LoRa Link Cube-Sat Mission As Part of Cal Poly's Sal-E Program

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CAL POLY

www.calpoly.edu

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www.project-owl.com

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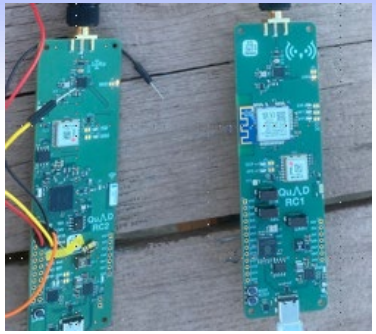
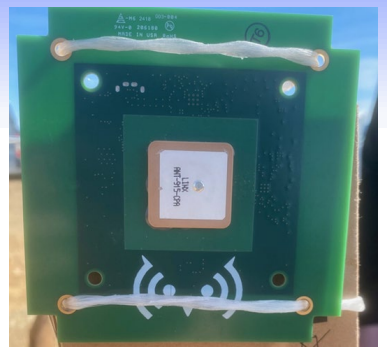
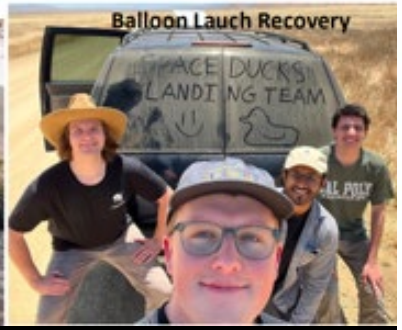


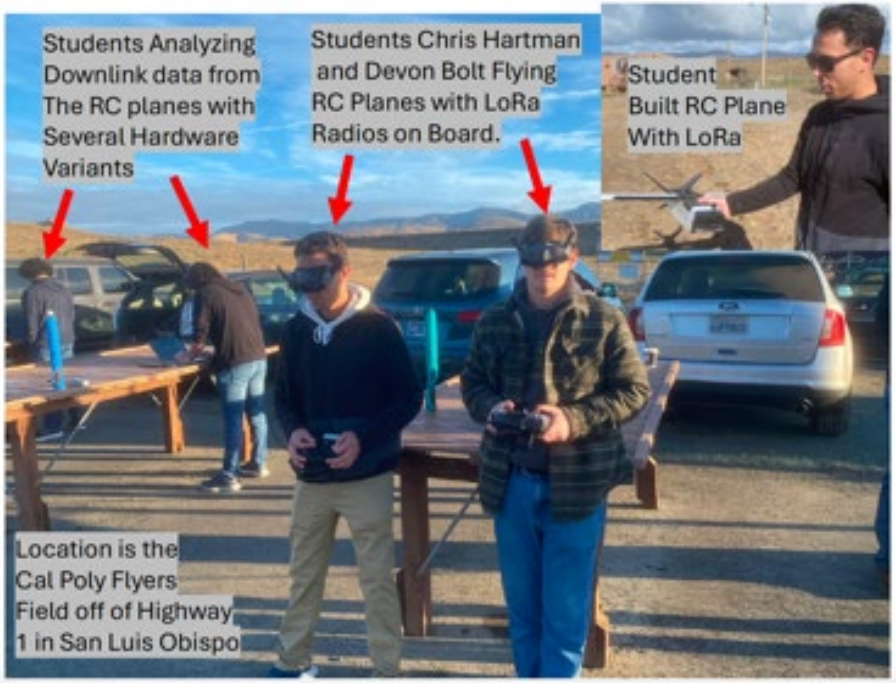


June 2024 91,000 Foot Balloon Launch Test

Construction with custom
LoRa Module payload
And Cluster Duck Protocol
(CDP) Software

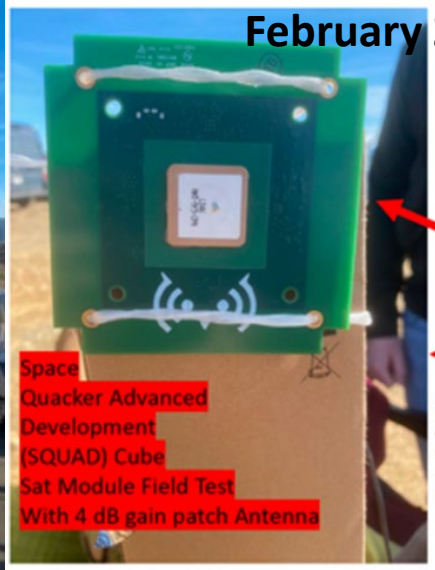


Nov 22-23, 2024 Field Testing Experiments



Nov 22-23, 2024 Field Testing Team

February 2025 Link Test



Fixed Attenuators are added
here in order to simulate
Additional path loss found
In a Low Earth Orbit (LEO) case.

Attached computer
Continually monitoring
Received Signal Strength
And Signal to Noise Ratio.

10 miles line-of-sight path

SQUAD Board
At 101 Cuesta
Grade Ridge
(Simulates
Satellite RX)

RC1 Beacon
Near Morro
Bay (Simulates
Ground Station
TX)

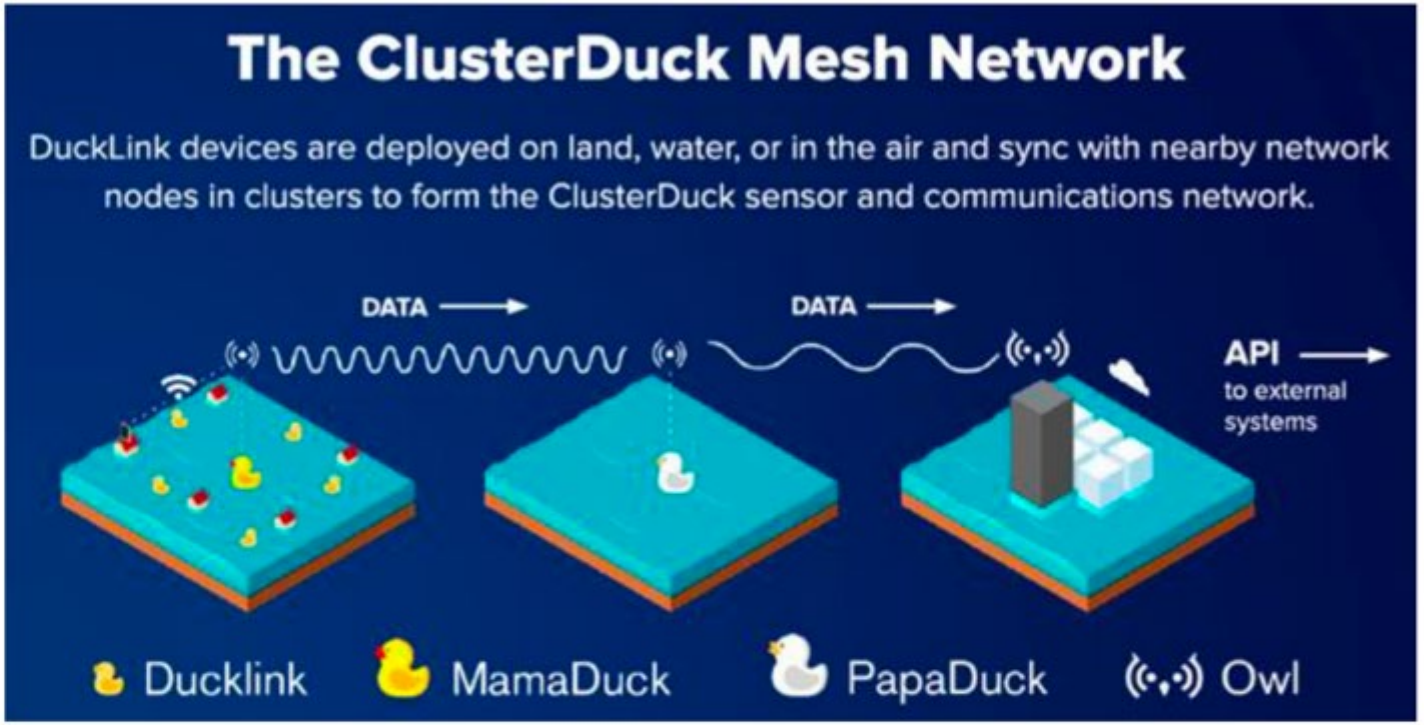
Outline

- Partnering with a start-up company OWL Integrations to help their product development
- LoRa modulation format for Low-Earth-Orbit Data Links
- Hardware and Software and Test Development
  - Balloon Launch Field Testing - June 2024
  - Radio-Controlled Airplane Field Testing - Nov. 2024
  - Cube-Sat LEO Satellite Testing as part of Sal-E mission
- Summary

OWL Integrations / Cal Poly Collaboration : LoRa Mesh Networks

Hardware

DuckLink Wireless Device

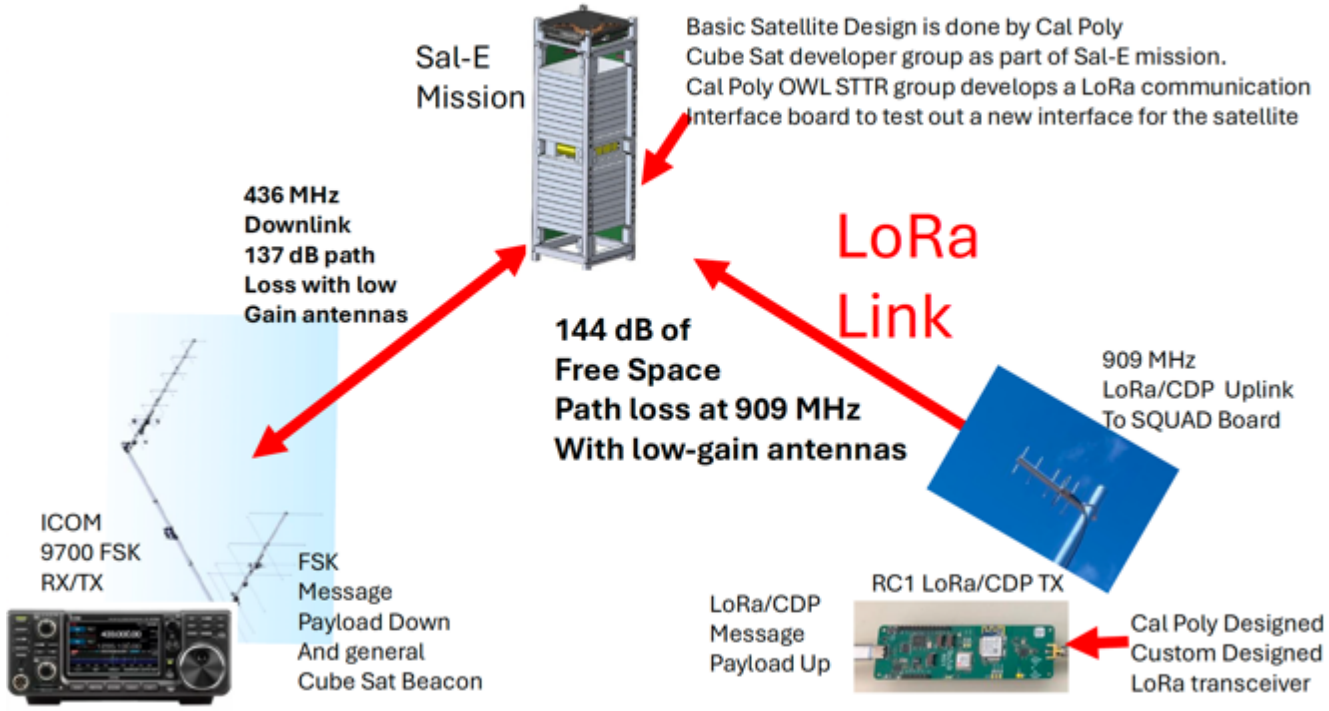


First OWL integrations product used Commercial-Off-the-Shelf (COTS) hardware With China Supply-Chain Components. Desire to have a new solution with US-based supply chain for military customers. Collaborating on new product Development hardware and software.

Start-up Technology Company Focused on Making Connections

OWL

Low Earth Orbit (LEO) LoRa Field Testing Project



1.Primary mission: Demonstrate Link

Demonstrate that a LoRa/CDP link can provide a reliable space Low-Earth-Orbit Communication link with low data rate and simple operation.

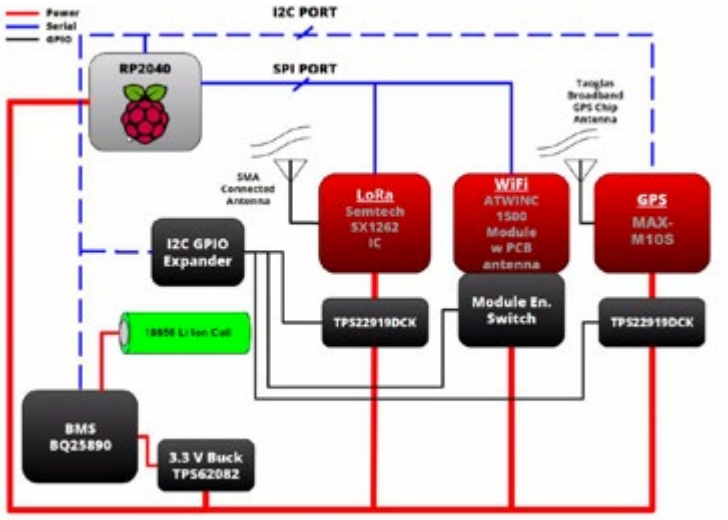
2. Secondary Mission: Characterize Parameters

Other LoRa links have been demonstrated to Low Earth Orbit in the past. Our unique contribution will be to thoroughly characterize the LoRa settable parameters and ground station requirements needs to produce a robust link.

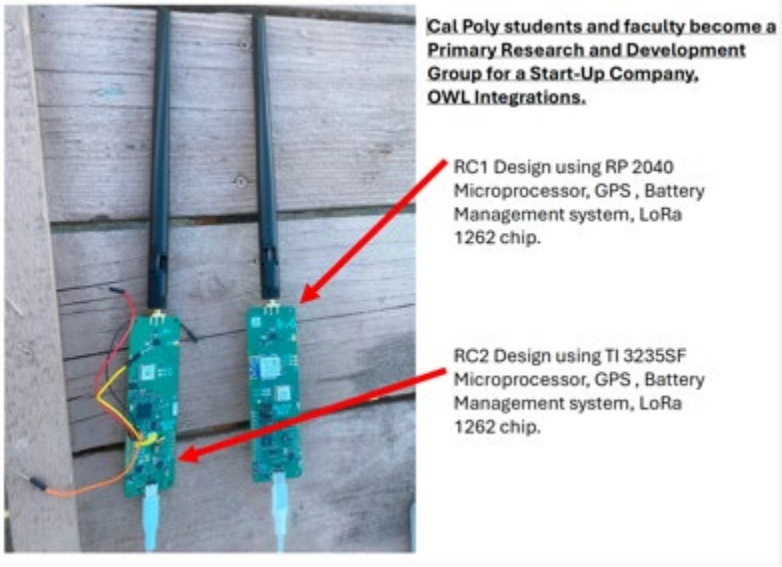
We will demonstrate our LoRa hardware design in LEO

LoRa Radio Hardware Design

RC1 Block Diagram – Cal Poly Developed LoRa Mesh Network Transceiver



Cal Poly Sal-E Cube Sat Hardware Block Diagram (Projected 2026 Launch)



Cal Poly students and faculty become a Primary Research and Development Group for a Start-Up Company, OWL Integrations.

RC1 Design using RP 2040 Microprocessor, GPS , Battery Management system, LoRa 1262 chip.

RC2 Design using TI 3235SF Microprocessor, GPS , Battery Management system, LoRa 1262 chip.

Space Hardware derived from updated radio design (both built & tested)

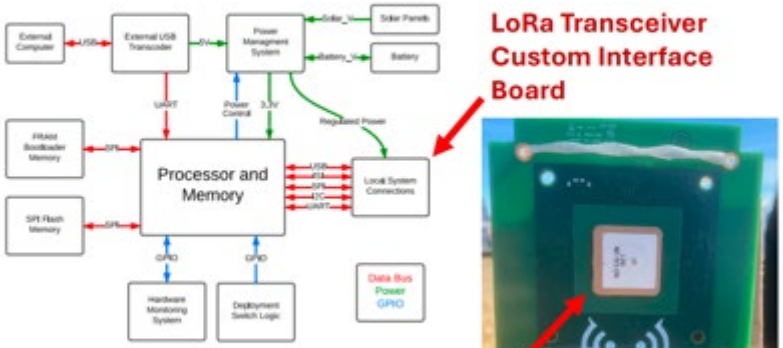


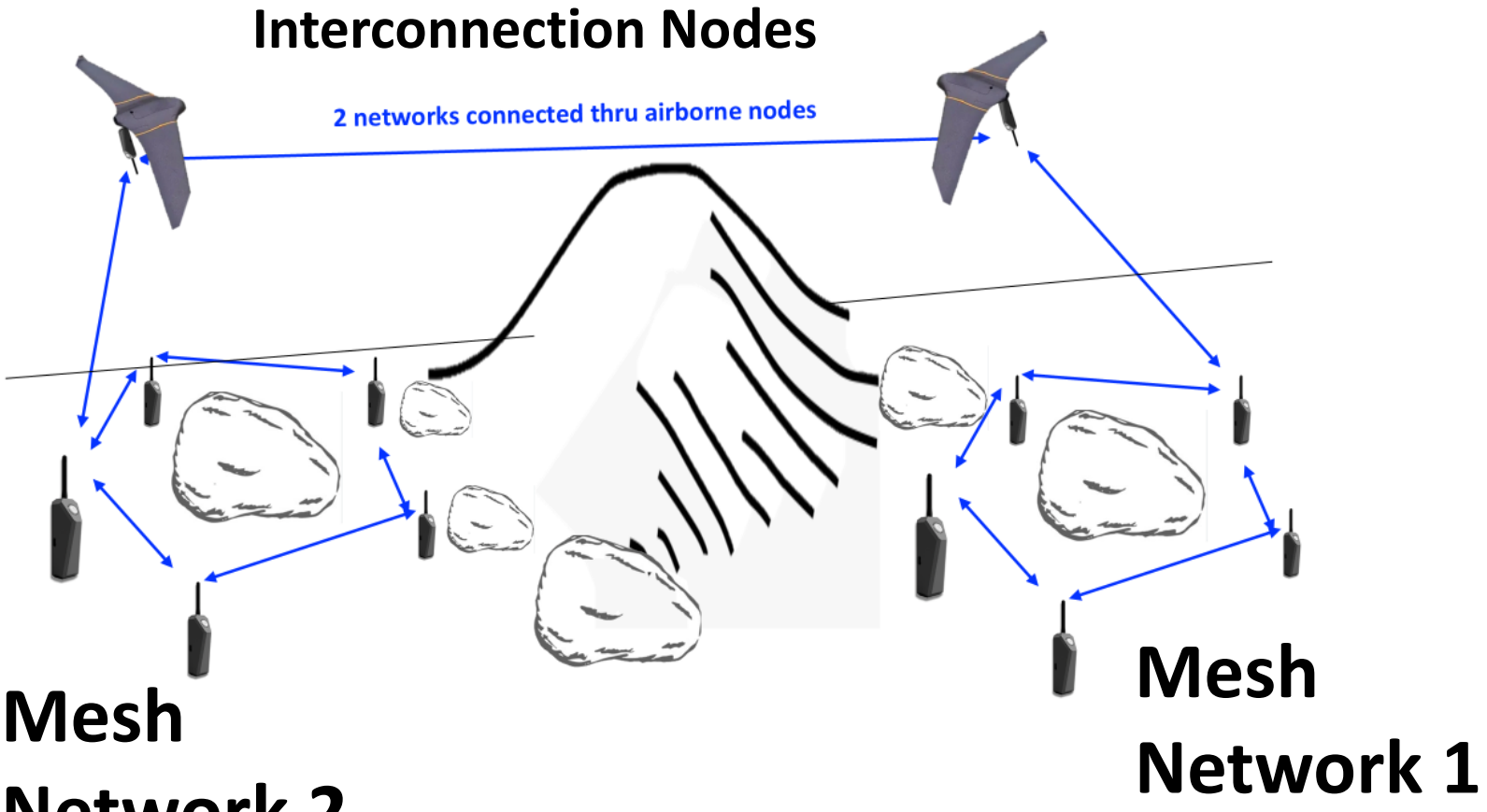
Figure 7: System Block Diagram

LoRa Transceiver Custom Interface Board

Ceramic Patch RX-only Antenna

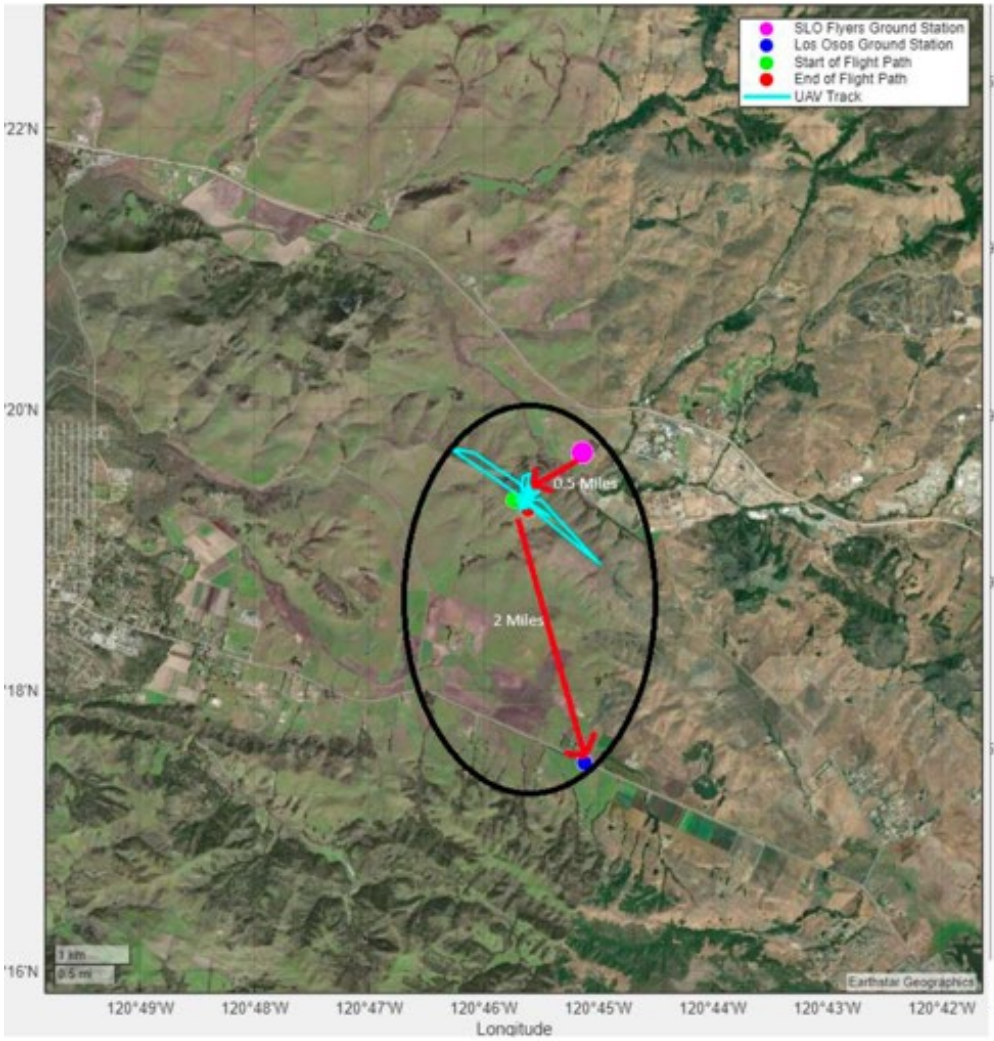
Cal Poly acts as start-up company OWL's primary R & D branch

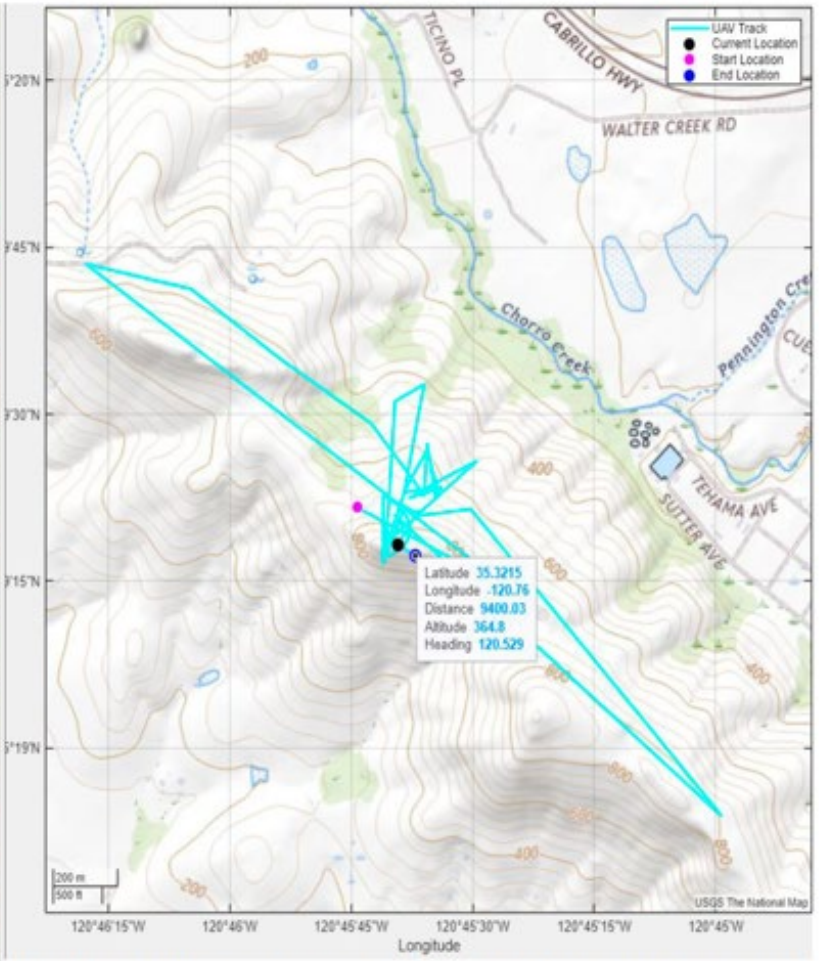
Nov 23/24 Field Test Experiments



Field Tests demonstrate network ops over large area
Best performance at closest range (as expected)

Field Testing Nov. 22/23, 2024

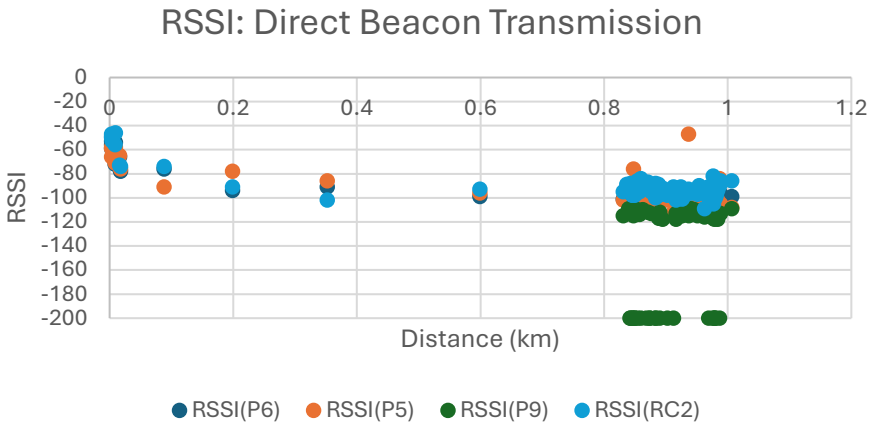


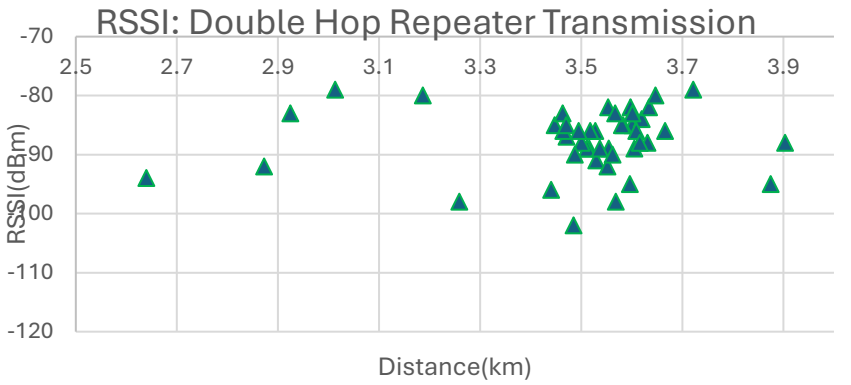


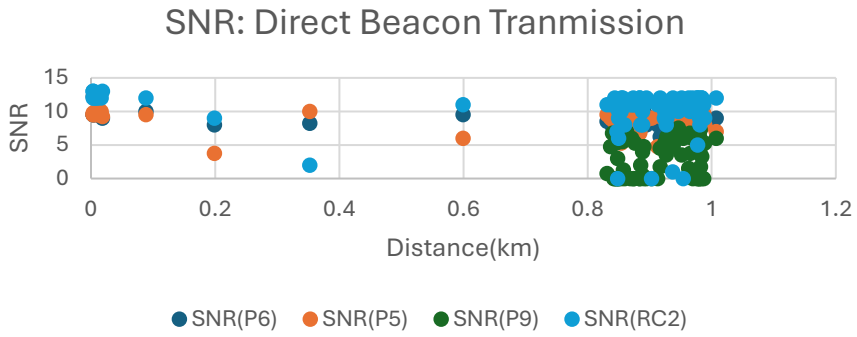
Flight path shows total distance flown by drone and direction it flies. Packets were sent every 30 seconds for two repeater drone experiment.

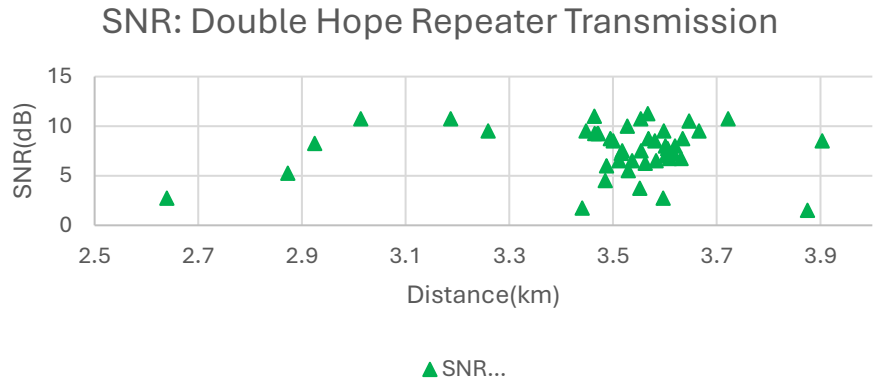
Result = Successful connection of two Cluster Duck Protocol Networks over A mountain range obstacle. Used custom LoRa Hardware and Software.

Nov 23/24 2024Field Test Results





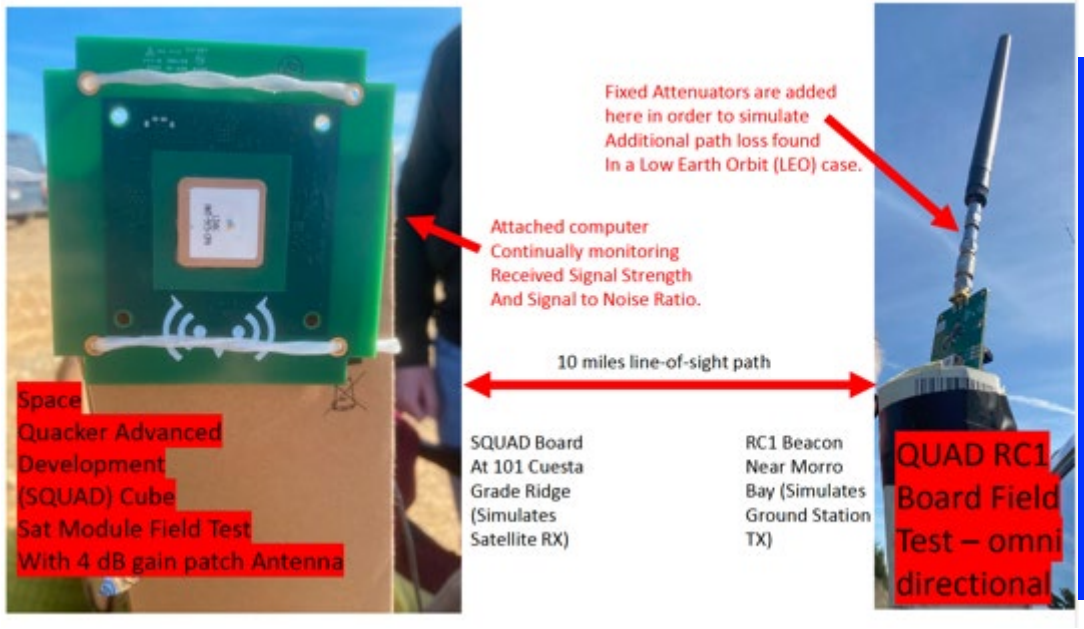




Field Tests demonstrate network ops over large area
Best performance at closest range (as expected) as well as strengthened signal when using repeaters (MamaDucks)

Field Testing with Cal Poly Developed Radios

Conclusion : THIS LINK COMBINATION WAS CAPABLE OF HANDLING A PATH LOSS OF 112 dB + 25 dB = 137 dB. The SEMTEC 1262 data sheet shows a sensitivity spec of -130 dBm and an output power of 20 dBm giving a 150 dB of measurement range with 0 dB SNR. We will use 1W+ TX power and gain antennas to improve link margins.



Initial Field Tests demonstrate space hardware>10 mi] with 25 dB Margin

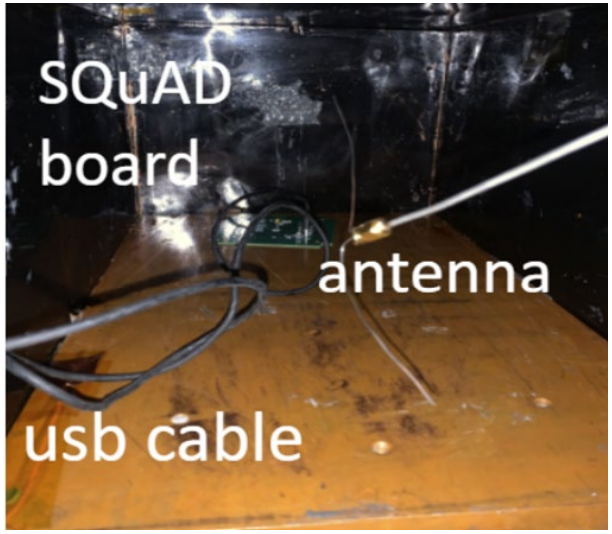
Expect to close link at LEO with low gain antennas and Modest power

Additional Field Test Planned

Thermal Vacuum Testing

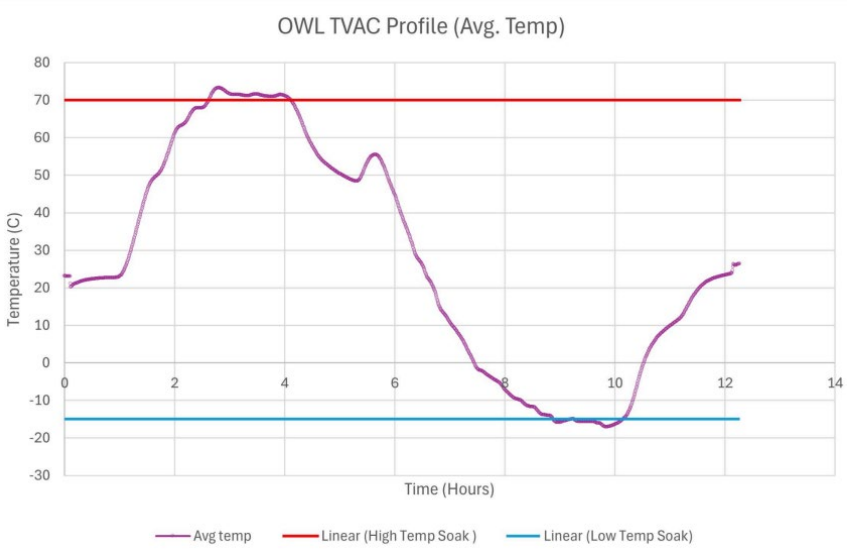
Test setup:

- The SQuAD Board inside chamber
- The TX antenna in chamber
- USB test access from chamber



The Results:

- 0 BER (mostly)
- 2 minor glitches (BER <0.01)
- Internal temperature sensor data correlated to external measurements
- Overall good



Future Plan:

- Repeat TVAC fully integrated with host cubesat (SAL-E)

Vibration Testing

Vibrations Test:

- 2-axis pathfinder test last year successful
- 3-axis test performed March 2025
- Sine sweep and random vibration profiles

Vibrations Test Results:

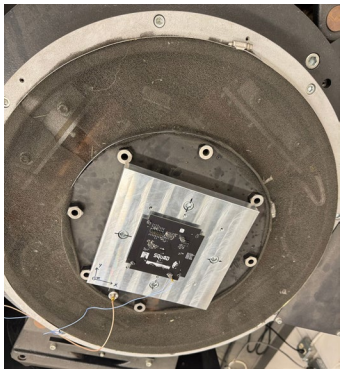
- Generally nominal
- Excursion on some sensors did not appear on reference sensor (loss cable)

Pre and Post Vibrations Test:

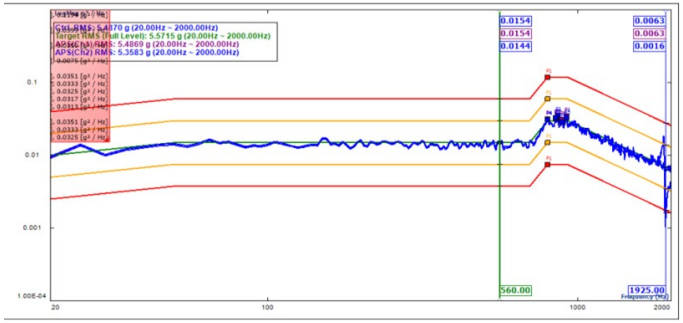
- Nominal

Future Plan:

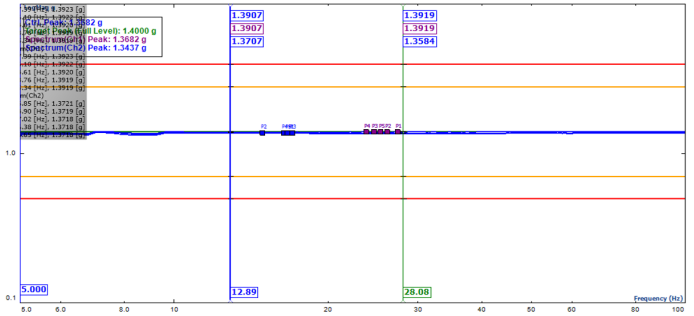
- Repeat test fully integrate with host cubesat (SAL-E)



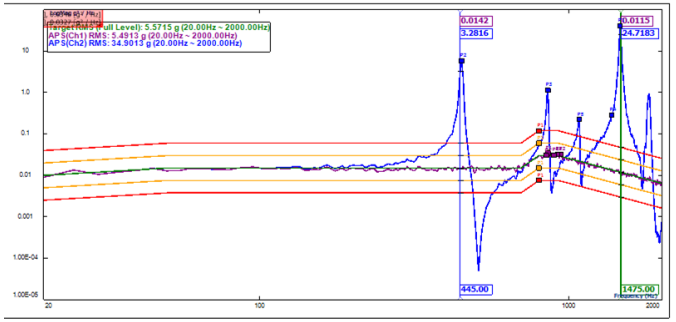
Random X-axis Results



Sine Sweep Y-axis Results



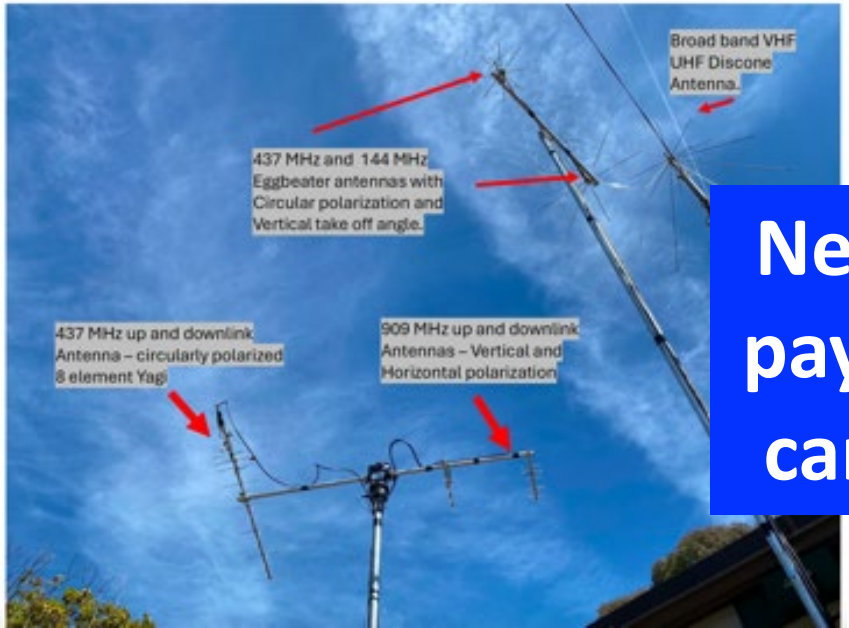
Random Z-axis Results



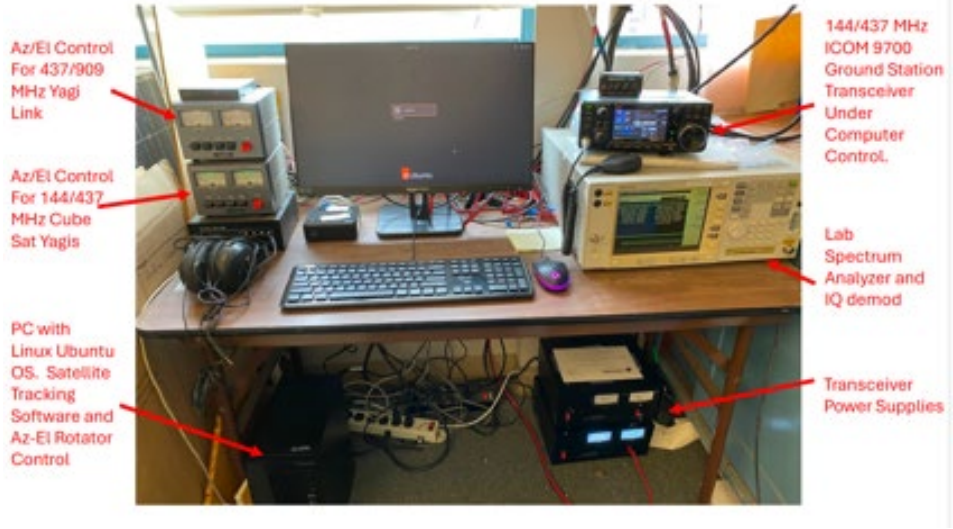
New Ground Station Includes LoRa Payload Network Operations Center (NOC)

NEW! Cube Sat Ground Station connected to Microwave Laboratory at Cal Poly for Satellite Control
Located in Cal Poly's Electrical Engineering Building 20-116 – Supported by the OWL Integrations STTR

Cube Sat Ground Station Antennas connected to Microwave Laboratory at Cal Poly for Satellite Control
Located in Cal Poly's Electrical Engineering Microwave Laboratory Building 20-116 – Supported by the OWL P



New Ground Station equipment for 902-928 MHz Uplink Testing



New Ground Station handles all payload/network ops (NOC) and can back-up Satellite Ops (SOC)

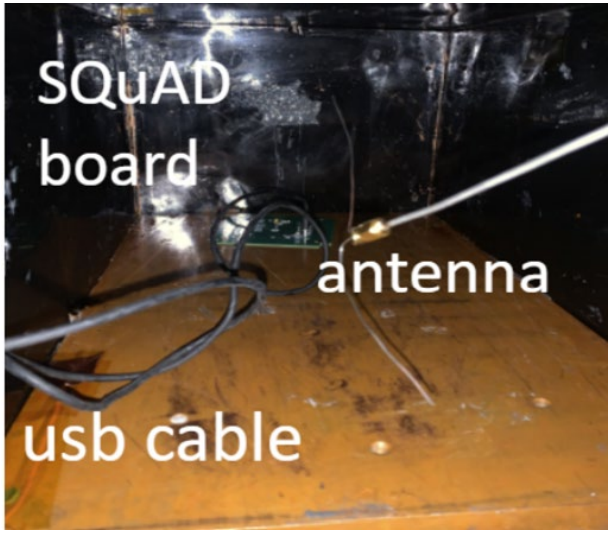
Summary

- Custom LoRa transceivers designed, built and tested for a LoRa Cube Sat communication interface in conjunction with Cal Poly's Sal-E mission for Launch in 2026. Thermal Vac and Vibration testing in progress for the Sal-E mission.

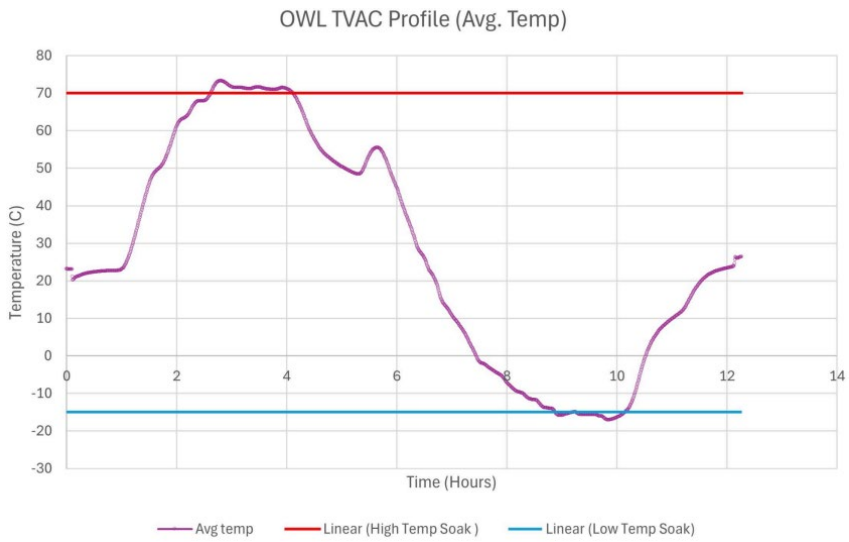
- Goal is to investigate and demonstrate requirements for a robust LoRa-based Link to a Cube Sat in Low Earth Orbit.

- Will investigate a wide range of LoRa parameters and ground station needs for a successful 902-928 MHz up link.

Backup-Thermal Vacuum Testin



- Test setup:
  - The SQuAD Board with a USB cable connected to it feeding outside to a computer was placed in the chamber with a half-wave dipole antenna as the TX antenna.
  - The TX antenna was then connected to a Duck Radio that would send 100 packets every 15 minutes and at every interested temperature plateau.
- The results:
  - There was a 0 BER for all of the temperatures except 2 that were both less than 0.01
  - The temperature sensors at each test gave very similar results to the actual temperature.
  - Overall the test results were very good and showed that the SQuAD board is able to continuously function under different extreme temperatures.



Future Plan:

- We will be repeating this test at the end of the Spring Quarter when the SQuAD Board is fully integrated on SAL-E.

Future Testing Area: 3 main nodes. With additional nodes scattered within the area to test a mesh network and paths it takes.