

# Colorado State University

## Demo-Sat B

Vertical CO<sub>2</sub> Profile  
May 19, 2014- July 25, 2014



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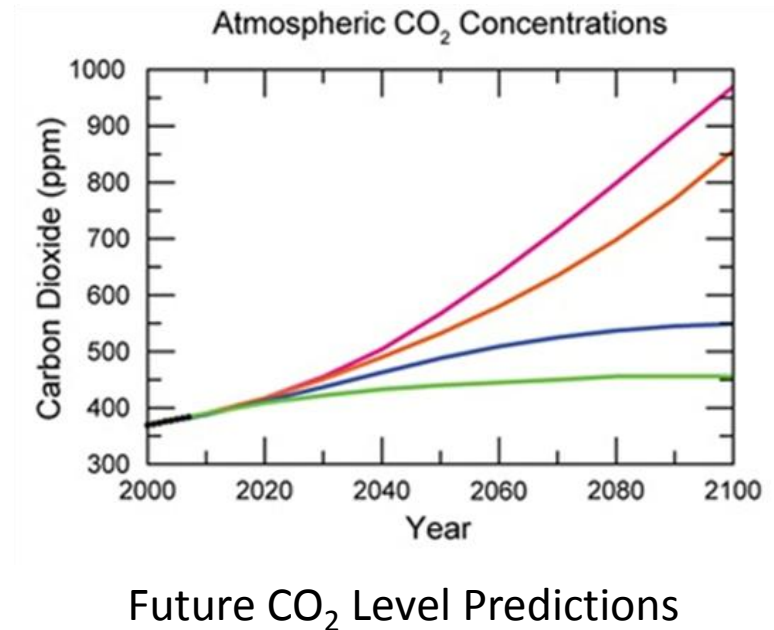
Ryan Russell

# Mission Statement and Goals

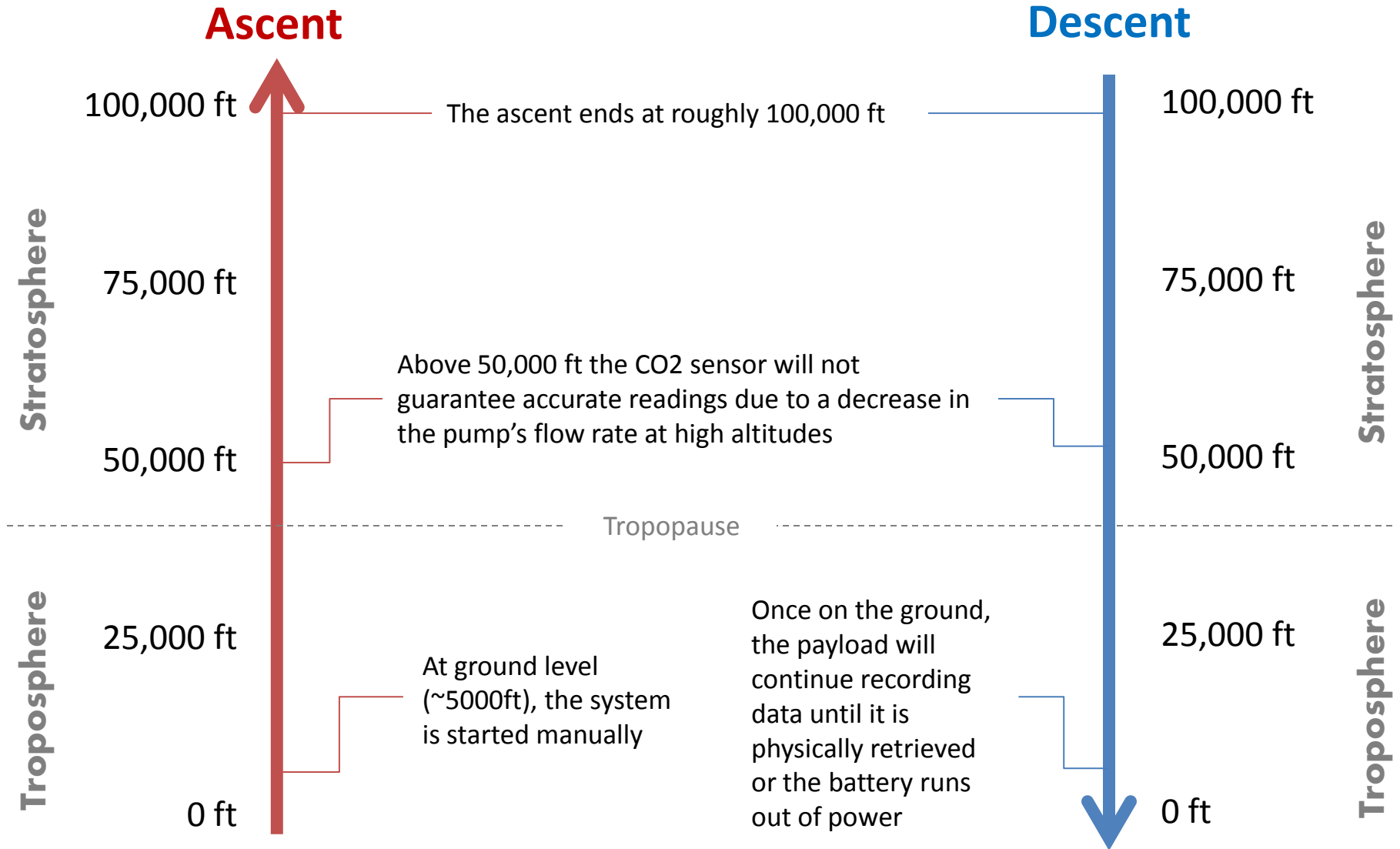
- **Primary Objective:** Measure CO<sub>2</sub> levels in the atmosphere
- **Secondary Objective:** Measure wind speed and direction as the balloon ascends to determine the source of a CO<sub>2</sub> plume
- **Mission Statement:** The mission is to provide a system which will be reusable, low cost and mobile to map the vertical profile of CO<sub>2</sub> and locate its origin to bring attention to the effects of human emissions of CO<sub>2</sub>.

# Scientific Theory

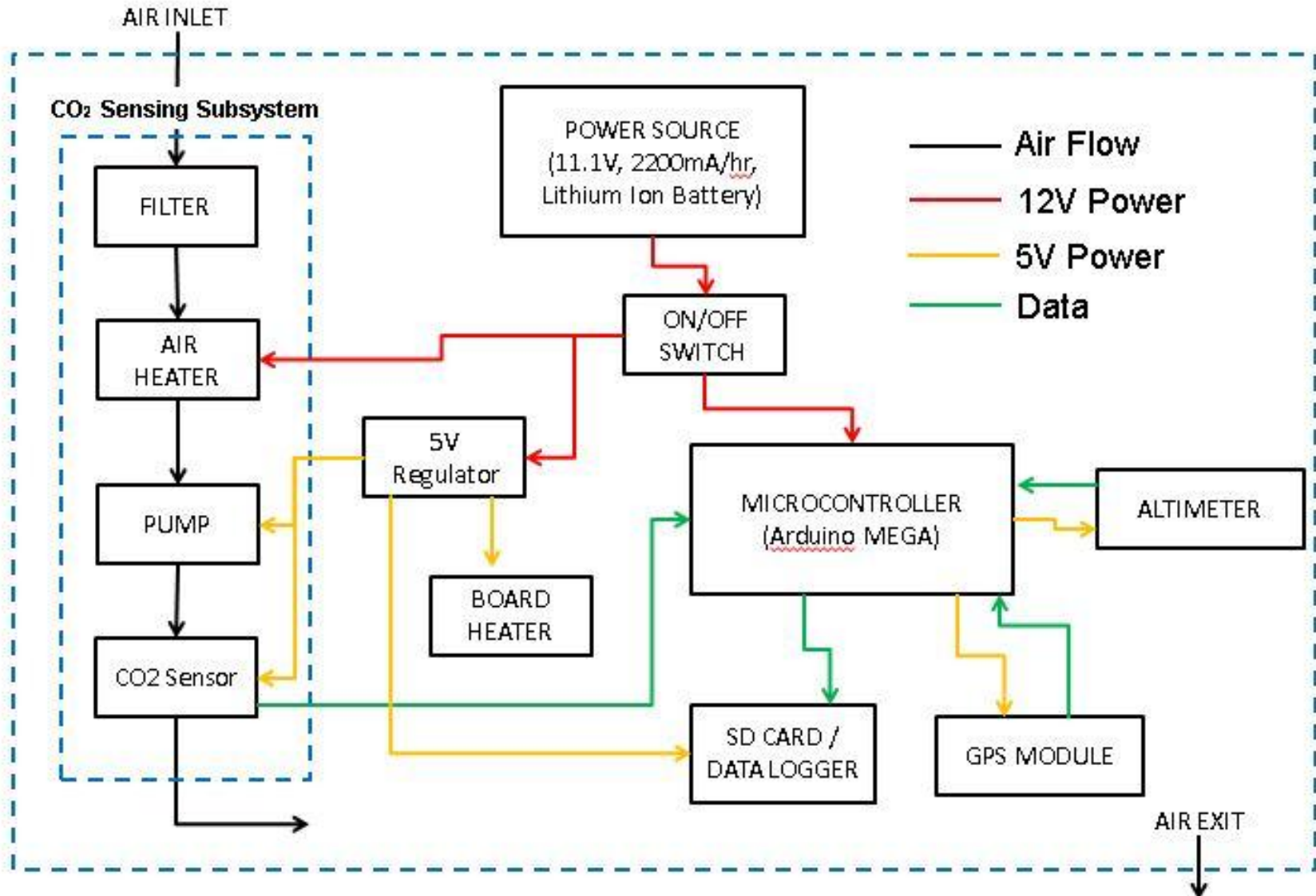
- CO<sub>2</sub> is the primary greenhouse gas emitted through human activities (82%)
  - Electricity
  - Transportation
  - Industry
- Greenhouse Effect
  - Levels of CO<sub>2</sub> increase the amount of heat retained in the atmosphere causing the Earth's surface to heat up



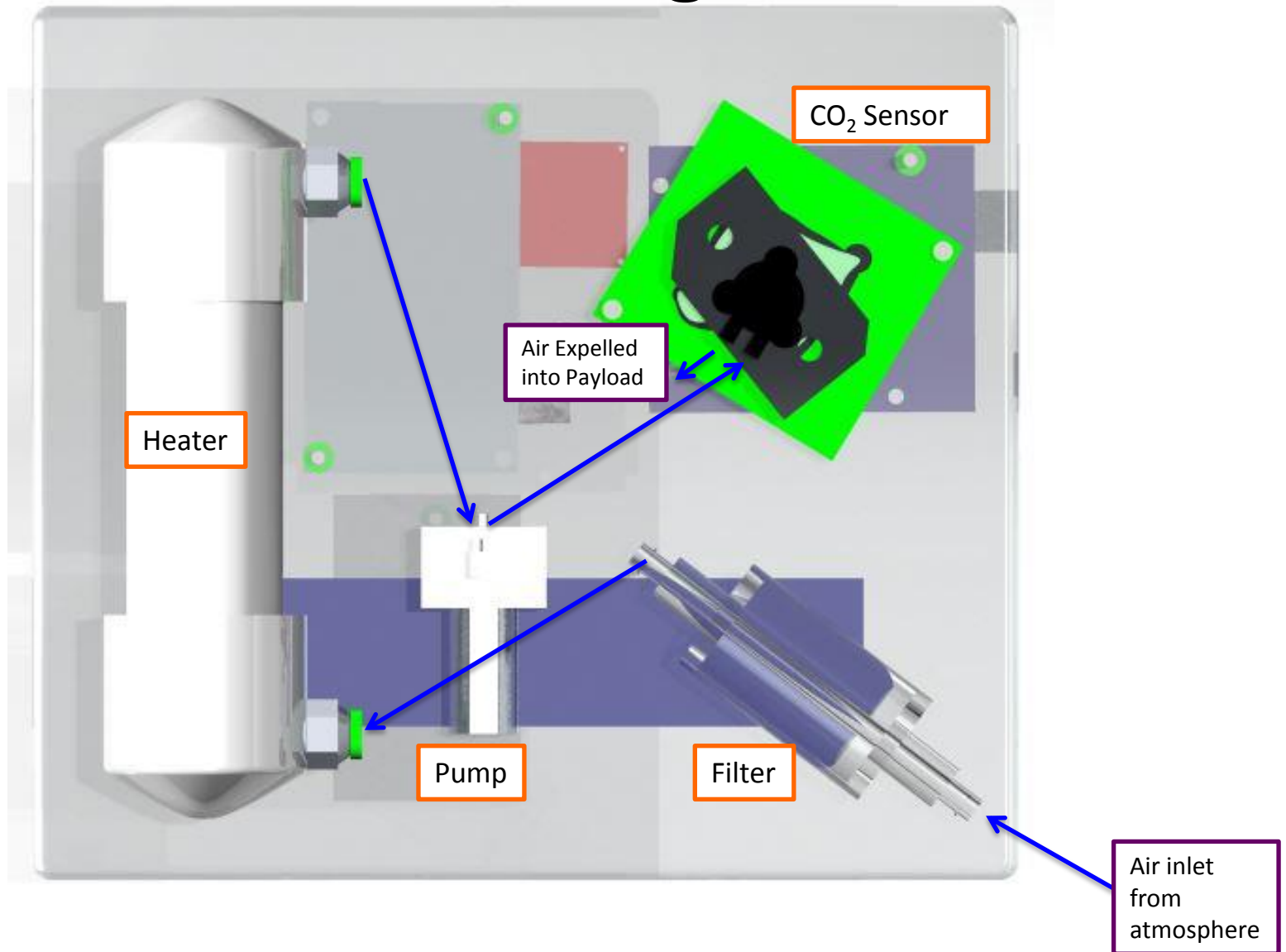
# Concepts of Operation



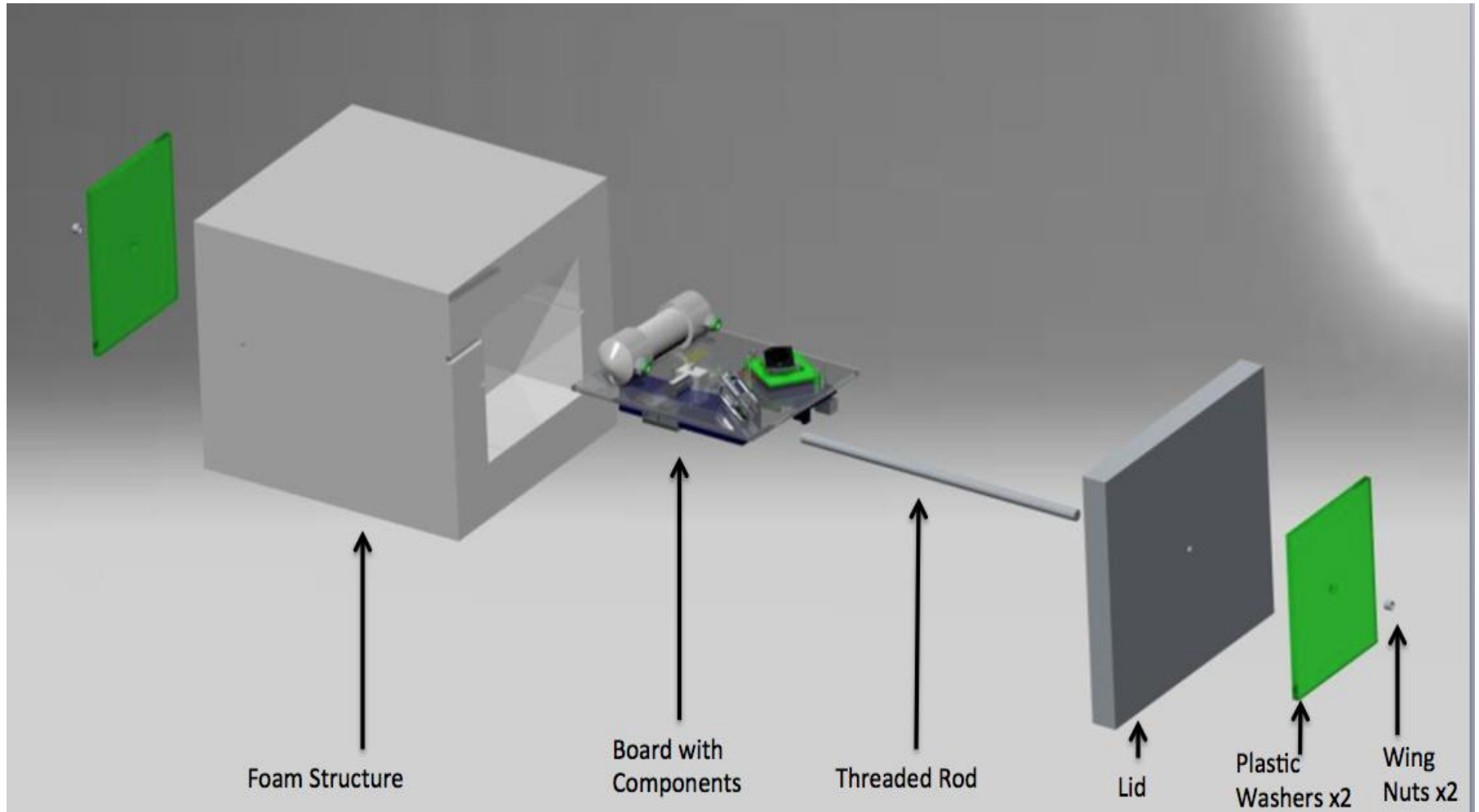
# Block Functional Diagram



# Air Flow Diagram

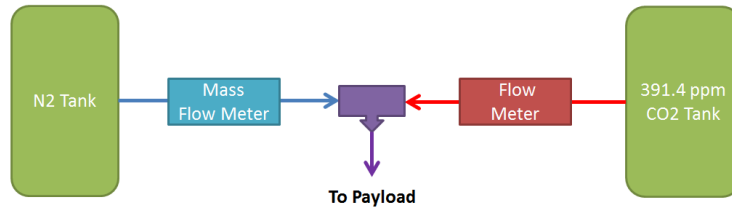


# Exploded View of Payload



# Testing

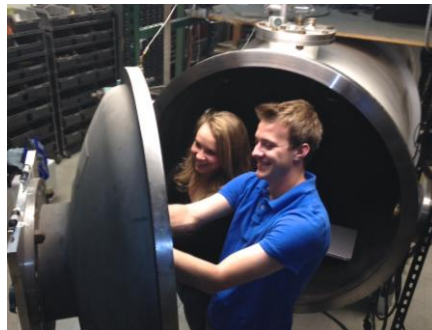
## Co2 Accuracy



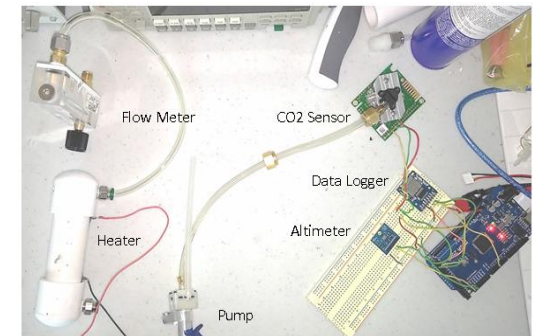
## Structural



## Cooler/ Vacuum Test



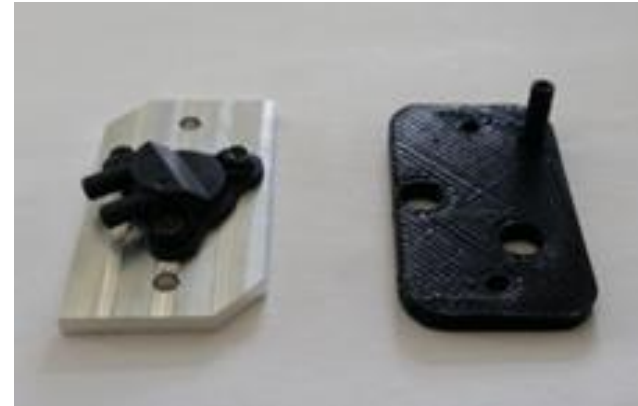
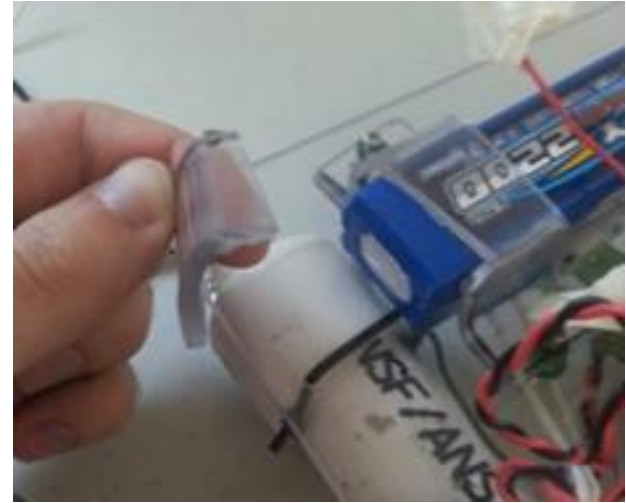
## GPS / Software and Electrical Software





# Testing Results: Additions

- **Structural:** Zip ties added
- **Cooler:** Aluminum foil wrap, heater to electronics
- **Vacuum:** 5V regulator replaced
- **Electrical:** Larger battery
- **CO2:** 3D printed new adapter



# Final Mass and Budget

- Budget: \$1,000
  - Total Spent: \$999.06
  - Remaining: \$ 0.94
- Weight: 1500 g
  - Total Mass of Payload: 1417 g
  - Remaining: 83 g



# Launch Day

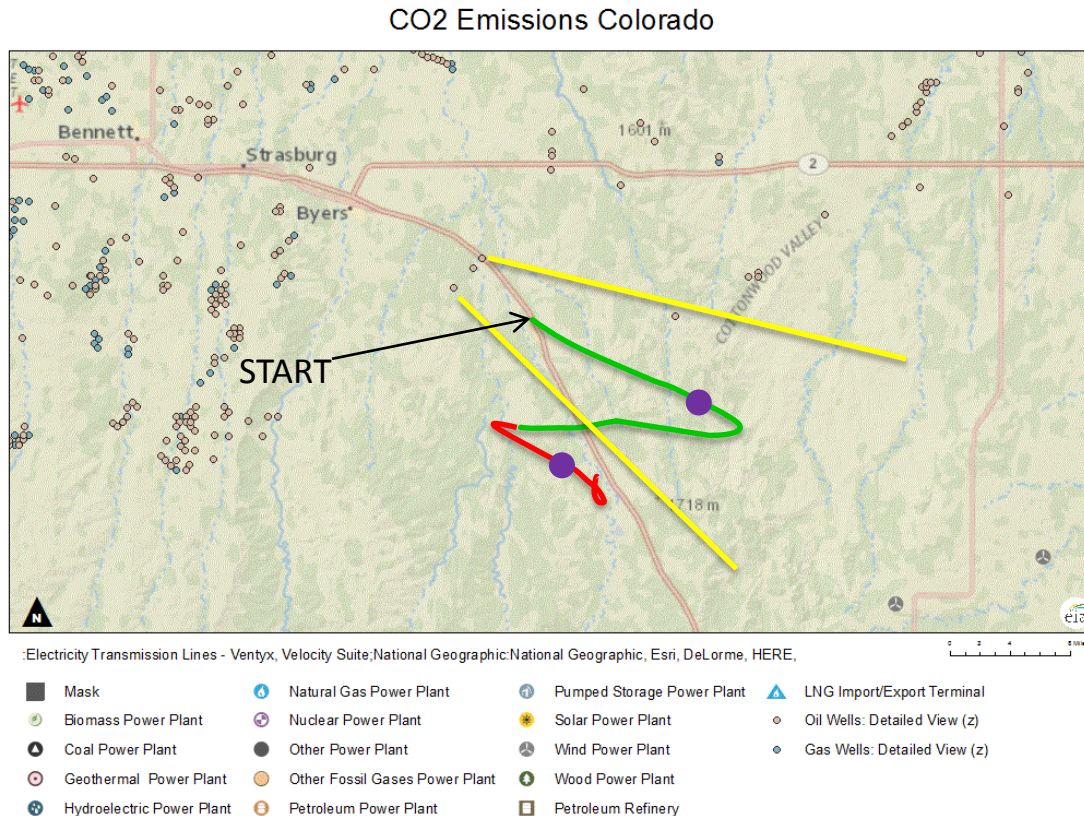


- Date: Aug 2, 2014
- Location: Deer Trail High School, CO





# Map of Ascent and Descent

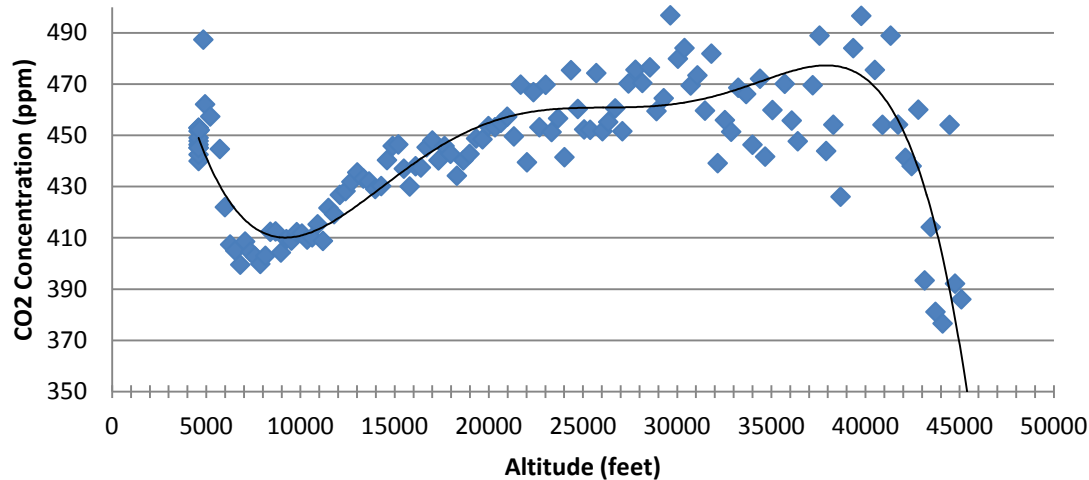


<http://www.eia.gov/state/>

- Possibly encountered a plume during the ascent
- The descent is a more accurate vertical profile
- Purple dots represent altitude cutoff point for CO2 sensor

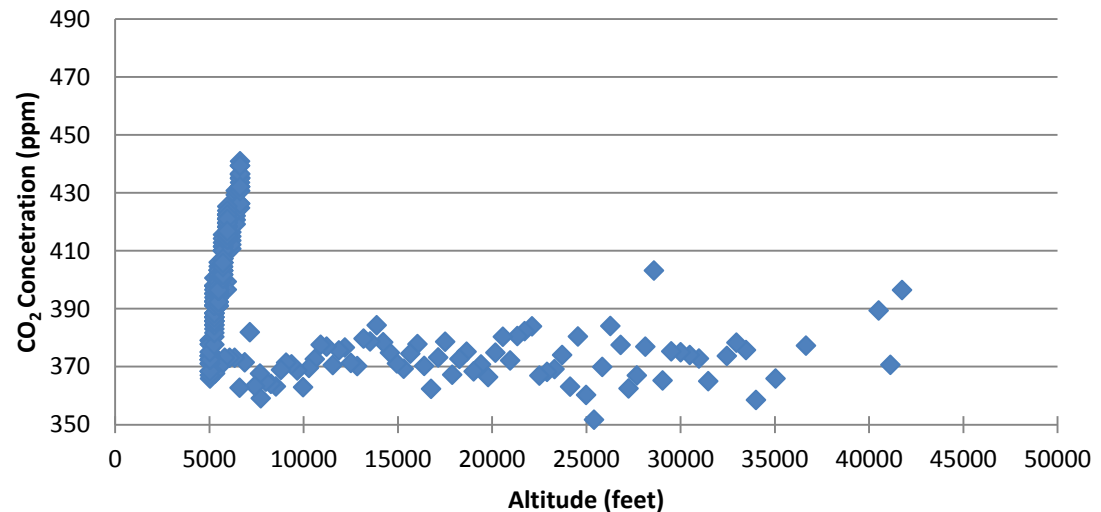
# CO2 Concentration Results

## Ascent CO2 vs Altitude



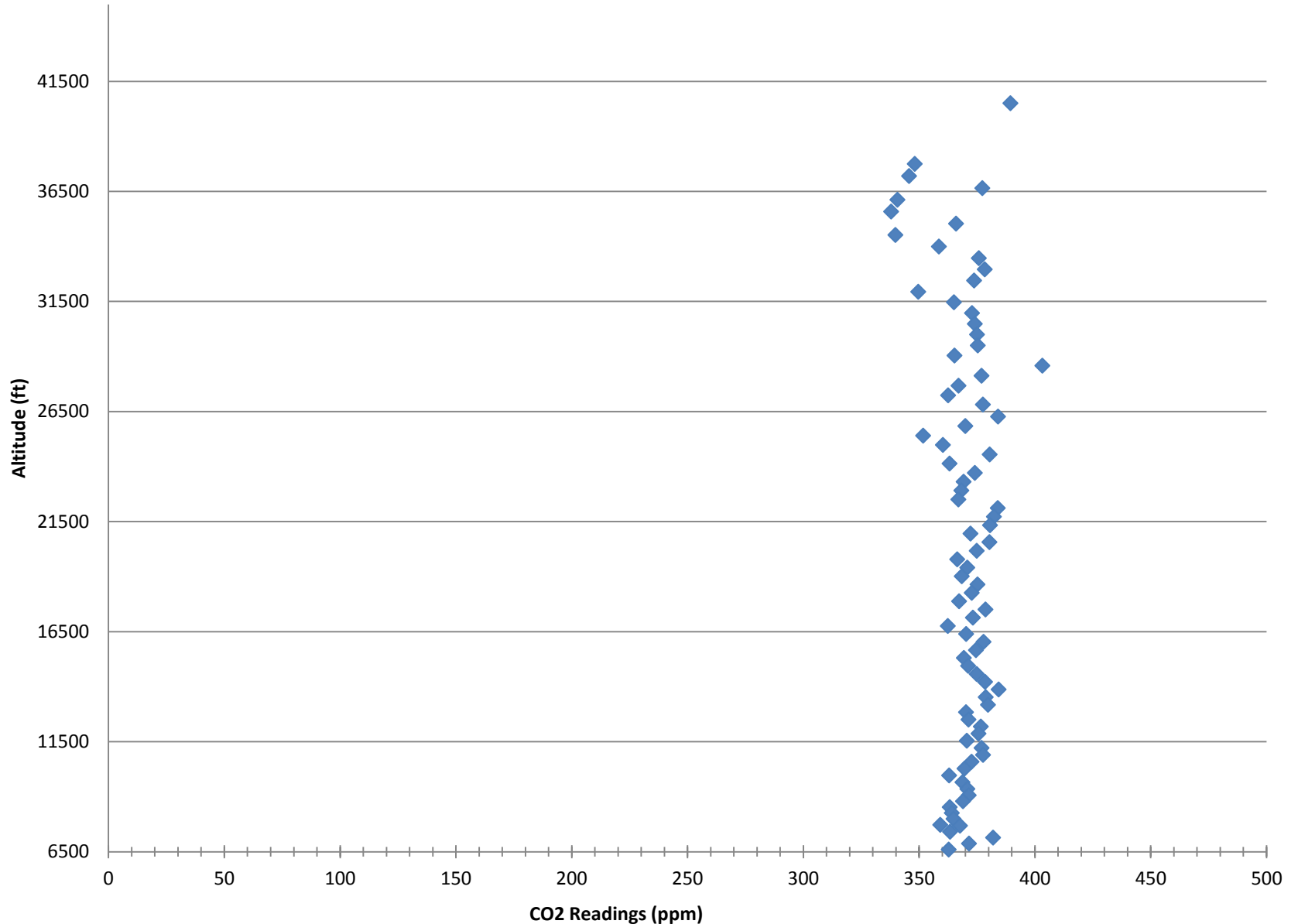
Values for the ascent generally increased with altitude

## Descent CO<sub>2</sub> Concentration vs Altitude



Values for the descent were within 20ppm with the exception a few outliers

# Results – CO2 Vertical Profile



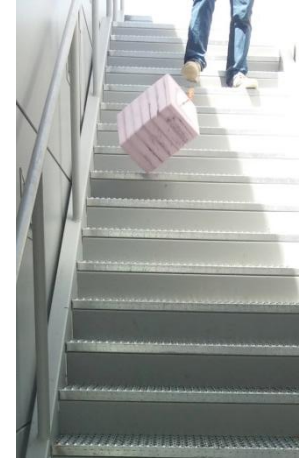
# **APPENDIX**

# Test 1: Structure Test

**Procedure Name:** Whip Test /Drop Test/ Stair Test

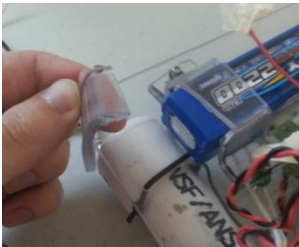
**Objective:** Simulate the worst case scenario of the device landing. This test will determine the fracture points and stresses of the payload.

**Completion Date:** June 16, 2014



**Damage/fixes:**

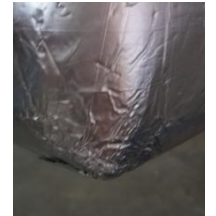
Zip ties and battery holder breaks → New 8" zip ties rated tensile strength of 75 lbs replace



Board moving out of the grooves on top → New tighter grooves carved into the foam

**Damage/Fixes:**

Corners fractured →  
Corners rounded and  
Wrapped in Al foil



Tubing coming loose from pump → zip tie and  
Goop the tubes to  
Inlet/outlet





# Test 2: Cooler Test

## Procedure Name: Cooler Test

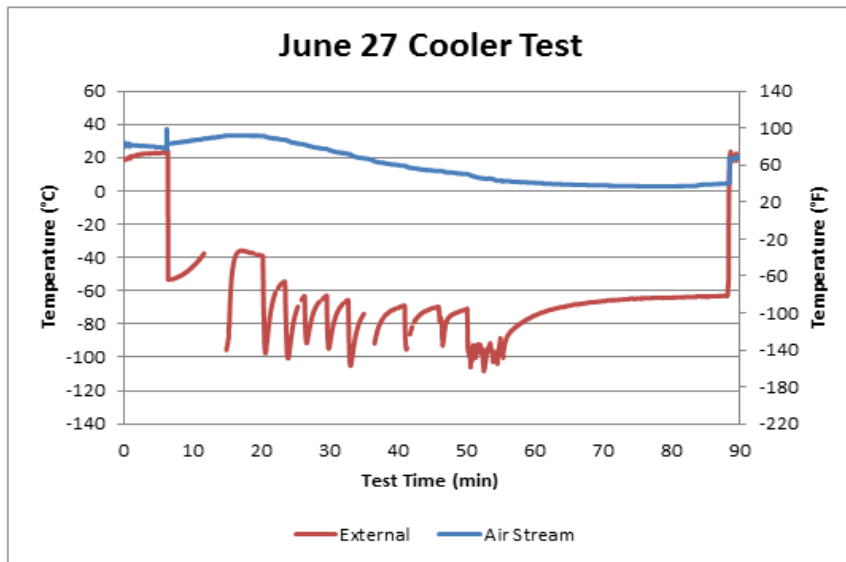
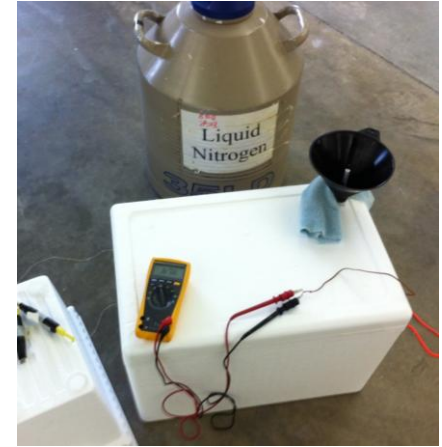
**Objective:** Test payloads under extreme temperatures experienced at 100,000 ft.

**Completion Date:**  
June 27, 2014



## Test Setup Overview:

Payload was turned on and suspended inside the Styrofoam cooler.



## Results:

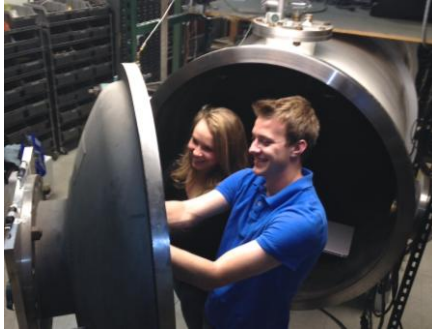
- **First Test:** the temp was not closely monitored and reached -120C. The SD card did not log, battery failed, frost build up
- **Second Test:** Temp closely monitored but SD card did not log
- **Third Test:** Temperature was -80C and everything worked. Tested for 1.5 hours.

# Test 3: Vacuum

## Procedure Name: Vacuum Chamber Test

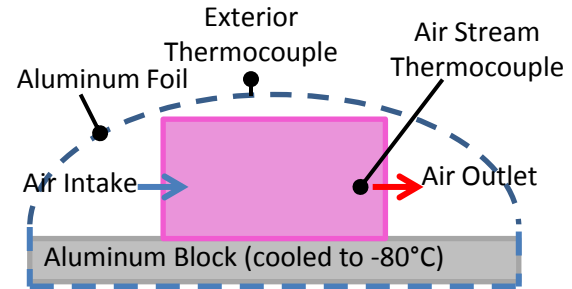
**Objective:** Test all components at low pressures and low temperatures and find their limits.

**Completion Date:**  
**July 17, 2014**



## Test Setup Overview:

Place payload inside the chamber to simulate low pressures during flight.

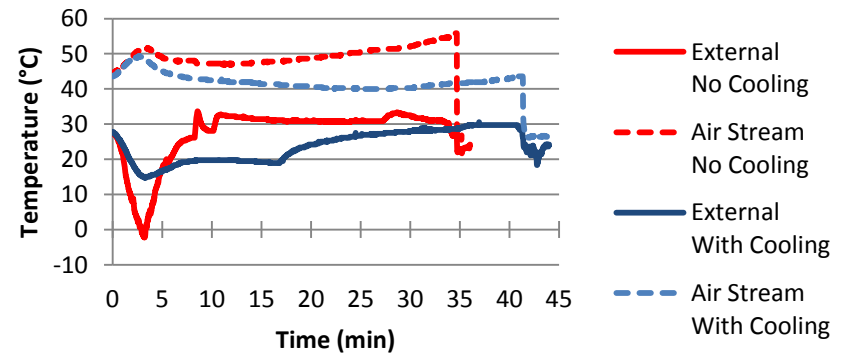


## Test Details:

- The test will start at atmospheric pressure and then lowered to a pressure similar to the max height of 100,000 ft (1 KPa).
- A thermocouple data logger will record temperatures external of the payload and at the air stream
- A cooled Al block is placed under payload on 2<sup>nd</sup> test

## Results:

- 5V regulator overheated and is the suspected cause for inaccurate CO<sub>2</sub> reading
- All other data recorded accurately



# Test 4: GPS

**Procedure Name:** GPS Accuracy

**Objective:** Check the accuracy of the GPS by walking a known route

**Completion Date:** July 11, 2014

**Test Setup Overview:**

- GPS was tested by wrapping the payload in Al foil and placed inside a cooler to see if the signal was distorted.



**Test Details:**

- Test was conducted by walking the perimeter of the building with the payload switched ON and compared readings to Google Maps
- This test had different scenarios including different weather conditions and with/without the Al foil and cooler.

**Results:**

- The GPS worked through the cooler but not through the Al foil. An external antenna was ordered to solve this problem.
- The GPS locked onto the satellites within 5 minutes of being outside. GPS does not record accurately inside.

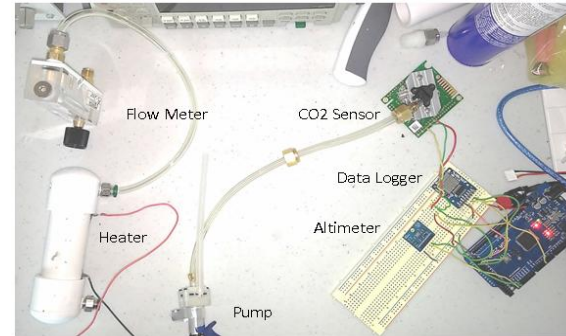
# Test 5: Electrical and Software

**Procedure Name:** Field Testing

**Objective:** Make sure all electronics are properly functioning on the ground

**Completion Date:** June - July

**Test Setup Overview:**



Test 1



Test 2

**Test Details:**

**1<sup>st</sup> Test:**

Test all components before wiring to the board

**2<sup>nd</sup> Test:**

Take a sample of CO2, pressure, altitude and temp as a base reading and make sure the data is recorded for all components. The data then can be compared to expected values of the area. Run the test for 4 hours.

Both tests were conducted numerous times.

**Results:**

**1<sup>st</sup> Test:**

- All sensors worked properly

**2<sup>nd</sup> Test:**

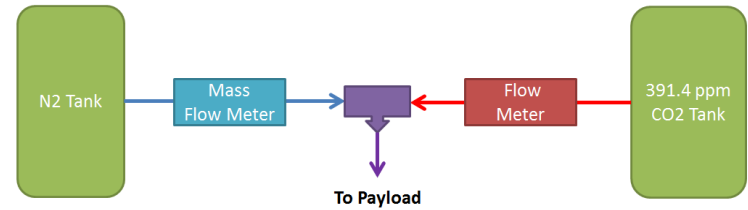
- Sensors not properly wired so the components broke. This issue was fixed when new sensors were ordered
- All sensors accurately recorded to the SD card. A larger battery was added to ensure it lasts for the entire flight

# Test 6: CO2 Accuracy Testing

**Procedure Name:** Field Testing

**Objective:** Test the accuracy and response time of CO2 Sensor

**Completion Date:** June - July



Flow Diagram



3d printed adapter

## Test Details:

### Tests 1-3:

Used 392 ppm CO2 tank and pure nitrogen tank. Ran 392ppm CO2 tank, slowly let in known values of pure nitrogen, decreasing CO2 levels by 3 ppm to see if sensor picked up changes.

**2<sup>nd</sup> Test:** Pulse test to check responsiveness of new adapter

## Results:

### 1<sup>st</sup> Test:

- Inaccurate test because mass flow controller not used

### Tests 2-3:

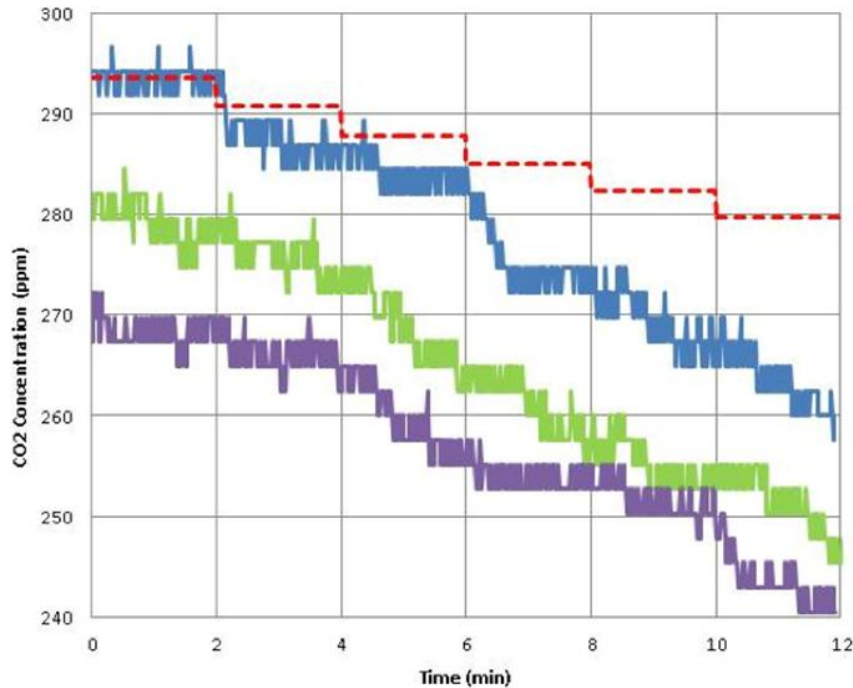
- CO2 Sensor will see fluctuations in ~3.5ppm changes
- Did not see indication of stagnant air with new adapter

### Pulse Test:

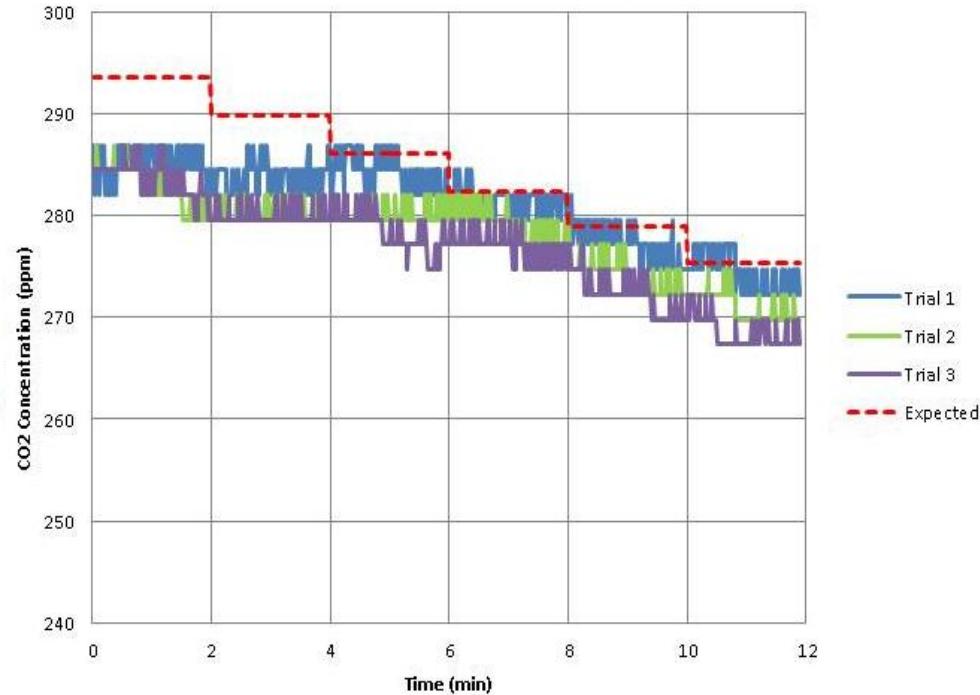
~3 increase in response time (11 seconds to 8 seconds) of sensor

# CO2 Accuracy Testing Results

CO2 Sensitivity Testing, July 11th



CO2 Sensitivity Testing, July 22nd



- Left test is before modifications, right test is after changes were made
- Results were far more consistent with new additions to sensor

# Wiring Diagram

