Atmospheric Characterization and Mesh Network Prototyping

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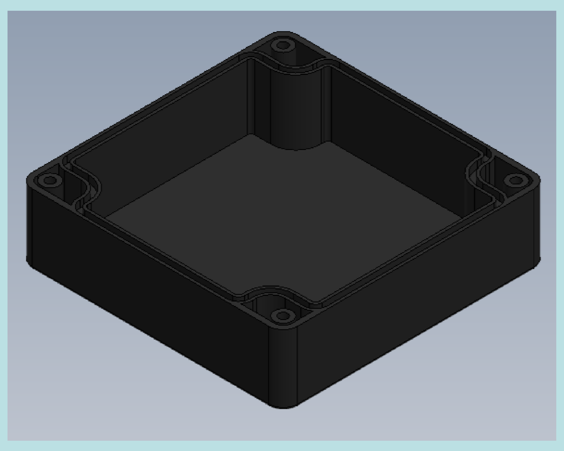
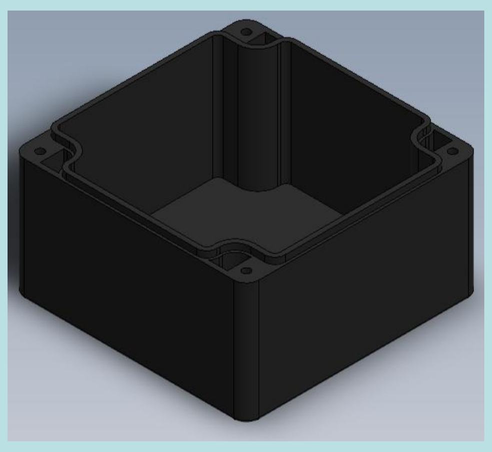
Introduction & Project Description:

This study details the design, construction, and deployment of high-altitude balloon payloads for atmospheric characterization and technological development. Employing Arduino Nano microcontrollers, payloads collected temperature, pressure, humidity, and UV-C data up to 100,000 feet, complemented by 4K and 360-degree imagery for Earth observation. . Initial missions focused on stratospheric and ozone layer traversal, demonstrating data logging to microSD cards. Subsequent iterations introduced an innovative enclosure design and dual payloads, incorporating RF transceivers for inter-payload communication and internal temperature monitoring. This work marks the team's first custom PCB development, integrating the microcontroller, RF, and temperature sensors. This research serves as a foundation for developing a mesh network for air-to-ground communication with autonomous rovers, advancing high-altitude balloon capabilities for scientific and technological applications.

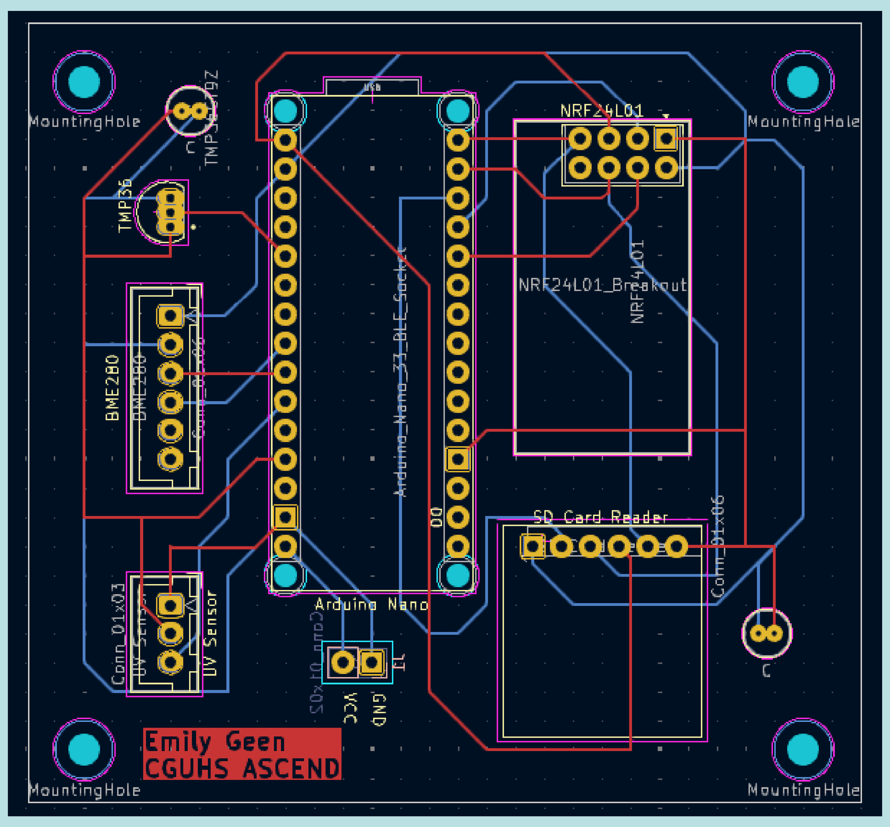


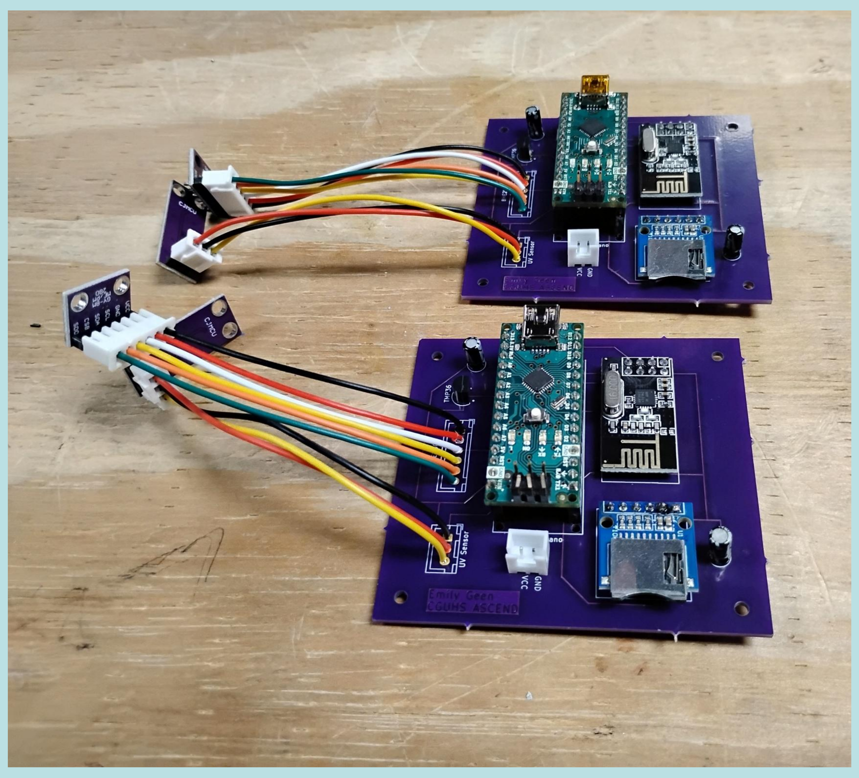


Results:

In Phase I: Single Payload Atmospheric Data Collection, we failed to obtain atmospheric data due to a coding issue. However, we did obtain approximately 60 minutes of 4K video depicting the balloon ascent and the curvature of the Earth.

In Phase II: Dual Payload RF communication, though the system worked on the benchtop, we failed to obtain atmospheric data or RF communication between our two payloads. However, we again obtained approximately 60 minutes of 4K video depicting the balloon ascent and the curvature of the Earth.





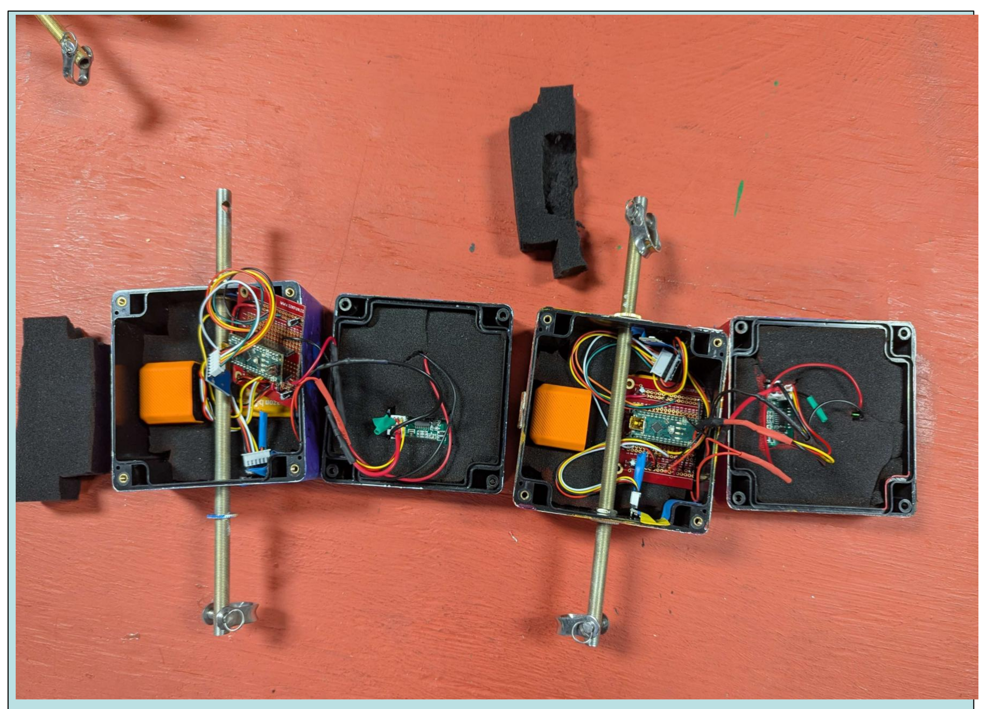
Methods:

Phase I: Single Payload Atmospheric Data Collection and Imaging
Goal: Successfully launch and recover a single payload, collecting atmospheric data and capturing high-resolution imagery.
Timeline: Fall 2024, 2-3 months (COMPLETED)

Phase II: Dual Payload RF Communication
Goal: Establish two-way RF communication between two payloads, transmitting internal payload temperature data.
Timeline: Spring 2025, 3-4 months

Phase III: Air-to-Ground Mesh Network Prototyping
Goal: Establish a mesh network between a balloon payload and three ground-based autonomous rovers.
Timeline: Fall 2025, 4-6 months

Phase IV: Multi-Balloon and Ground Rover Mesh Network
Goal: Expand the mesh network to include two balloon payloads and ground rovers.
Timeline: Spring 2026, 3-4 months



Conclusion:

At this point we have realized that our errors are the result of our process.

Payload #1: Red Payload

- No SD Card
- Loose Lamp-rod
- Missing lamp rod nut (why lamp-rod might be loose)
- Wiring still looks good
- Only minor chipped paint on the outside of our enclosure.
- Tape didn't hold well in holding sensors
- Minor battery damage

Payload #2: Blue Payload

- Loose Lamp-rod
- Missing an inside screw
- Semi-ruined shrink tube (Arduino Nano Vin Pin)
- Minor battery damage
- Chipped paint

Future Plans

Given the unsuccessful completion of Phases I and II, future plans prioritize a focused, iterative approach. Immediate steps involve a thorough failure analysis of both phases to pinpoint the root causes. The project will then revert to the core objectives of Phase I, redesigning and rebuilding a simpler single payload dedicated to reliable atmospheric data collection and robust microSD card logging. Cameras may be temporarily excluded. Rigorous bench and tethered testing will validate these fundamental systems.

Separately, efforts will concentrate on achieving stable ground-based RF communication between two radio modules, focusing on reliable two-way data exchange before balloon integration.

Future iterations will prioritize reliability over complexity, with strict adherence to weight limits and emphasis on proven components. Integration of data logging and RF communication into a dual-payload system (Phase II objectives) will only occur after achieving stable individual functionalities, with cautious and incremental testing. Phases III and IV (mesh networking and rovers) are postponed. Meticulous documentation of all steps, including failures and modifications, will be crucial for building a solid foundation for future progress. The timeline will be adjusted to reflect this more deliberate approach.

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