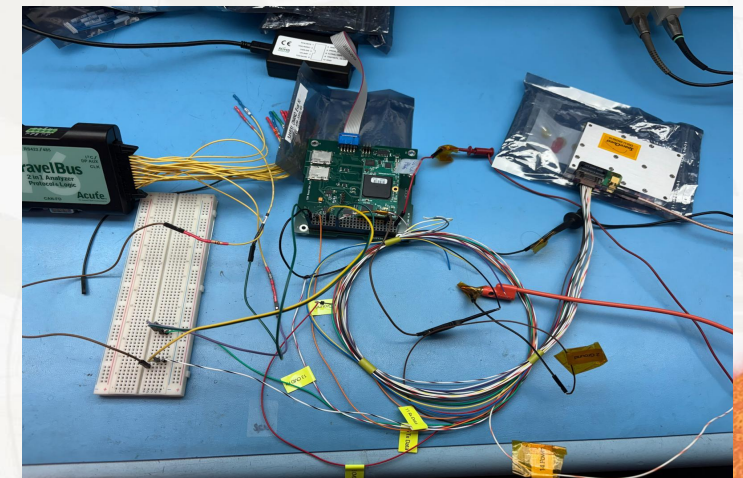
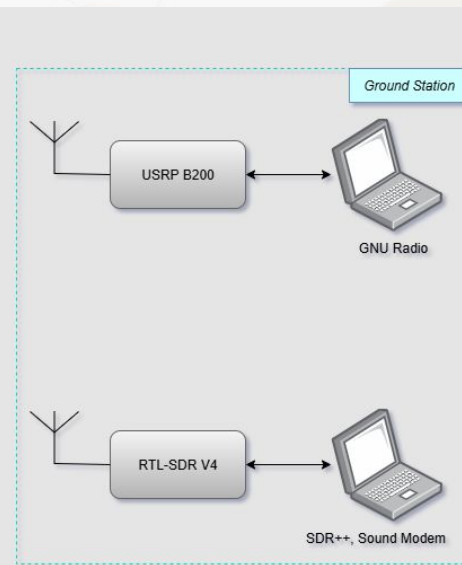
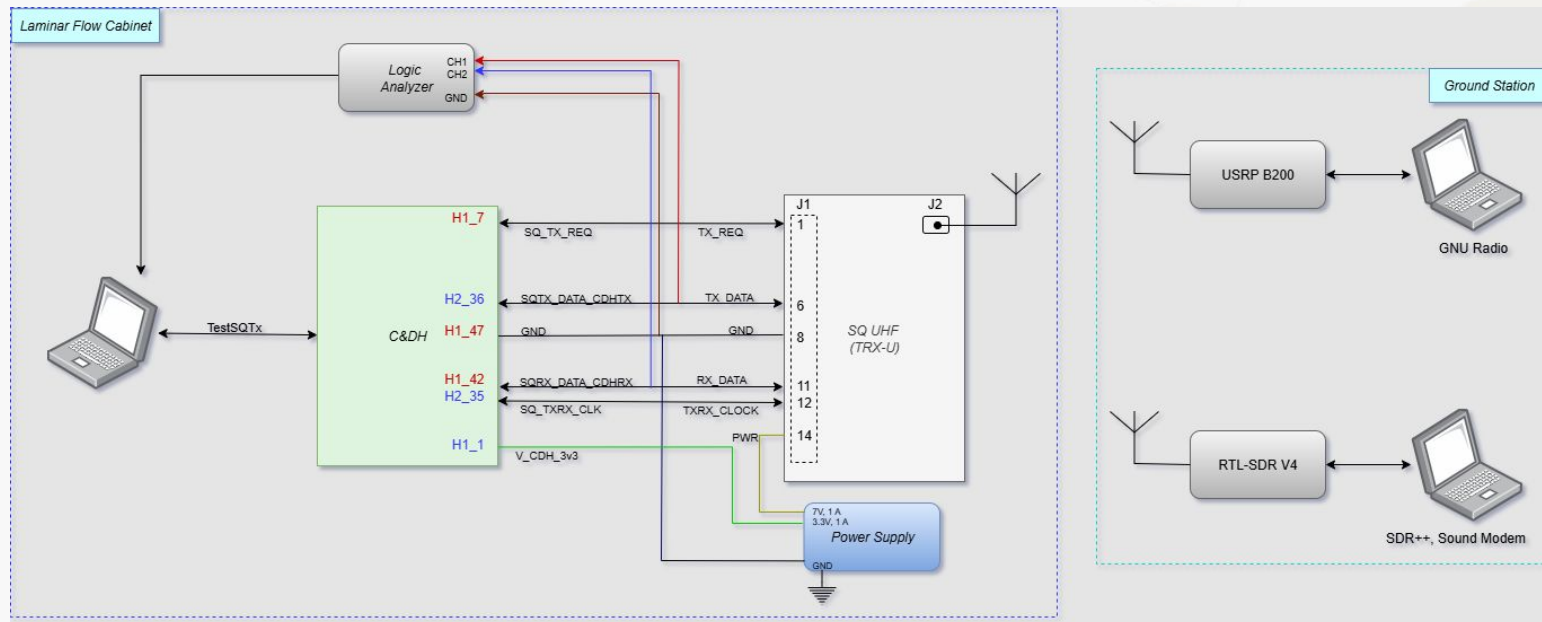


# TRX-U + CDH: Tx Testing - Configuration

## AX.25 Transmission Flow:

- C&DH sends AX.25 frame via TX\_DATA
- TXRX\_CLOCK provides bit-level sync
- TX\_REQ sets TRX-U to TX mode
- Data modulated using GFSK internally
- RF signal amplified and transmitted via antenna (401.2 MHz, 9.6 kbps)

CDH Pin	TRX-U Pin	Signal	Function in the Test
H1_7	Pin 1	TX_REQ	Enabled transmission mode on the TRX-U (logic high activated the RF output path)
H2_35	Pin 12	TXRX_CLOCK	Provided the clock signal for synchronizing data from the C&DH
H2_36	Pin 6	TX_DATA	Data line used by the C&DH to transmit AX.25-encoded packets
H1_42	Pin 11	RX_DATA	Not active during this test, as the TRX-U operated in transmission mode only

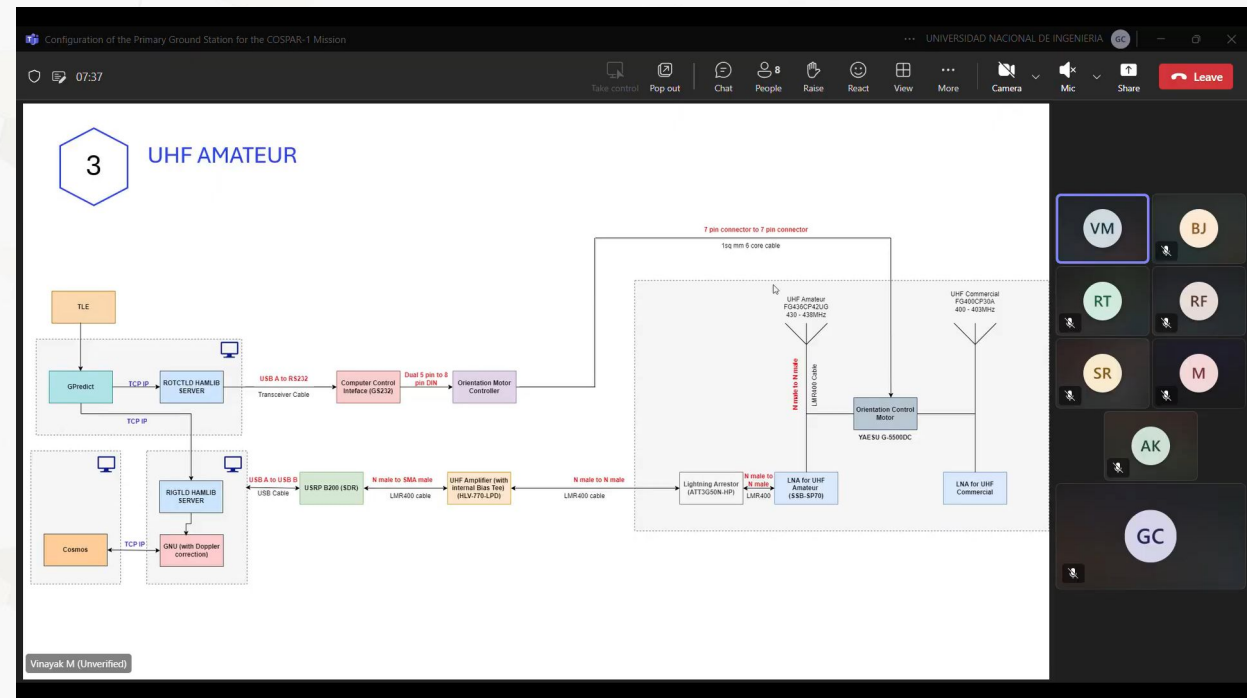


# Development of the main ground station in Peru

## LASP Support:

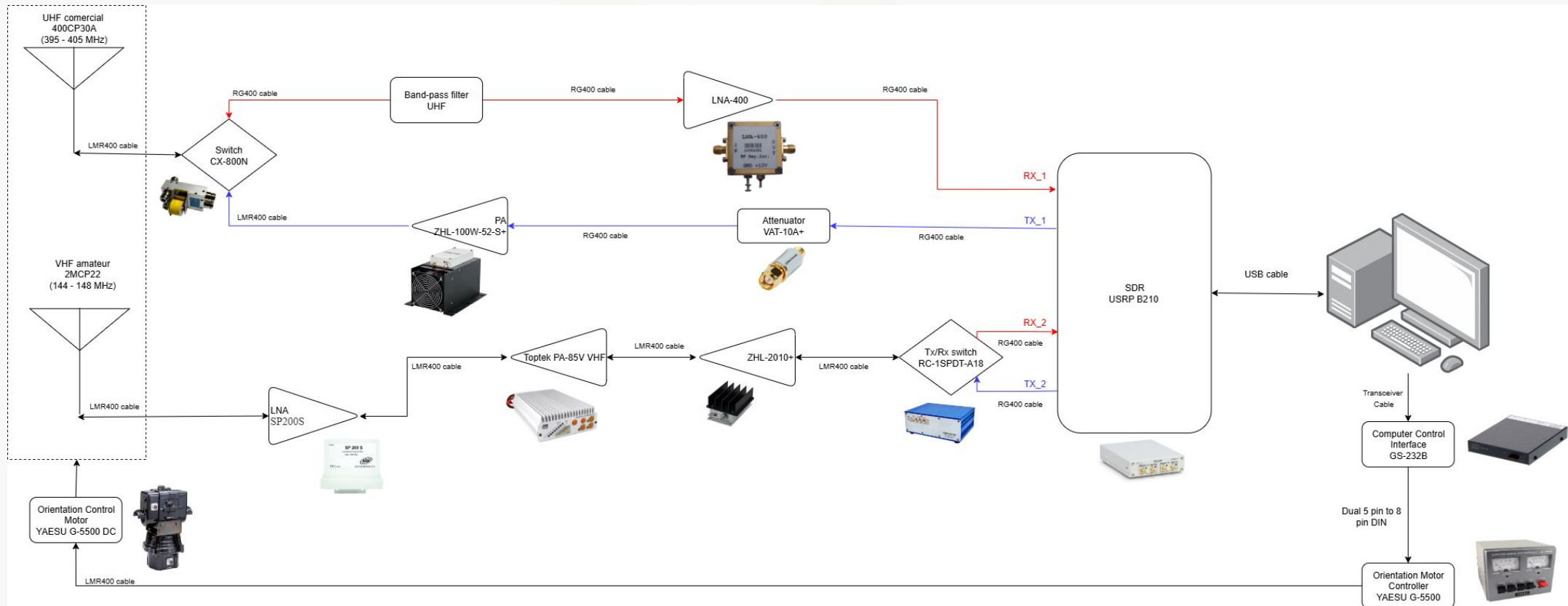


## HEX20 Support:



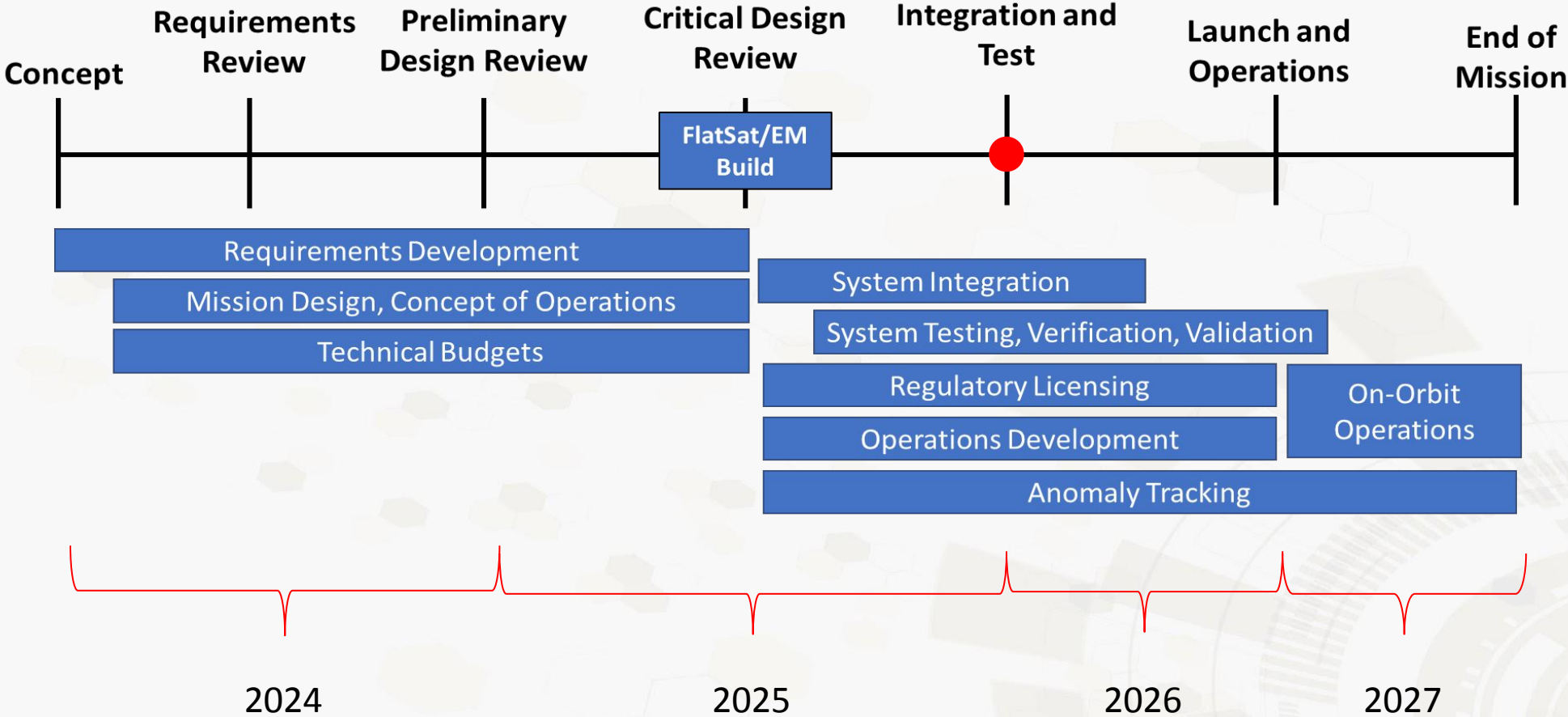
# Development of the main ground station in Peru

With the support of LASP and HEX20, we now have a final architecture for the main ground station that will be developed in Peru.



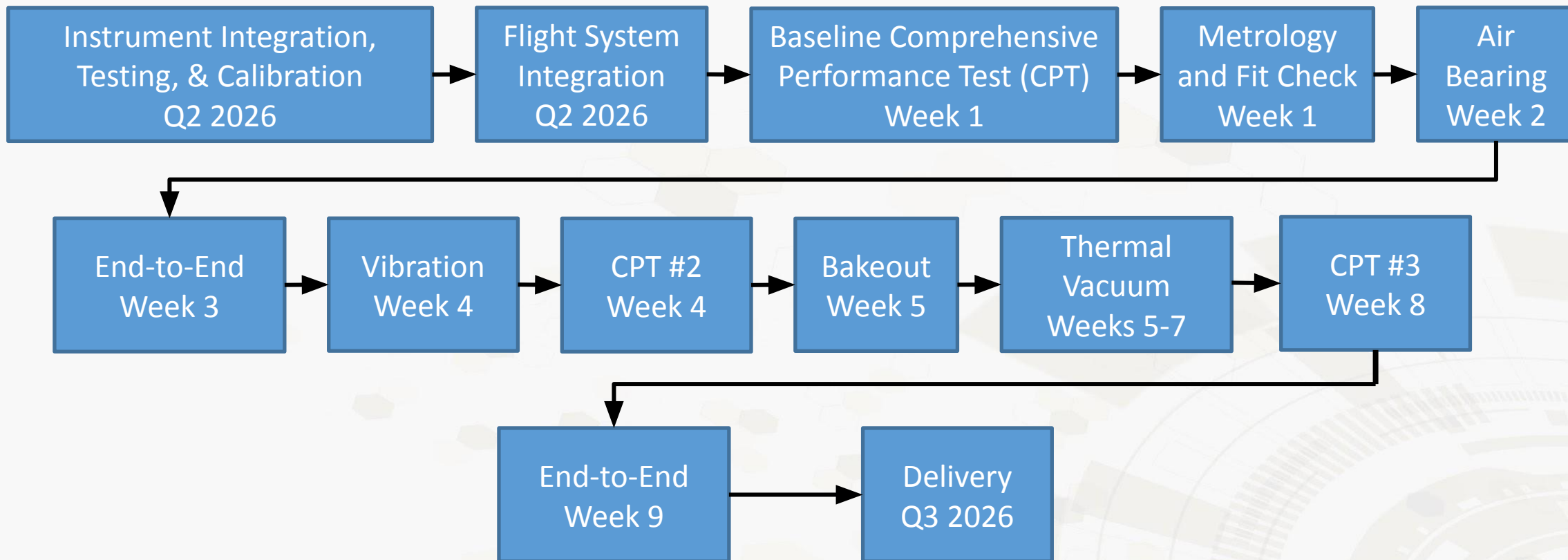
# INSPIRE-COSPAR Pilot Program for Capacity Building – COSPAR-1

## COSPAR-1 – Timeline



# COSPAR-1 System Integration & Test

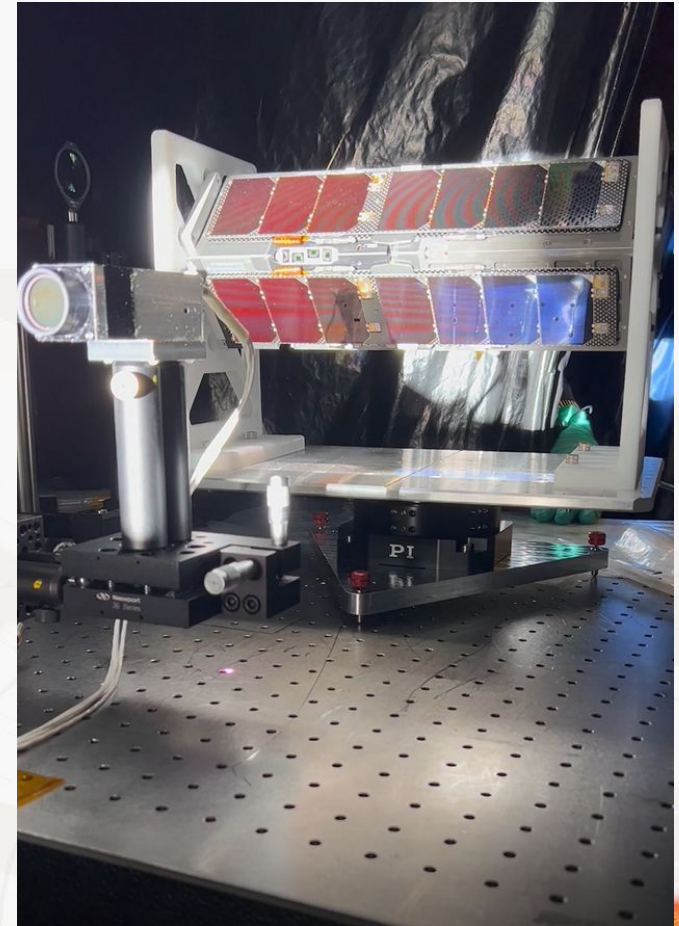
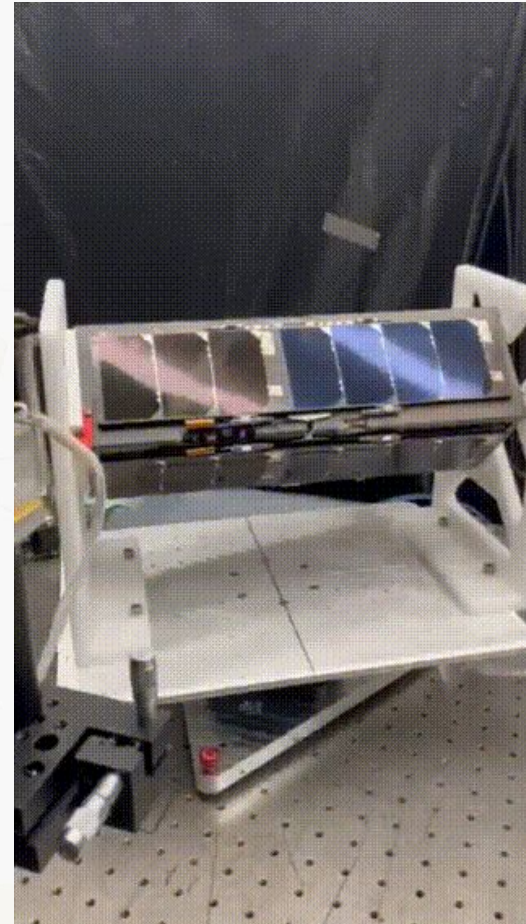
## Summer 2026 Schedule



# Air Bearing Test

Air bearing testing verifies the performance of the ADCS system

- Ensures correct polarity of reaction wheels and sun sensors
- Two separate coarse sun sensors and the Bright Object Sensor will be tested



# End-to-End Test

- The end-to-end communications test retires significant project risk by validating the full system across flight-like interfaces
  - Science data is generated from the payload, stored on the bus, transmitted through the radios, retrieved by the ground station, and processed in the SOC



# Vibration Test

FM will be tested to NASA GEVs Acceptance levels, unless mission maximum-predicted-environments are provided beforehand

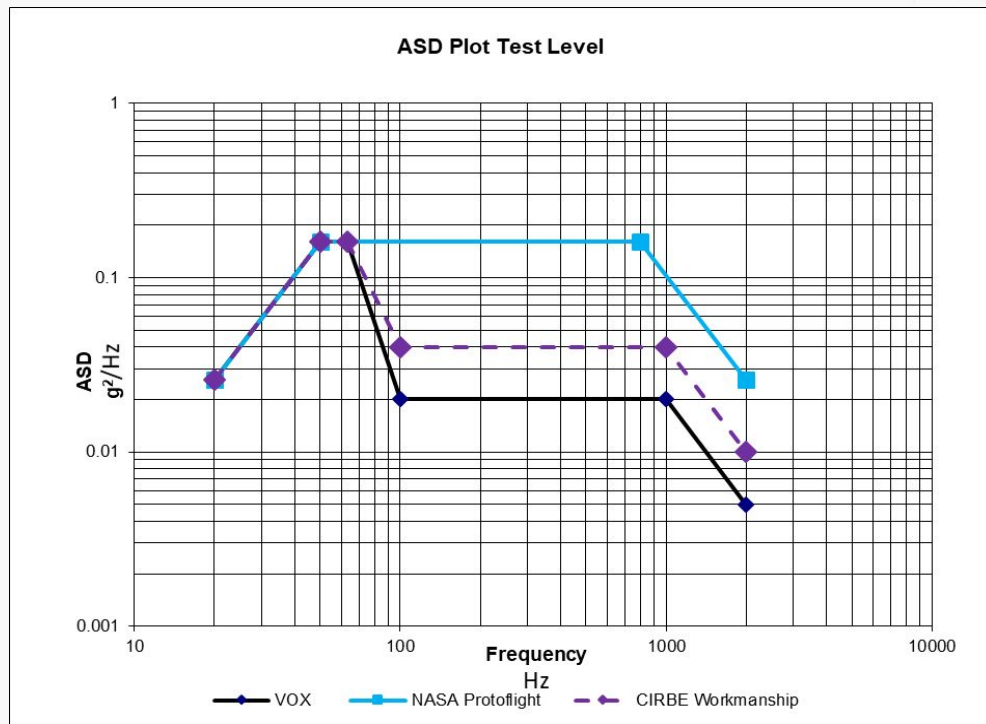


Table 2.4-4  
Component Minimum Workmanship  
Random Vibration Test Levels  
45.4-kg (100-lb) or less

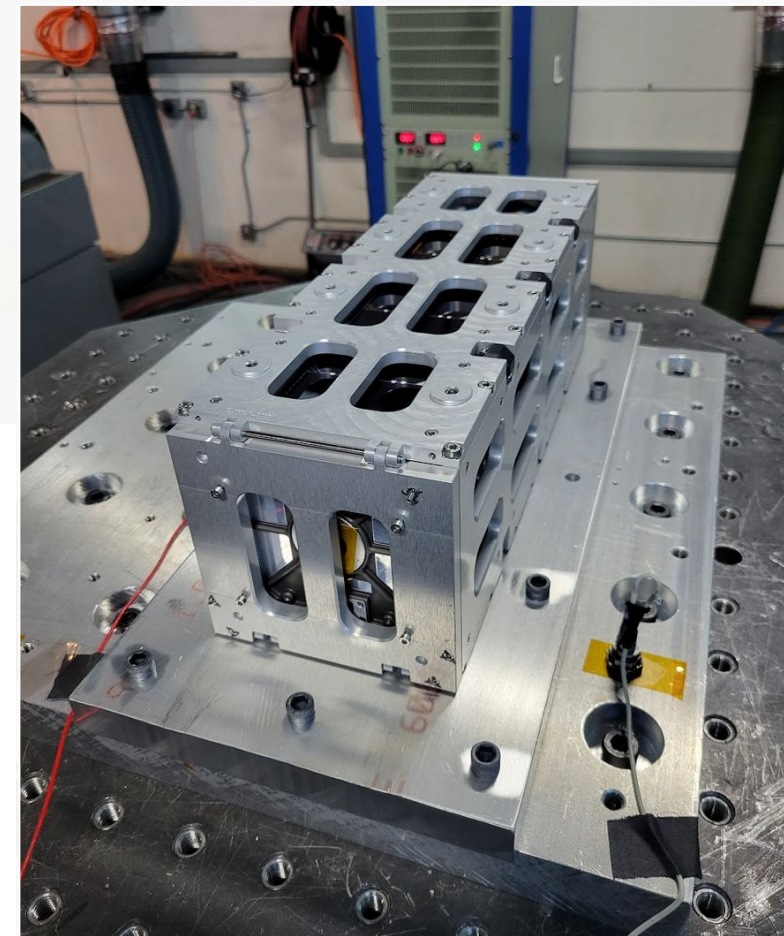
Frequency (Hz)	ASD Level (g²/Hz)
20	0.01
20-80	+3 dB/oct
80-500	0.04
500-2000	-3 dB/oct
2000	0.01
Overall	6.8 grms

The plateau acceleration spectral density level (ASD) may be reduced for components weighing between 45.4 and 182 kg, or 100 and 400 pounds according to the component weight (W) up to a maximum of 6 dB as follows:

	Weight in kg	Weight in lb
dB reduction	= $10 \log(W/45.4)$	$10 \log(W/100)$
ASD(plateau) level	= $0.04 \cdot (45.4/W)$	$0.04 \cdot (100/W)$

The sloped portions of the spectrum shall be maintained at plus and minus 3 dB/oct. Therefore, the lower and upper break points, or frequencies at the ends of the plateau become:

$F_L = 80 (45.4/W) [kg]$	$F_L = \text{frequency break point low end of plateau}$
$= 80 (100/W) [lb]$	
$F_H = 500 (W/45.4) [kg]$	$F_H = \text{frequency break point high end of plateau}$
$= 500 (W/100) [lb]$	

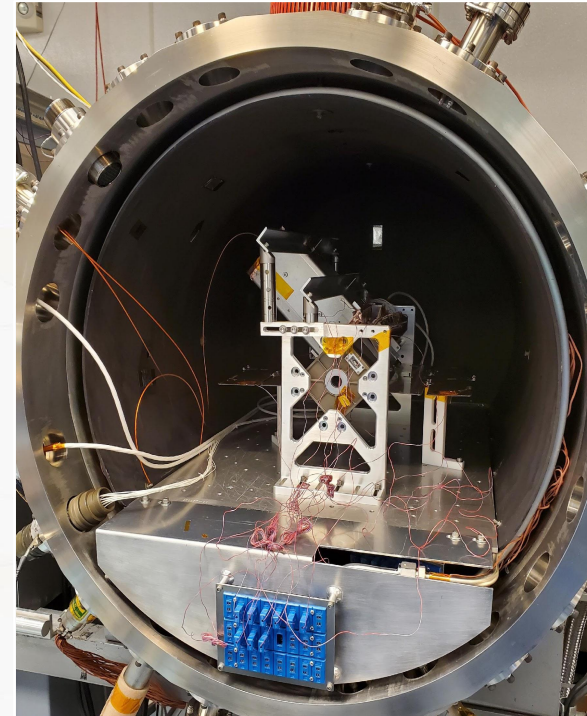
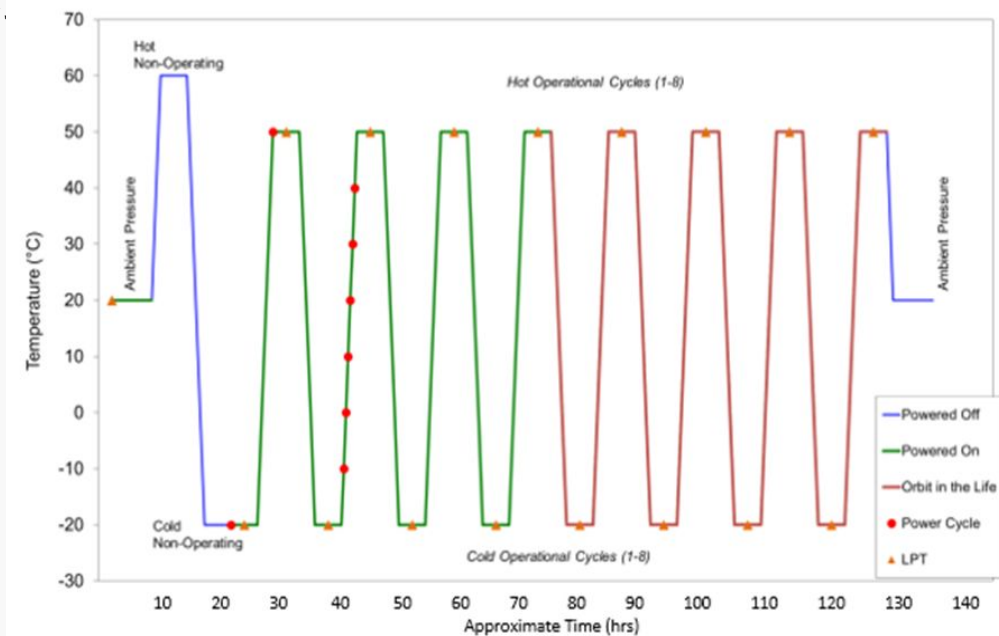


CIRBE (3U) CubeSat in Vibration Testing at Element, 2022

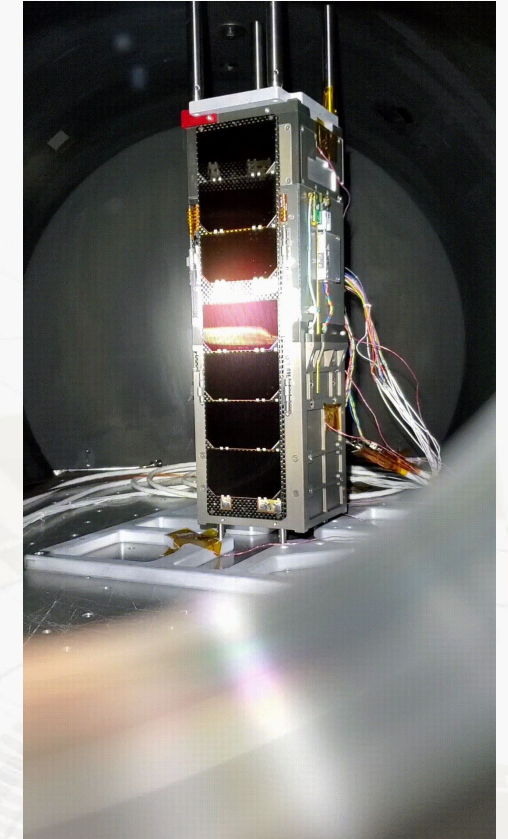
# Thermal Vacuum Test

Thermal vacuum testing accumulates two weeks of runtime on flight hardware

- Vacuum bakeout (~2 days)
- Thermal Balance (~2 days)
- Performance testing (~5 days cycling)
- Day-in-the-life test (~5 days cycling)



Spacecraft with external thermistors and RF hats applied  
Day-in-the-life testing

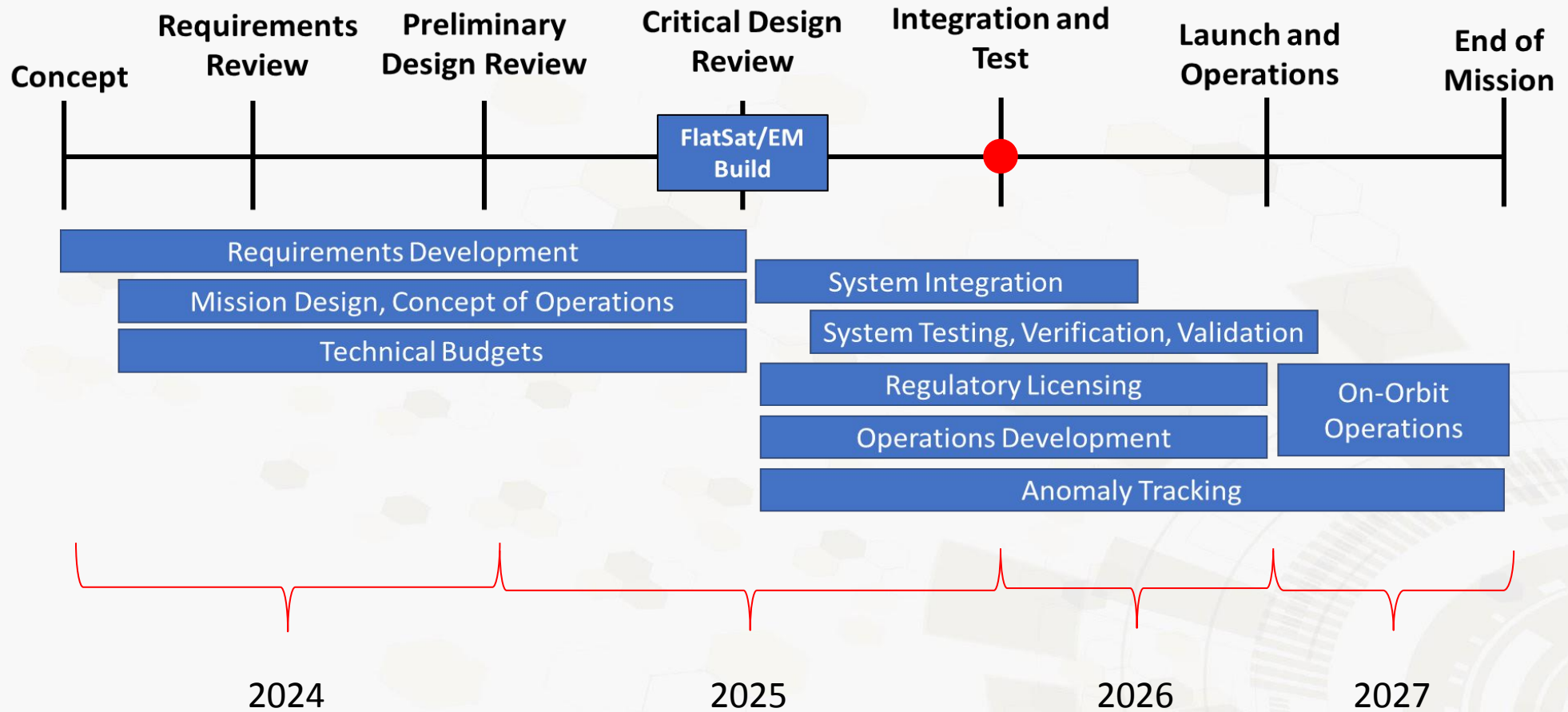


Vacuum Deployments



# Summary of the INSPIRE-COSPAR Pilot Program for Capacity Building

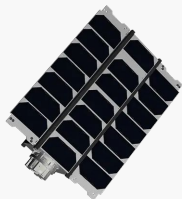
## COSPAR-1 – Timeline



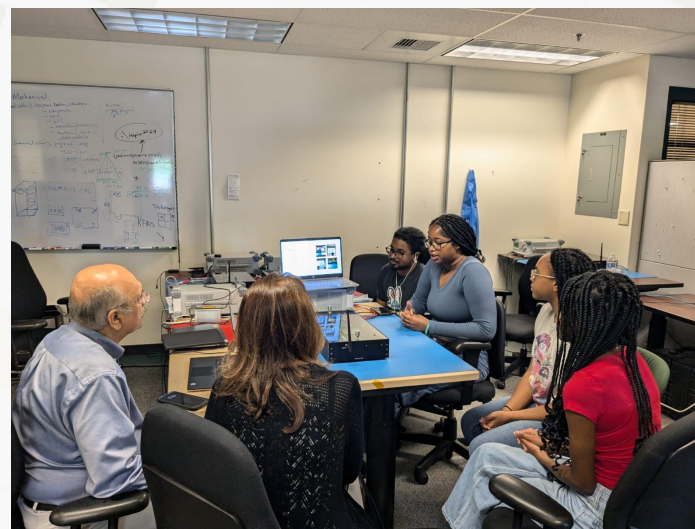
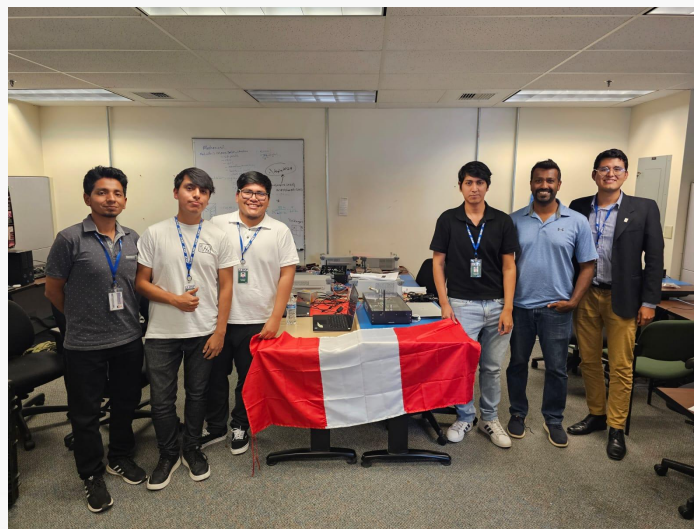
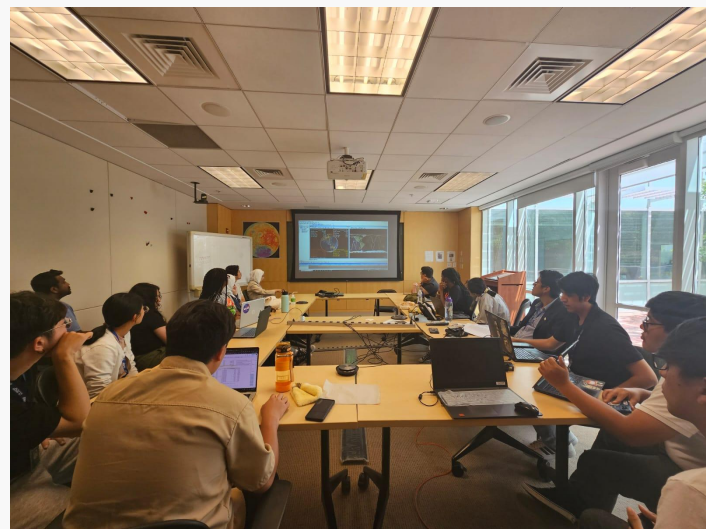


# HEX20





# HEX20





# HEX20

