

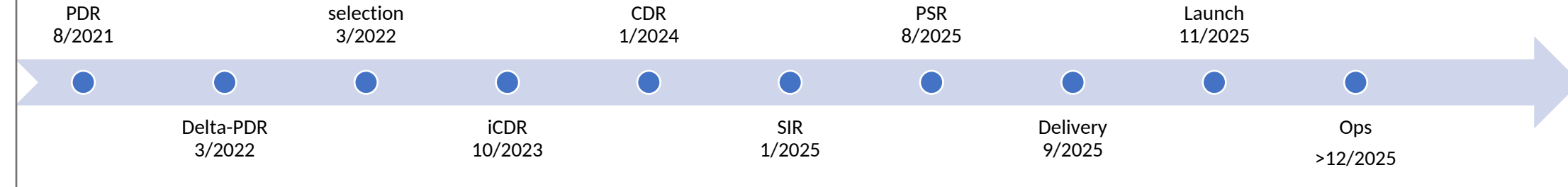


# IMAP Student Collaboration: 3UCubed Concept of Operations, Flight Software, and Testing

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## INTRODUCTION

3UCubed is the student collaboration of IMAP. This is a NASA-funded project to give hands-on experience in space hardware and software to undergraduate students from the University of New Hampshire, Sonoma State University, and Howard University. The 3UCubed team built a 3U CubeSat that launched on November 28th, 2025, to investigate thermospheric upwelling in the cusp region caused by electron precipitation. We built ground stations at SSU and UNH and developed flight software. We performed extensive testing of all software and hardware.



## GROUND STATIONS

At SSU and UNH, we built ground stations to communicate with the satellite.

- Amateur UHF band.
  - 437 MHz, ~0.7-meter wavelength.
  - Left/Right Hand Circular Polarization switching.
- Both SSU and UNH built stations to get more opportunities to communicate with the satellite.

LINK BUDGET

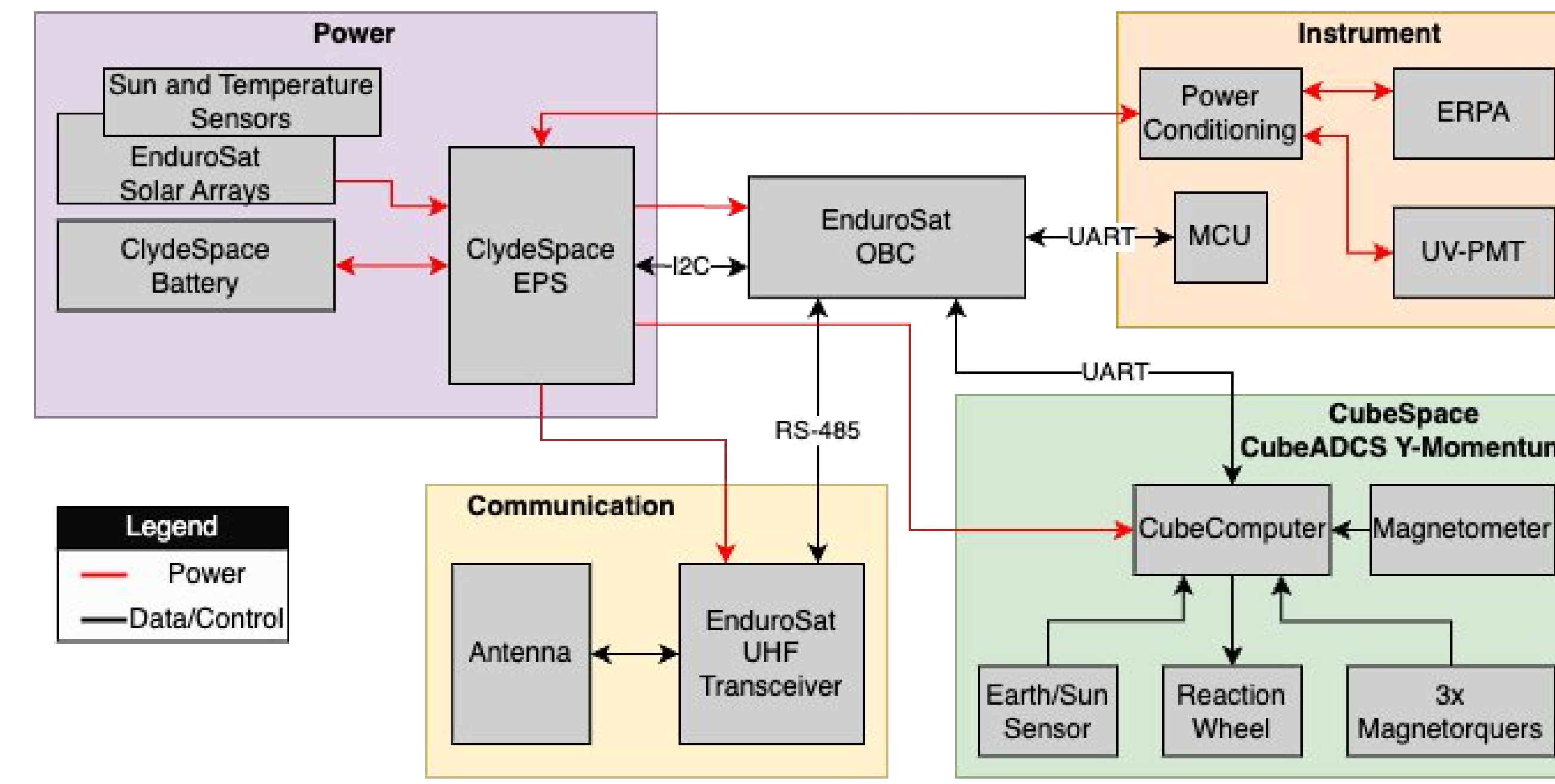
	Uplink	Downlink
Transmitter power (W)	30.00	1.00
Transmitter power (dBW)	14.77	0.00
Line loss (dB)	2.00	1.00
Transmitter antenna gain (dB)	18.95	0.00
Transmitter EIRP (dBW)	31.72	-1.00
Transmission loss (dB)	150.40	150.40
Receiver antenna gain (dB)	0.00	18.95
Isotropic signal at receiver (dBW)	-118.68	-132.45
Receiver line loss (dB)	1.00	1.00
Receiver noise temperature-T (K)	225.00	442.00
Bitrate (bps)	9600	9600
Bandwidth-B (Hz)	14400	14400
Receiver noise power-Pn=KTb (dBW)	-163.49	-160.56
Receiver signal-to-noise ratio-SNR (dB)	44.82	28.11
Required demodulation SNR (dB)	19.00	19.00
Link margin (dB)	25.82	9.11



## FLIGHT SOFTWARE

### Onboard Computer (OBC)

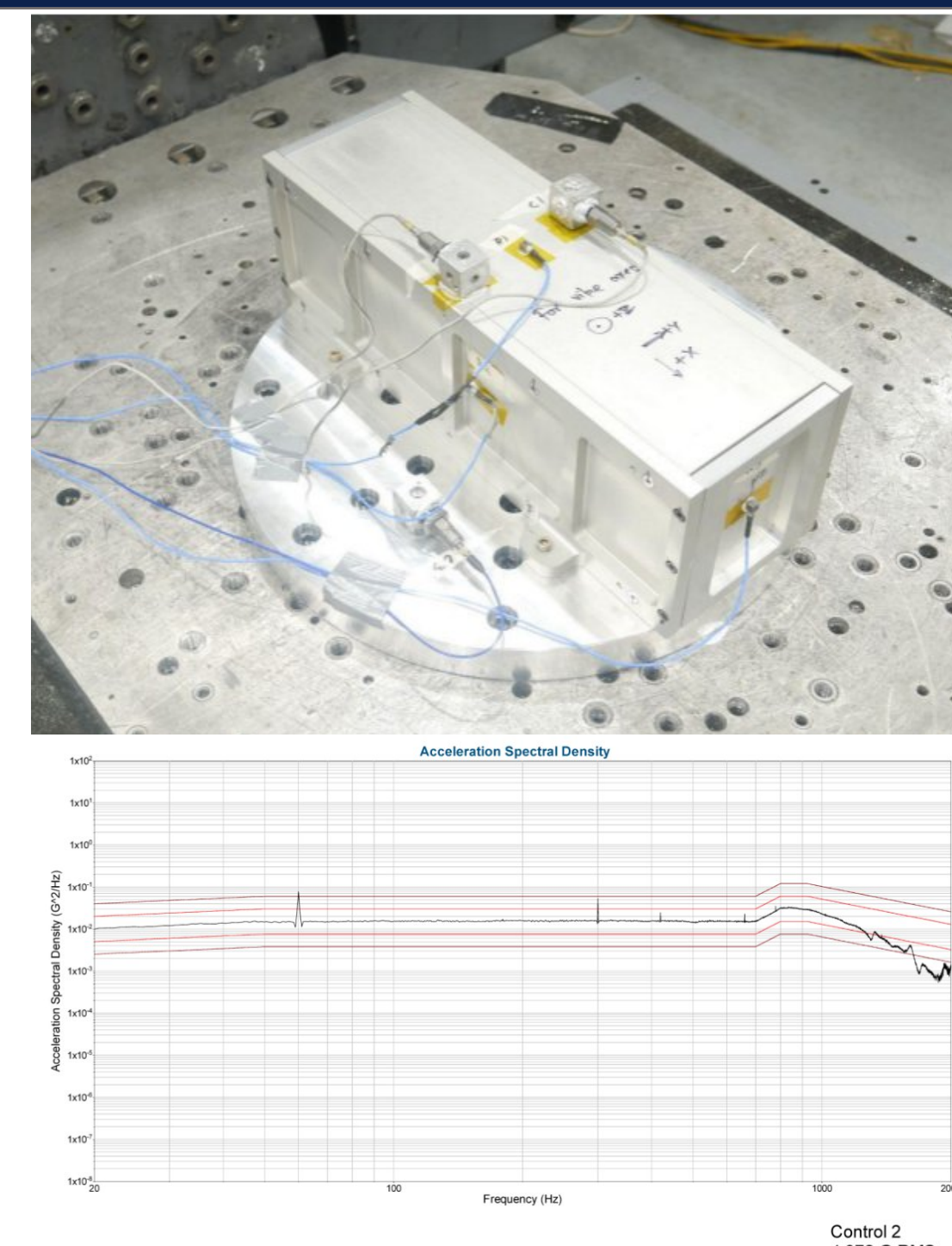
3UCubed has an OBC from EnduroSat. It runs an STM32 ARM Cortex M7 MCU. The OBC commands the power conditioning, attitude control, instruments, and passes data to UHF radio for downlinking. Students wrote the flight software and performed extensive testing through day in the life testing (DILT) with orbital simulations.



## THERMAL VACUUM AND VIBRATION TESTING

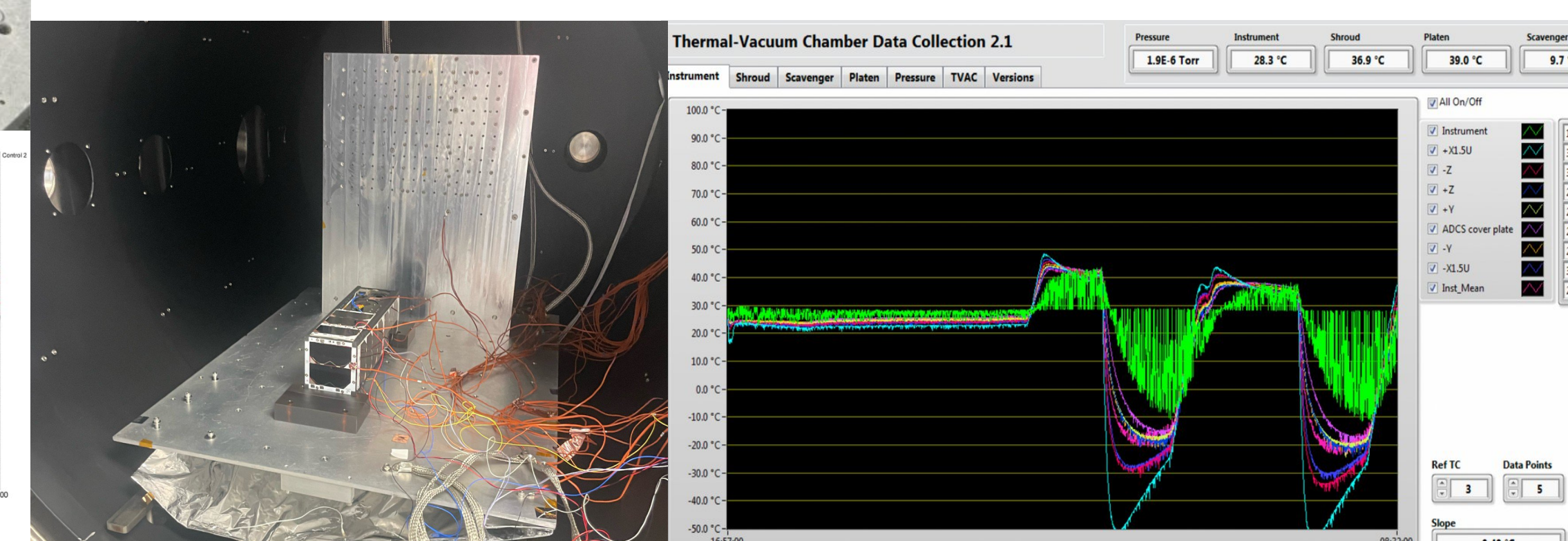
### Vibration test

- Completed to SpaceX profile at Element Materials.
- Random vibration of 5.57 Grms in 20-2000 Hz for 1 min. on each axis.
- 0.5G sine sweep pre and post random vibrate.
- DILT post vibrate.



### Thermal Balance Test:

- 3 cycles from +40°C to -20°C with 1 hour dwell at extremes, as expected from simulation.
- Temperatures were monitored from thermocouples installed on outside, and subsystems internal temps.



## GROUND STATION SOFTWARE

The UNH Ground Station features fully custom tracking software for low-level control when communicating with the satellite.

- Directional 42-element yagi antenna on G5500 motor.
  - ~19 dB gain, 21° beamwidth, B200 radio with Tx/Rx.
- SkyField API to track satellite based on TLE.
- Dynamic polarity switching (LHCP/RHCP) at culmination.
- Automated motor calibration check after each pass.
- Automated notification and commanding option.
- Omni-directional eggbeater antenna
  - ~5 dB gain, hemispheric pattern, BladeRF radio with Rx.
- Shared database on server for logging pass information.
- Both SSU and UNH store results on database.



## LAUNCH AND ORBIT

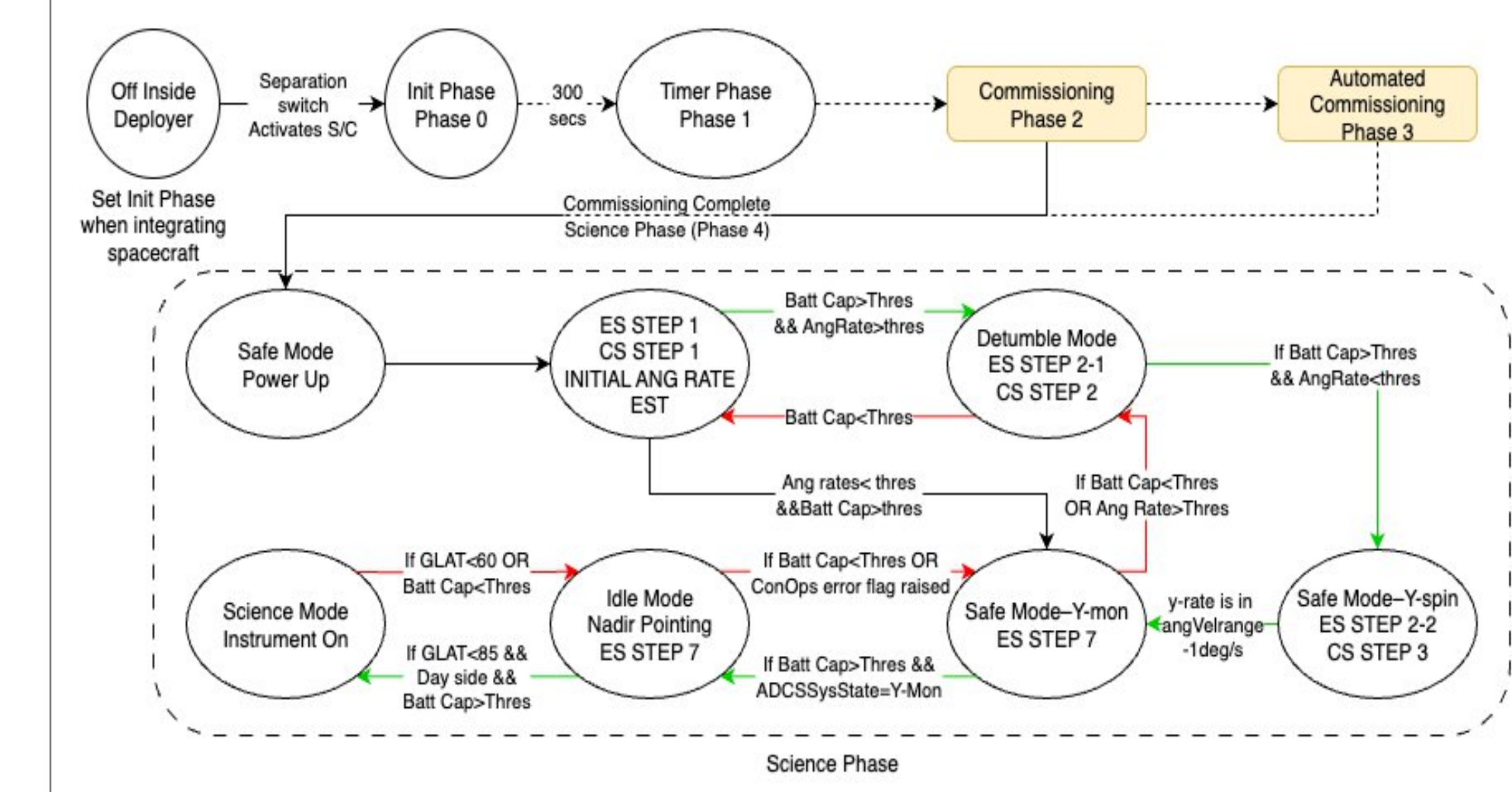
The satellite launched aboard SpaceX Transporter 15 on a sun-synchronous orbit at 515 km with LTN 10:40. Deployment was nominal.

This orbit passes over UNH and SSU on average 8 times each day, allowing sufficient time to downlink data.



## COMMISSIONING

- We are currently in the commissioning phase.
- The satellite needs to stabilize using the attitude determination and control system (ADCS).
- When the satellite passes over our ground stations, we listen for beacons and try to send commands.
- Launch provider has been updating our TLE.
- **No communications have been established yet.**



## ACKNOWLEDGMENT

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