ODDITY Manufacturing Status Review

Members:
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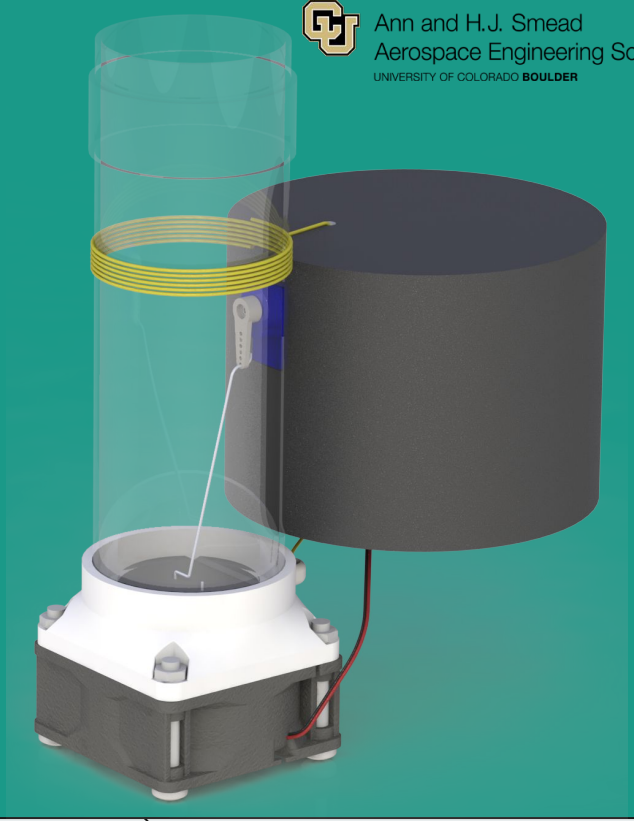
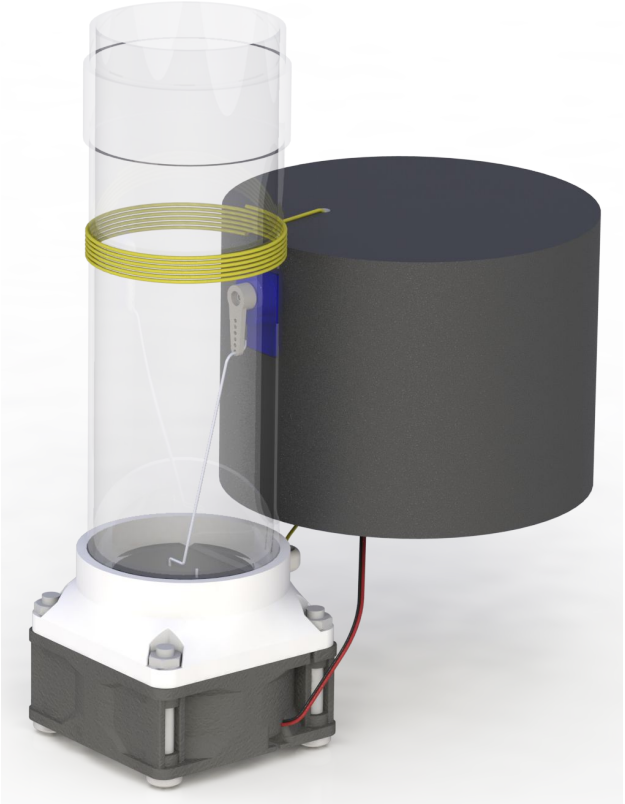
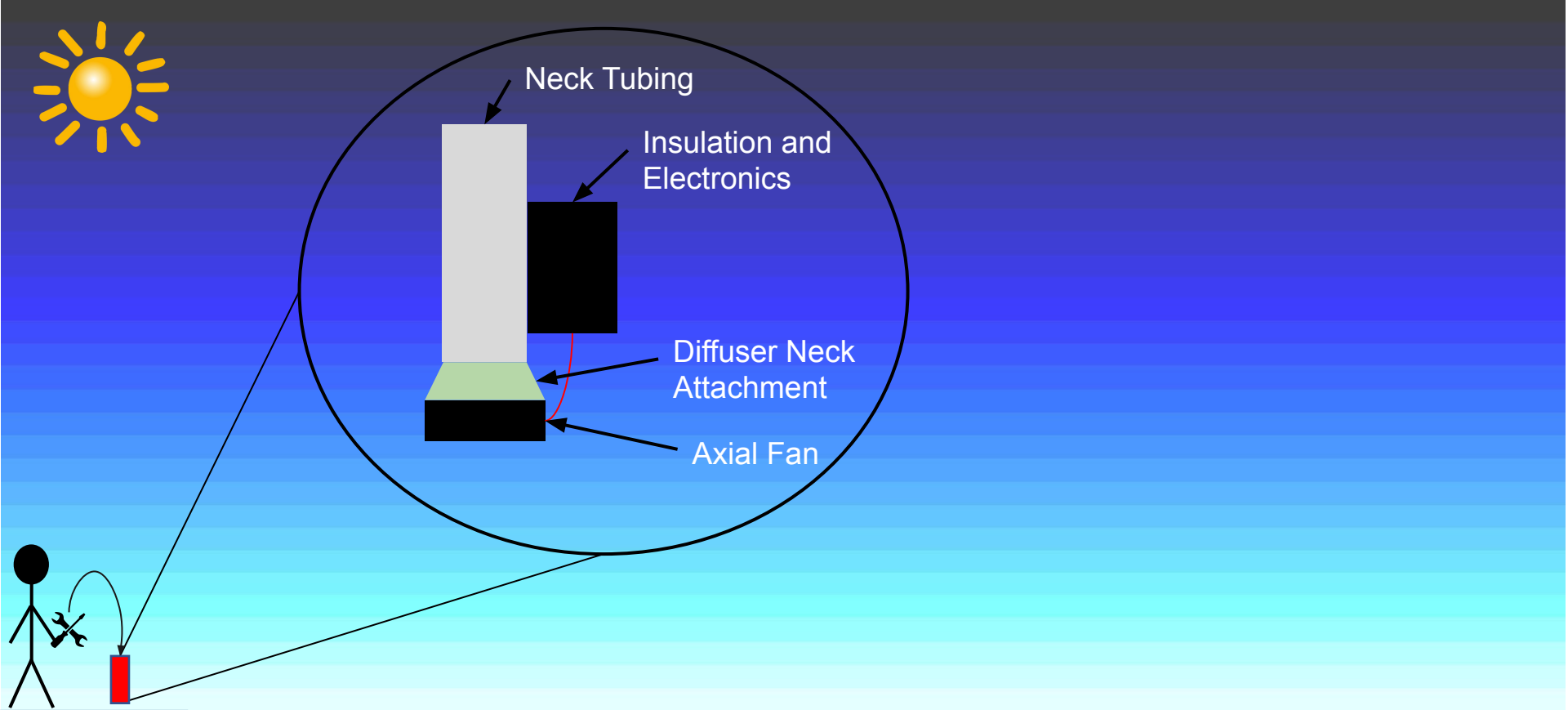
Overview



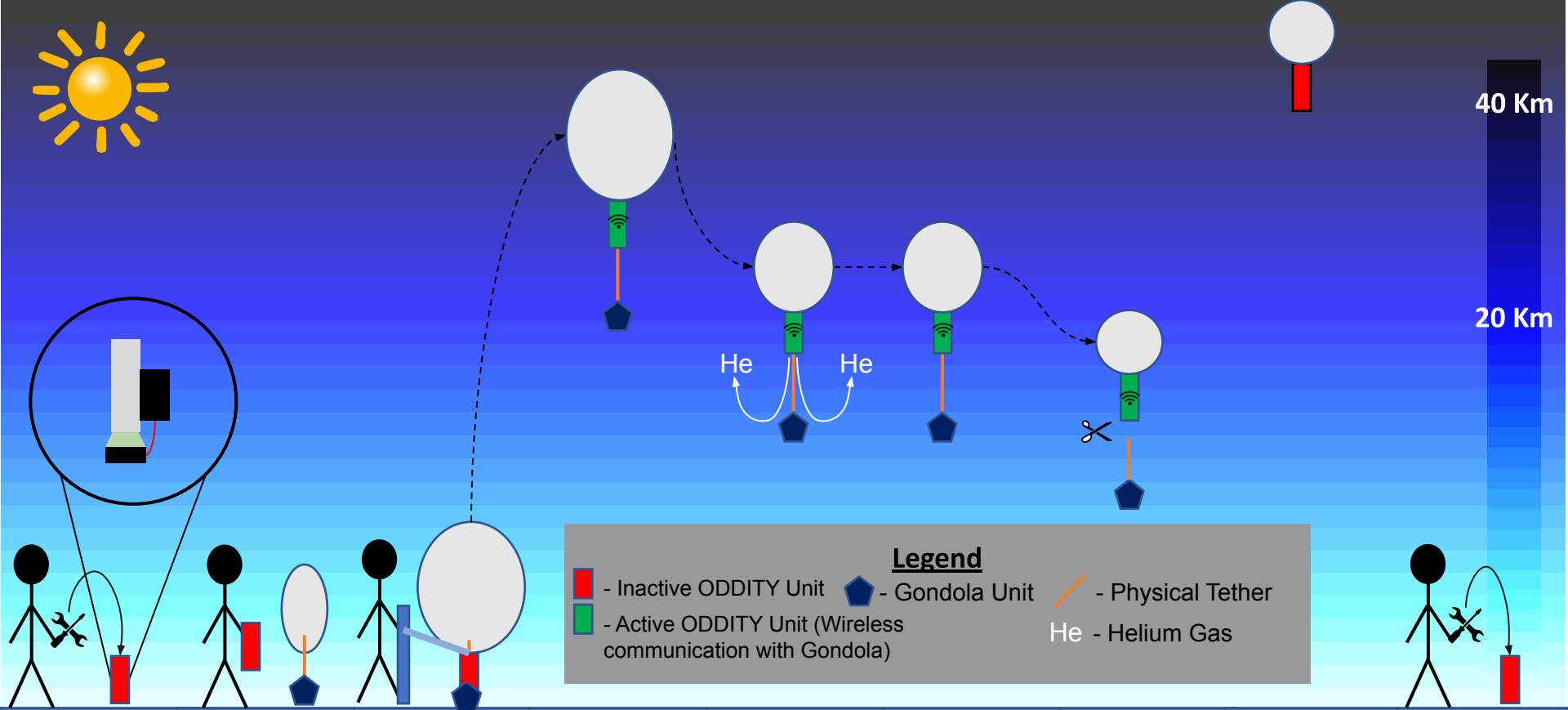
Mission Summary

- Turbulence data is required for high altitude hypersonic aircraft design
- Helium vent aids in proper high altitude turbulence data collection
- Altitude conditions deform balloon canopy which forms an effectively trapped “helium bubble”
- Active helium withdrawal is required due to this plastic deformation of the balloon





1. Assemble ODDITY



1. Assemble ODDITY	2. Attach ODDITY to Balloon	3. Fill Balloon with Helium	4. ODDITY receives command from Gondola	4.1. Command: Vent Helium	4.2. Command: Close Vent	4.3. Command: Cut Tether to Gondola	5. Balloon and ODDITY drift out of air traffic	6. New ODDITY assembled for next flight

Levels Of Success

	Descent Control	*Balloon Attachment*	*Communications*	*Survivability*
Level 1	System is able to extract helium from balloon in conditions similar to those at 35km	ODDITY is able to attach to a 5cm neck diameter Kaymont balloon prior to being filled	ODDITY shares communication link with the Gondola via XBee radio	ODDITY is able to withstand pressures and temperatures similar to those seen at 35km
Level 2	ODDITY and Gondola will match legacy system performance in flight testing (35km altitude)	ODDITY is able to be installed on 8cm neck diameter Hwoyee balloons prior to being filled	ODDITY is able to receive data and commands from the Gondola	ODDITY is able to withstand pressures and temperatures similar to those seen at 40km
Level 3	ODDITY and Gondola are able to reach a target apogee of 40km		ODDITY is able to transmit data to the Gondola	ODDITY is able to abort the mission if conditions become undesirable

Levels Of Success

	Descent Control	*Balloon Attachment*	*Communications*	*Survivability*
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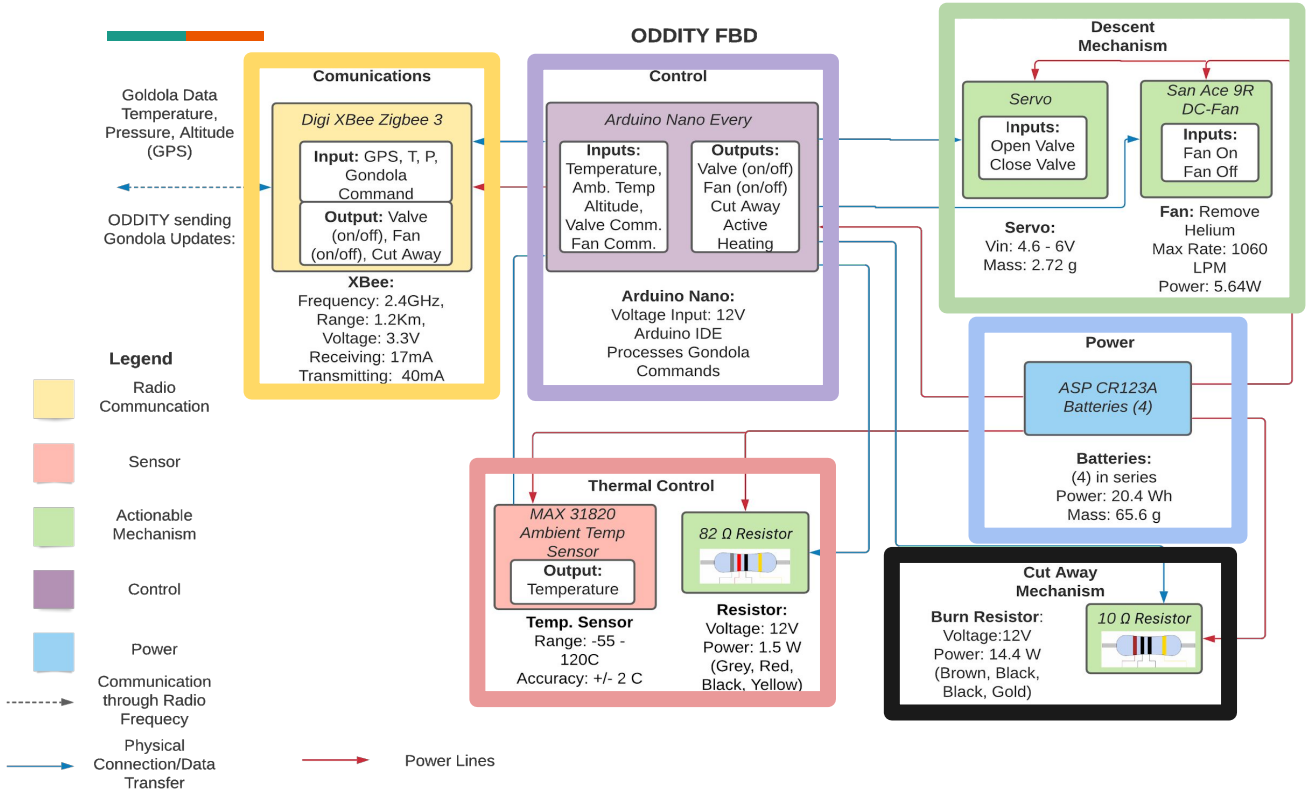
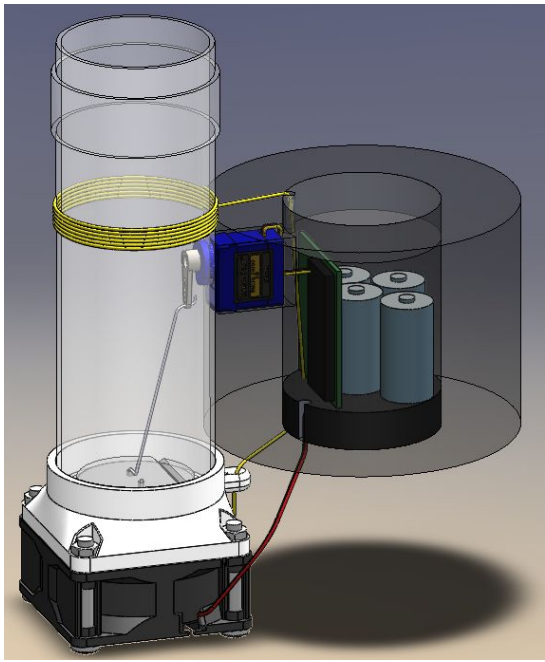
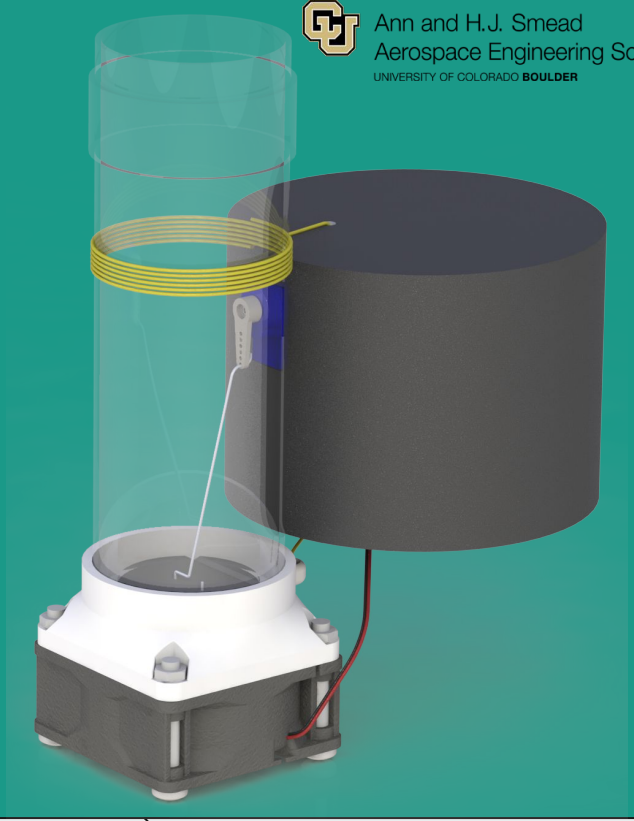
Level 3	ODDITY and Gondola are able to reach a target apogee of 40km		ODDITY is able to transmit data to the Gondola	ODDITY is able to abort the mission if conditions become undesirable

Functional Block Diagrams





Schedule



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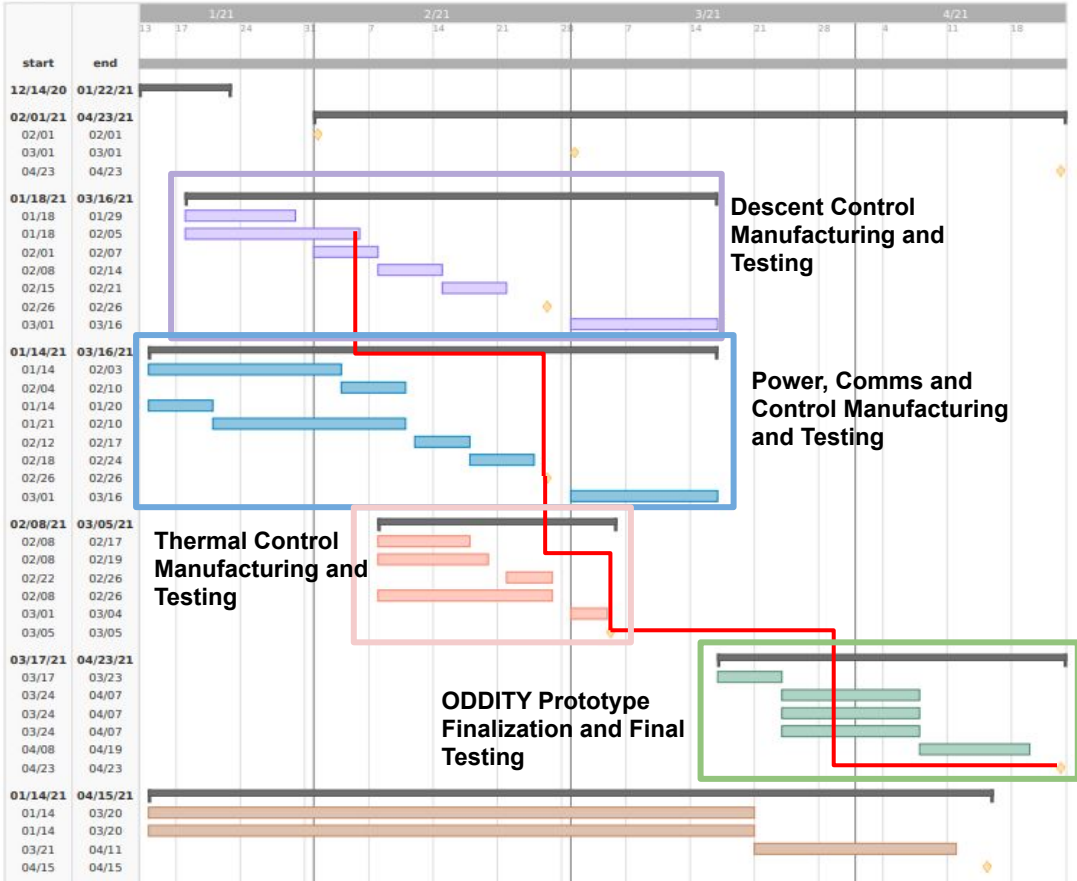
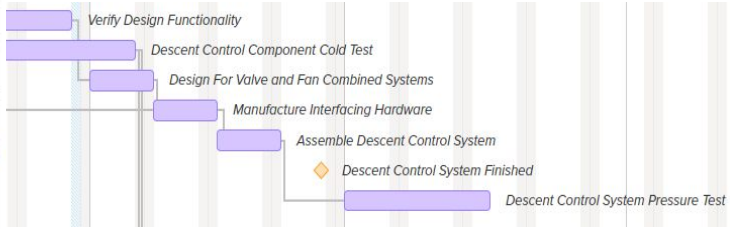
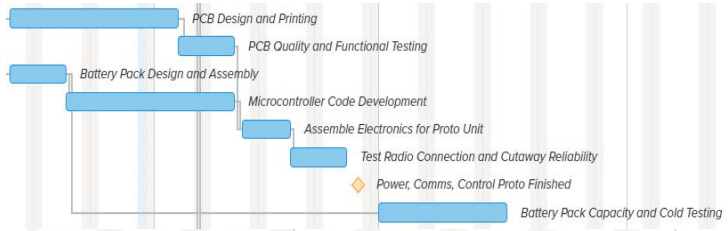
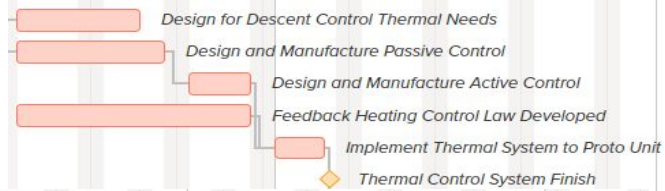
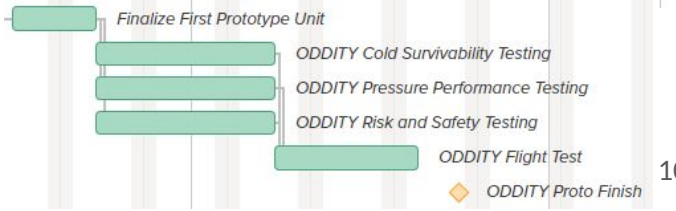
Gantt Chart - Spring Semester



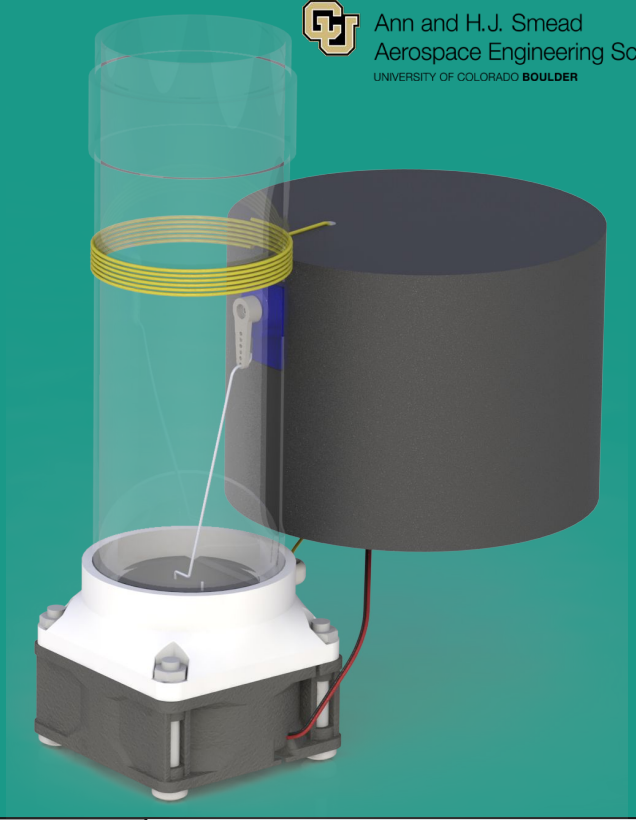




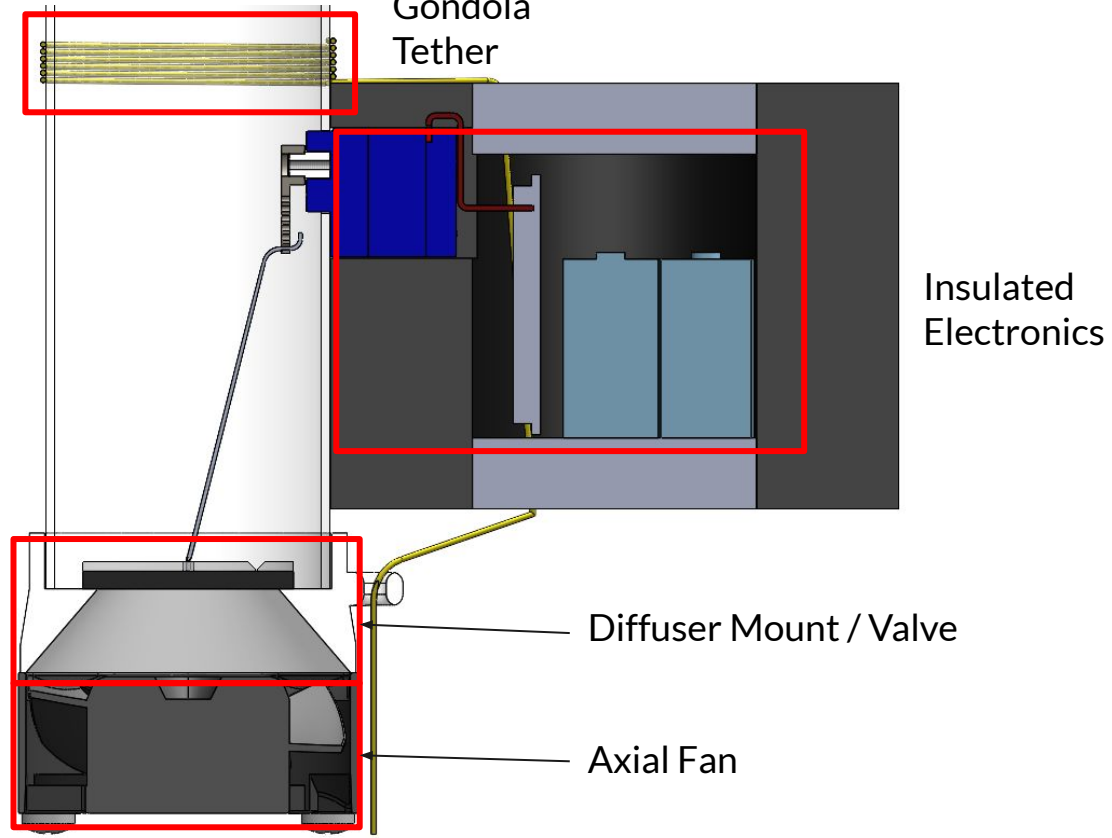


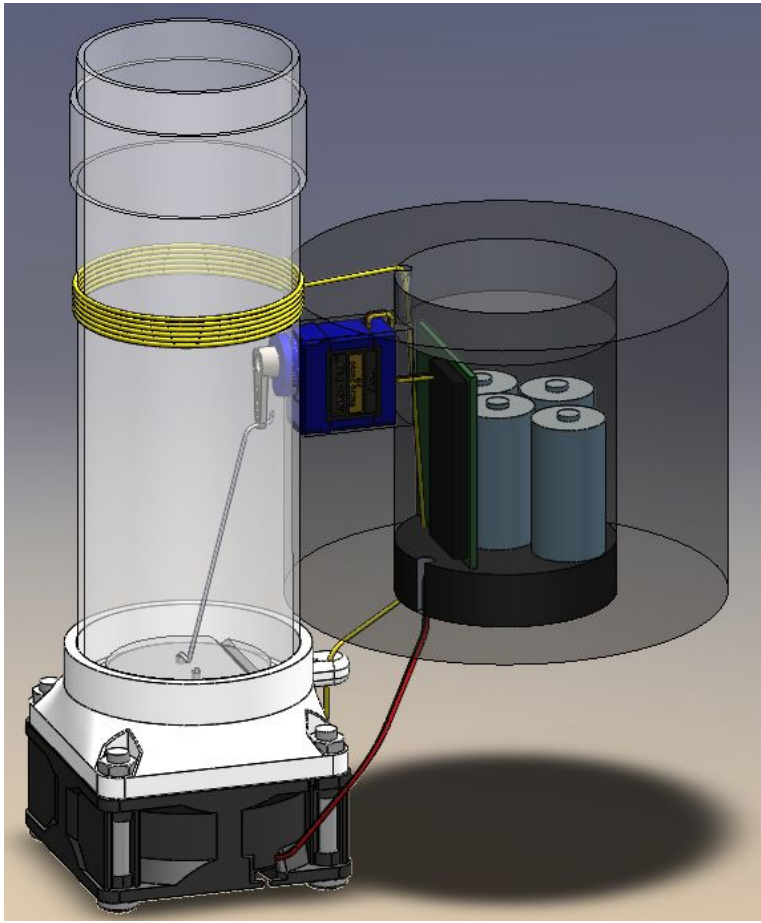


Manufacturing



System Overview

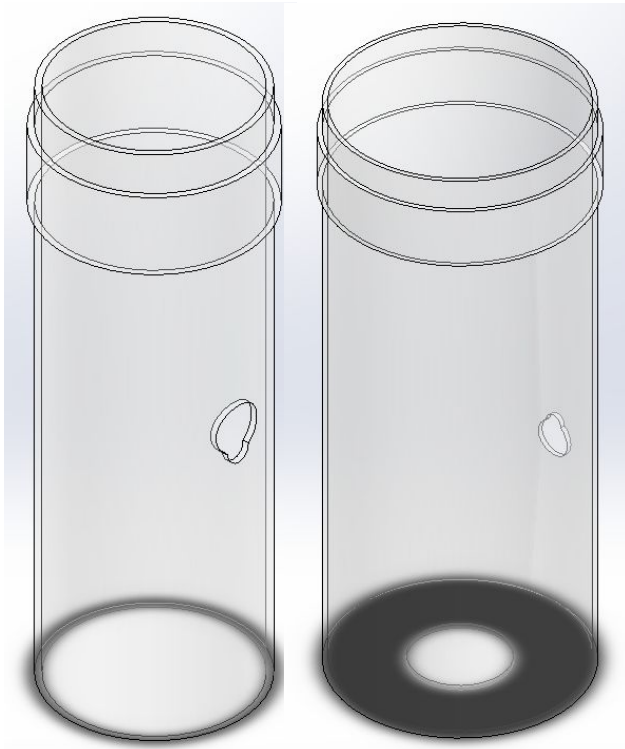




Neck Attachment - Tube Preparation

5 cm & 8 cm

- Tube Length 6in
- Servo hole at 2.75 in from the bottom
- Tube Stencil
- Top Cap for balloon mount



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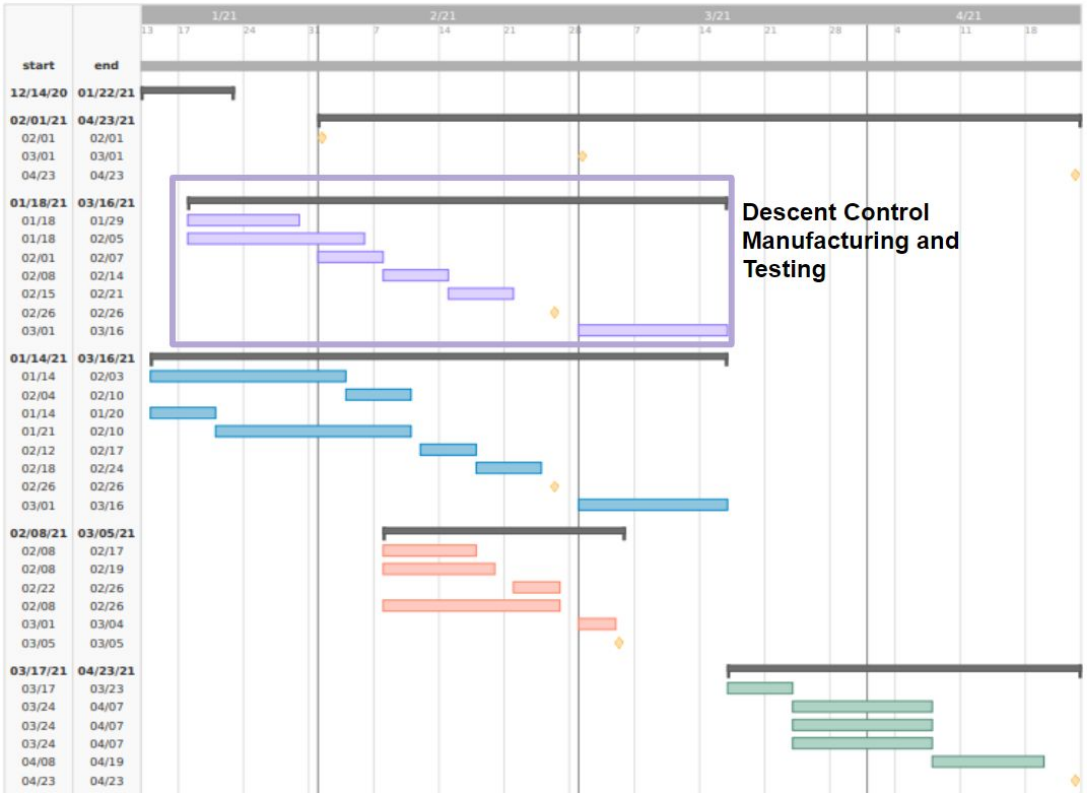
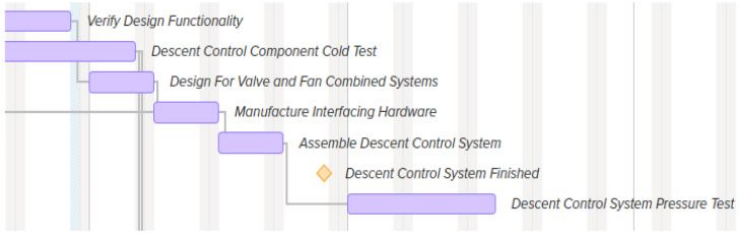
Descent Control Manufacturing





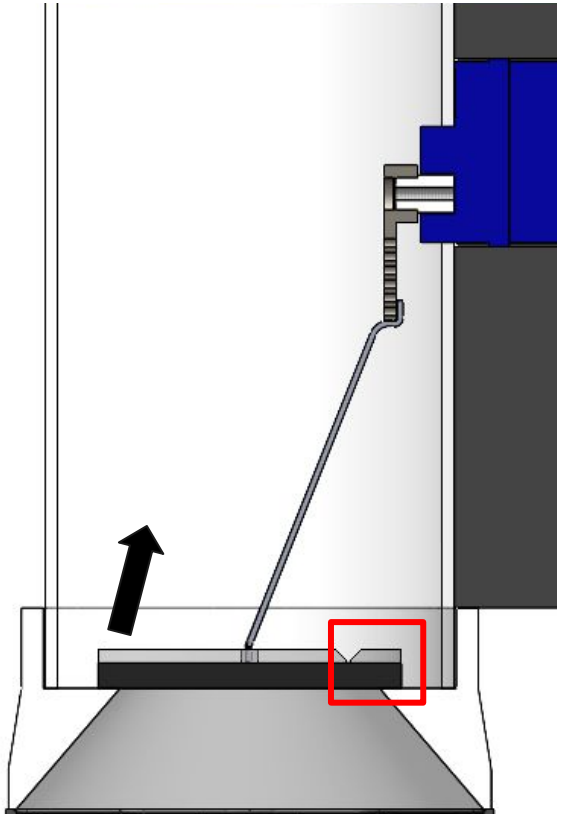
Descent Control - Valve Assembly

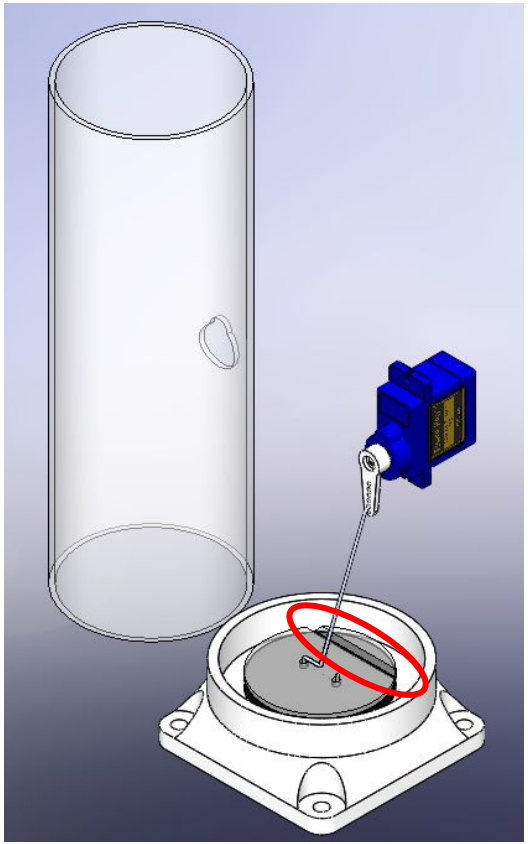
Materials (~1 week)

- 1/16” polycarbonate sheet
- 1/8 “ Foam sheet
- Music Wire
- Shoegoo

Manufacturing

- Valve & holes Cut with CNC machine (~2 weeks)
- Foam - scissors
- Hinge
- Diffuser





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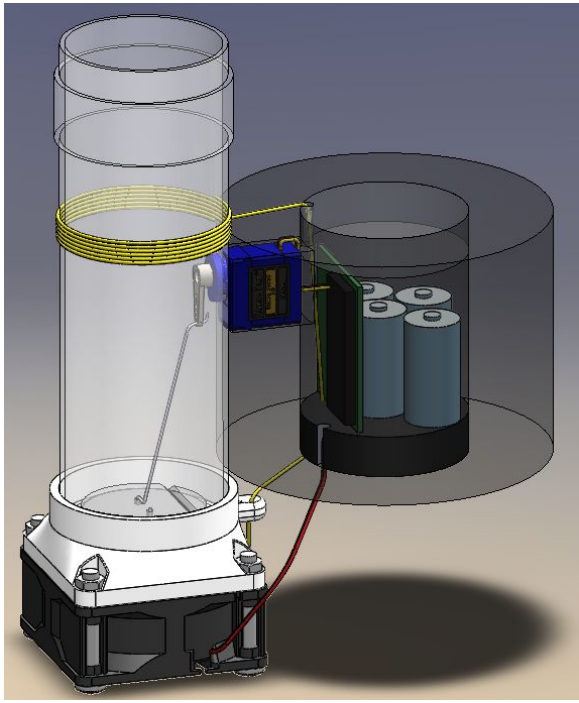
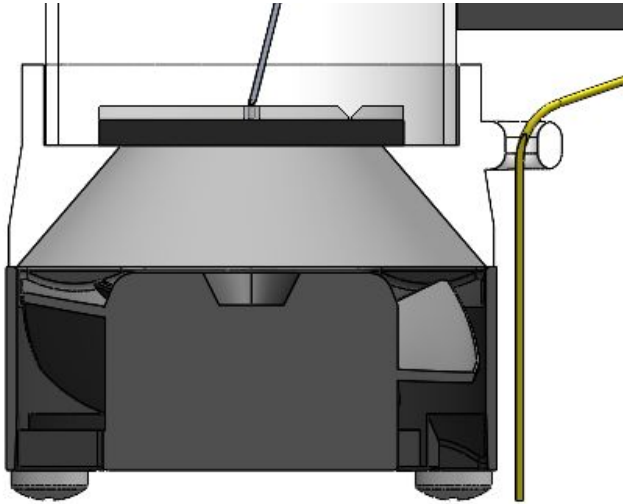
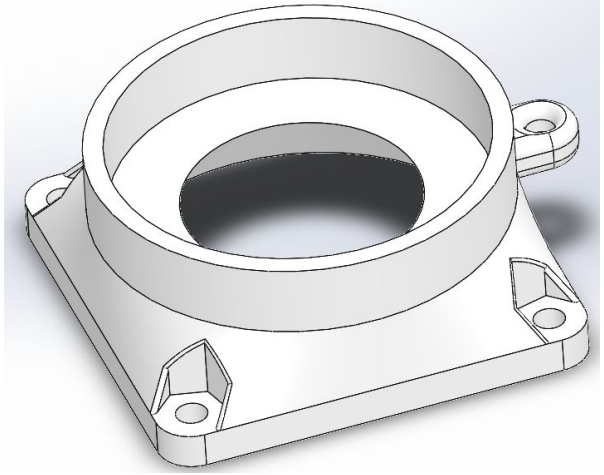
Descent Control - Fan & Diffuser

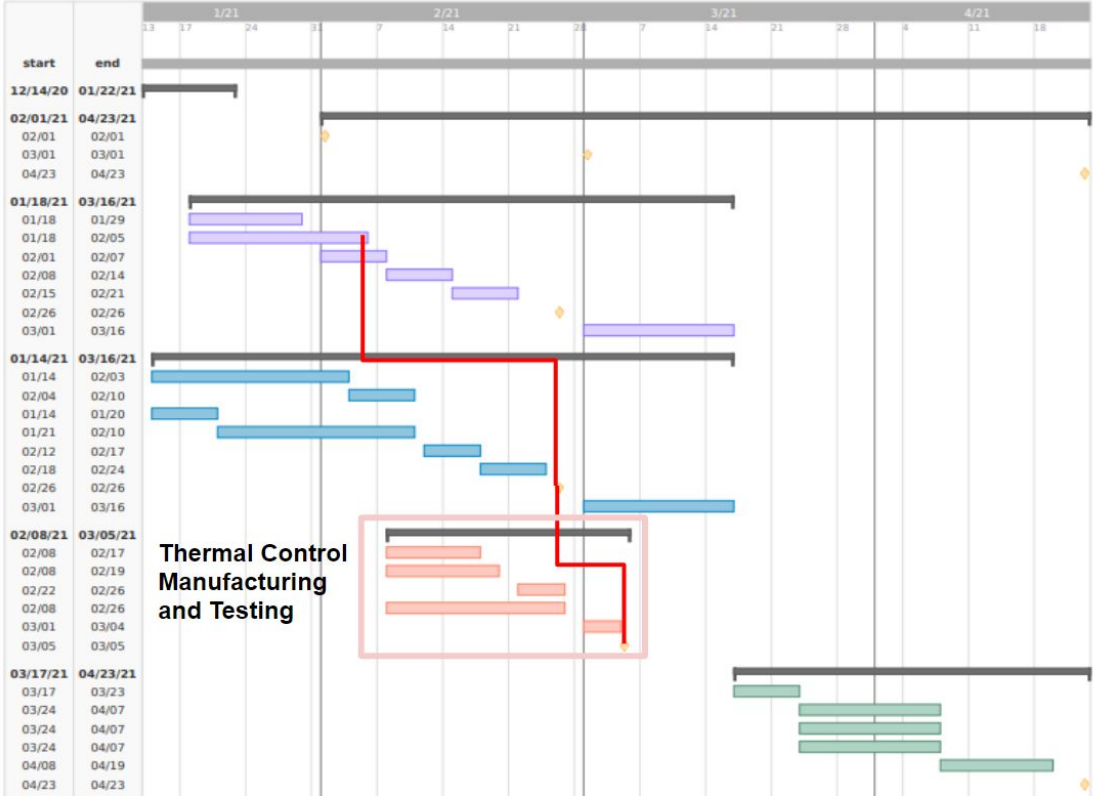
- DC fan attached to 3D printing diffuser/mounting hardware using simple nut and bolt fasteners
- Nylon Nuts and bolts - 4.544 g Total weight
  - 17% the weight of steel
- The team will be ordering Nylon fasteners this week
- Diffuser has been printed and works

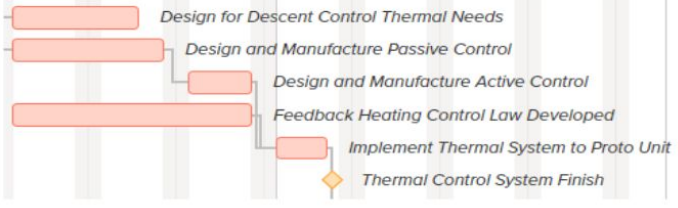






Thermal Control Manufacturing

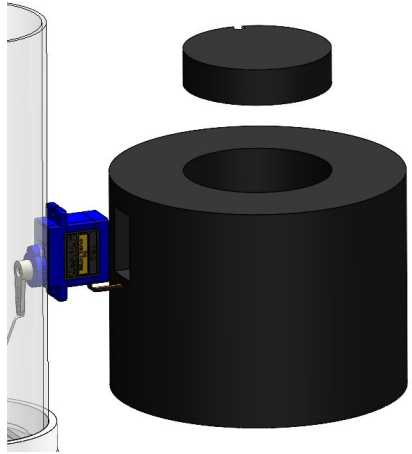


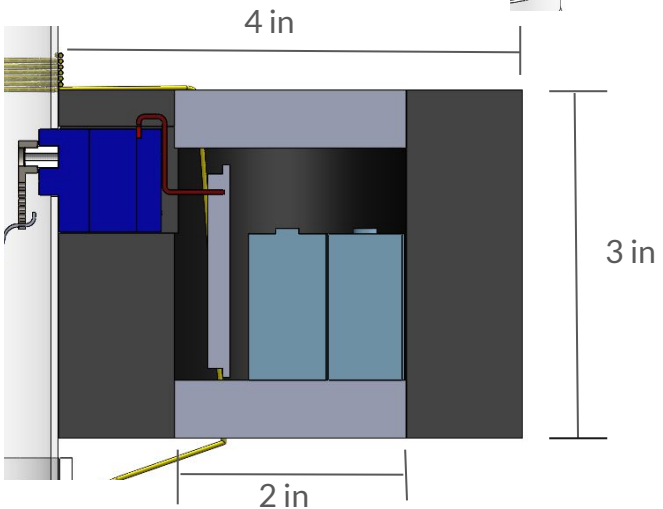


Thermal Control - Insulation

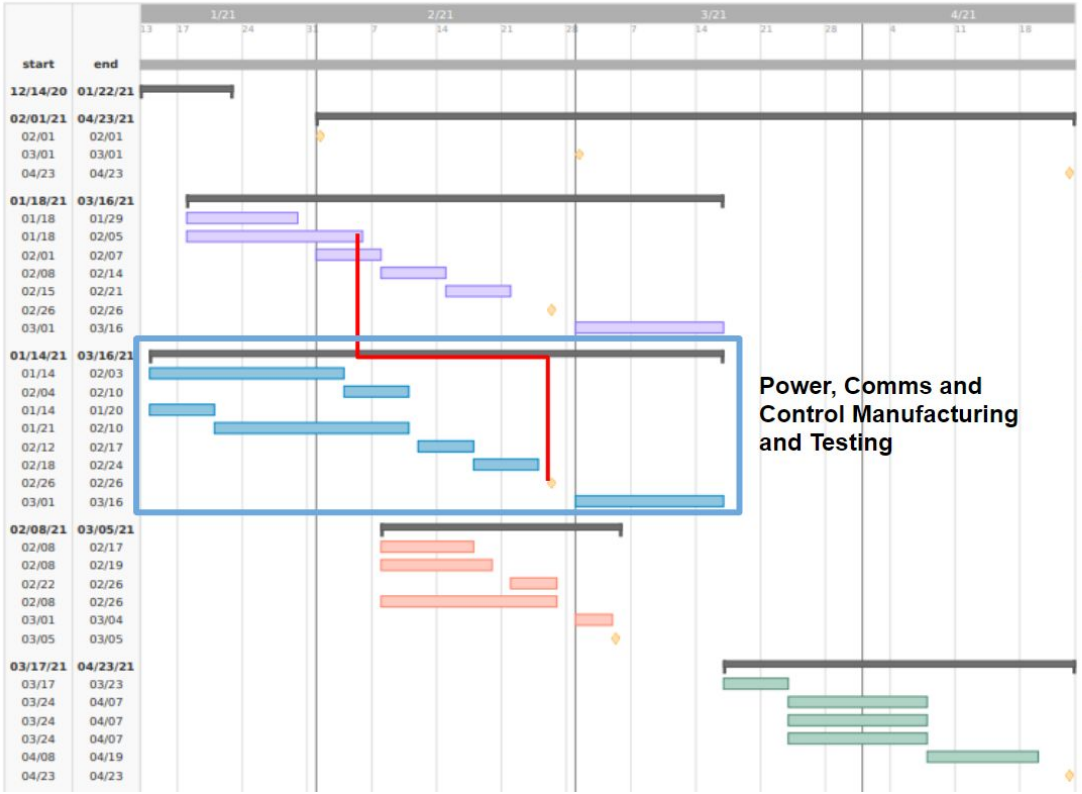
- Polyisocyanurate Foam Pipe Insulation
  - 1 inch thickness
  - 2 inch inner diameter
  - Cut to 3 inch length with knife
  - Cut 24x15 mm hole for servo
  - Cut endcaps
  - Secured with Shoe Goo
    - Reinforced with fiber tape

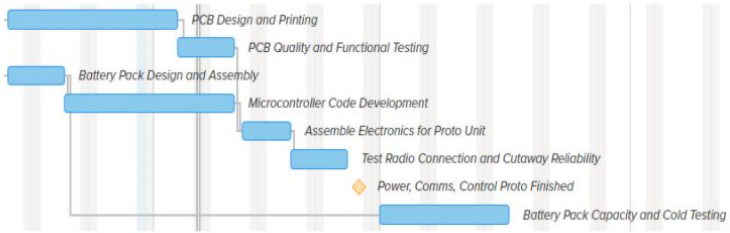
- Status: Not constructed (~1 day)
  - Foam will arrive this week





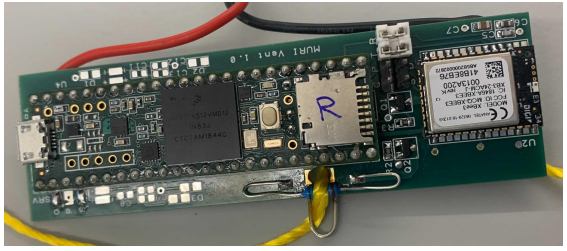
Comms, Power and Control Manufacturing

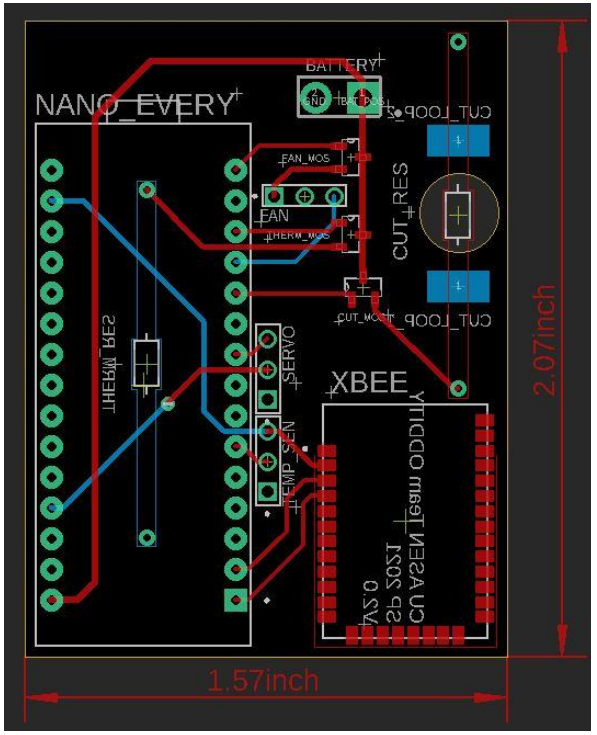




Comms, Power, & Control - PCB Design

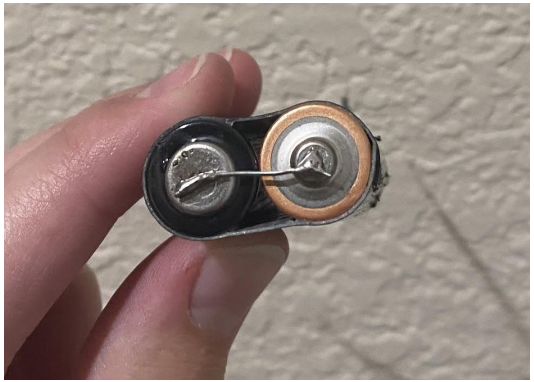
- General Characteristics
  - ODDITY Size: 2.07” x 1.57” (3.25 in^2)
  - Legacy Size: 3.65” x 1.1” (4 in^2)
  - Mass: ~25g
- Manufacture with Advanced Circuits
  - 3 Day turnarounds (including weekends)
- Placing Components
  - Reflow MOSFETs and XBee (~1 day)
  - Hand solder all other components (~1 day)
- Testing
  - Component testing beginning now (~1 week)
  - PCB testing begin once it is here (~1 week)

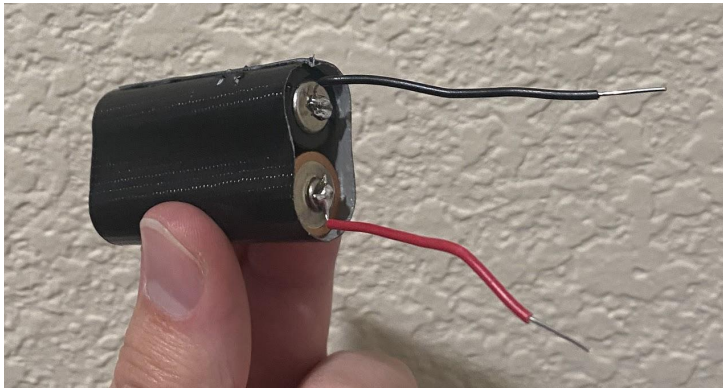




Comms, Power, & Control - Battery Pack

- Battery Packs
  - Tape together with thermal tape
  - Solder connecting wires between batteries
  - Solder leads for Positive Terminal and Negative Terminal
  - Taped to the back of PCB with thermally conductive tape
- Batteries should arrive within a week
  - Testing will begin once batteries are here (1-3 weeks)

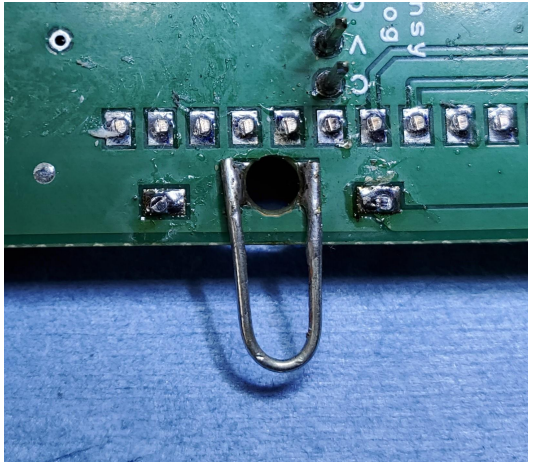


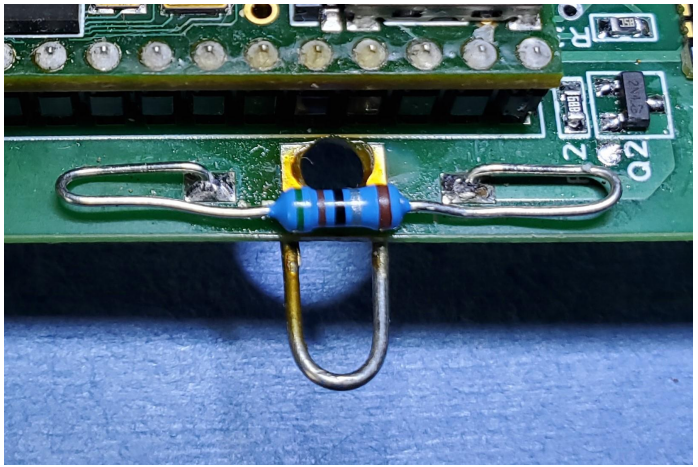


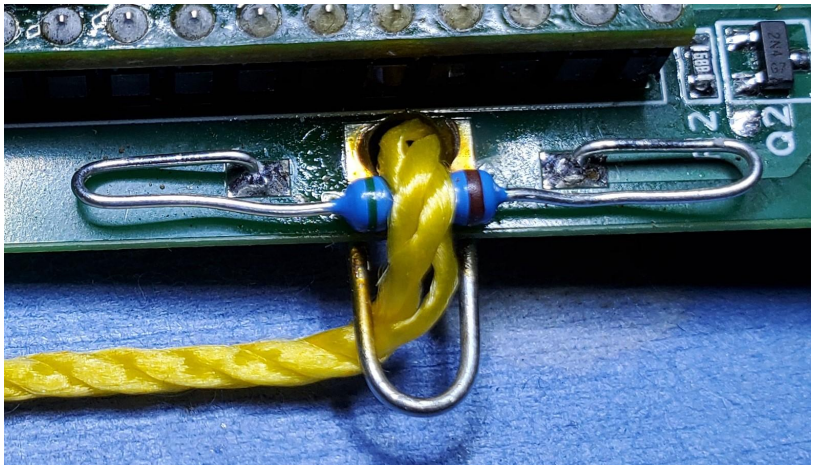
*For demonstration purposes only
*We will not be using Duracell AA batteries

Gondola Cutaway

- Gondola Cutaway Design
  - 10 Ω Resistor
  - Hole in PCB
  - Metal Loop







Software Plan

- **Building off of legacy Gondola flight code**
  - Written in C
  - Handles gondola activity, communication with ground, and **legacy valve device**
- **Software Integration**
  - Confirm ODDITY works with current flight code
  - Make modifications accordingly
- **Modifying command and data packets to support functionality of ODDITY**
  - More commands
- **Implementing Arduino code**
  - Thermal Control loop
  - Activation and status of fan
- **Oddity Software Testing**
  - Turning on elements, receiving communication from Xbee, etc.

```
//////////////////////////////////////////////////////////////////////
//   Form XBee 3 transmit command packet
//////////////////////////////////////////////////////////////////////
void XBee3_TX_command_packet( void )
{
    uint16_t loc = 0;

    // Packet Position 1: packet ID
    loc = add_uint16_t((uint16_t)XBEE3_COMMAND_PACKET, loc, payload);

    // Packet Position 2: command to vent board
    loc = add_uint32_t(command_send, loc, payload);

    XBee3TXpacket.data_length = loc;

    XBee3TXpacket.data = payload;

}
```

Balloon_Shield_flight_Code-LowPaMod

```
//    Convert digital signal to voltage
      diffPressure = analogRead(A2);
      diffPressure = (diffPressure * (5.0/1024.0));
//    Convert voltage to Pressure in PA
      diffPressurePa = ((diffPressure - 2.0) / 0.0040146);
      Serial.print(",");
      Serial.print(diffPressure,8);
      //Serial.print(analogRead(A2));
      digitalWrite(6, HIGH);
```

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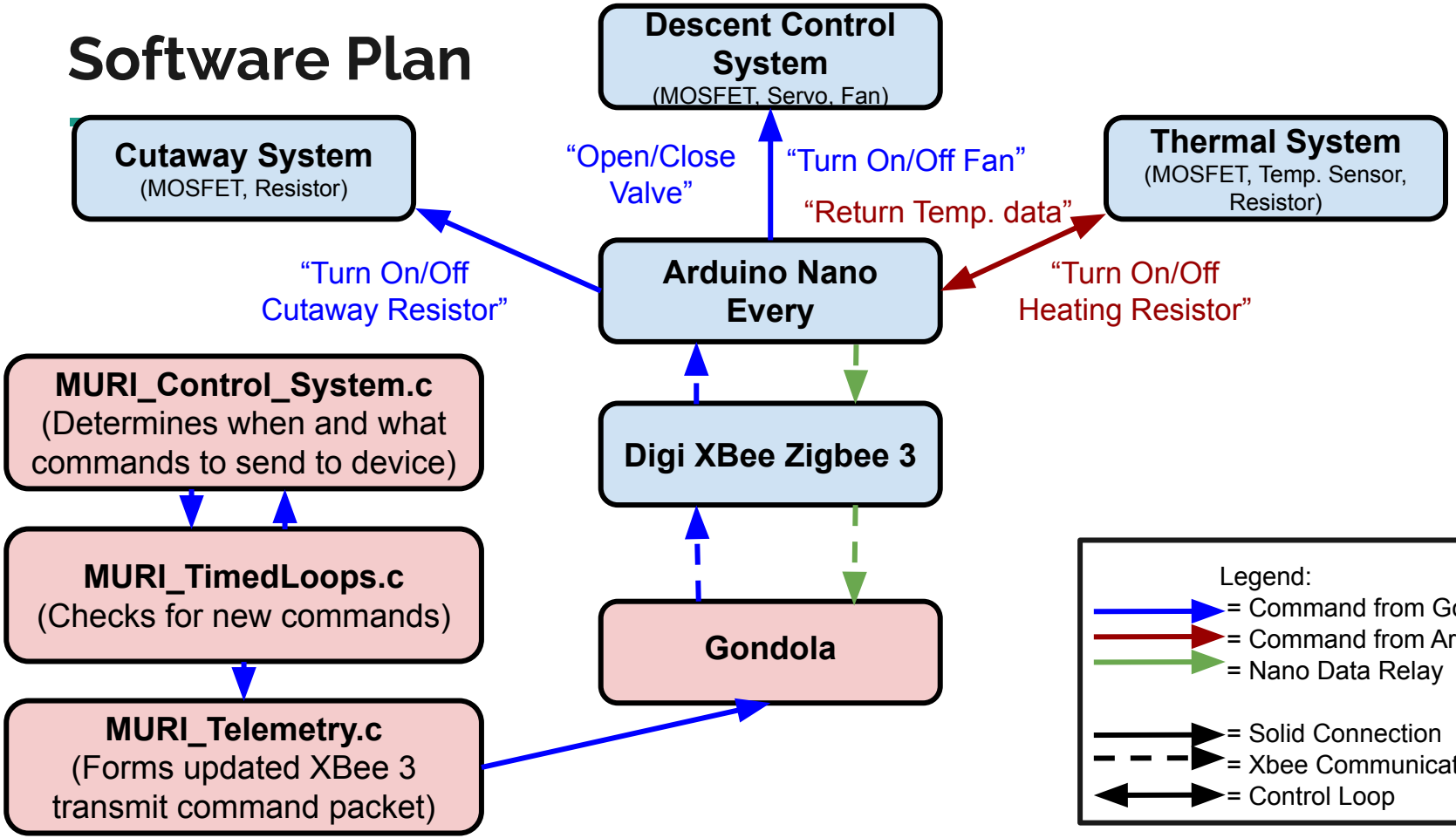
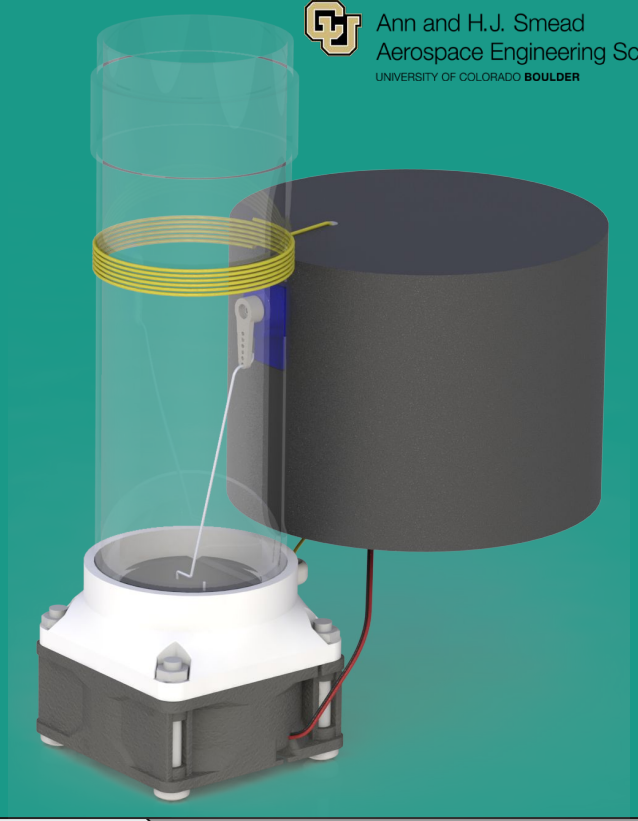
Software Plan



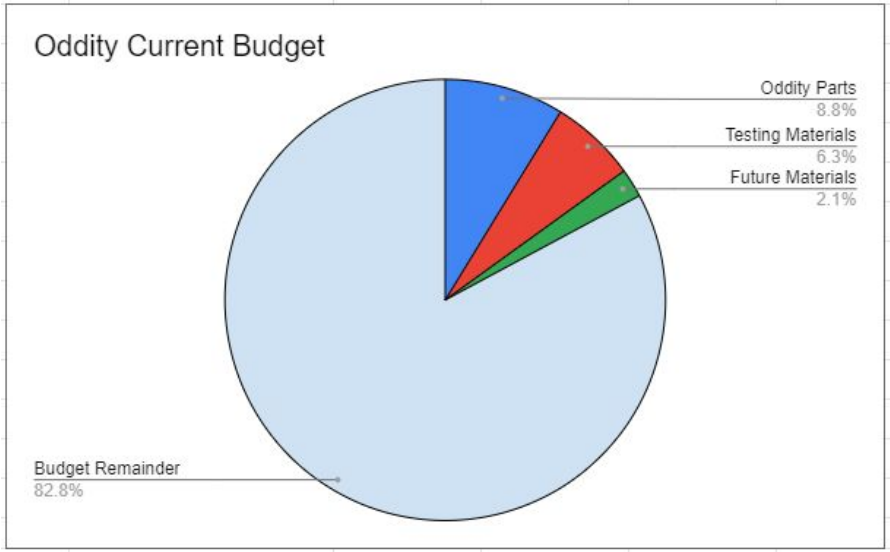
Budget



Budget Slides

ODDITY Parts	Quantity	Cost	Total	Uncertainties
Electronics			$227.14	$20.34
Arduino Nano	3	$12.90	$38.70	$7.35
Xbee Zigbee 3	4	$16.21	$64.84	$7.99
ASP CR123A Batteries	**12**	**$1.90**	**$22.80**	**$5.00**
Transistors	4	$0.45	$1.80	$0.00
Printed Circuit Board	***3***	***$33.00***	***$99.00***	***$0.00***
Thermal Control Parts			$55.38	$15.76
Insulation (6ft)	2	$20.09	$40.18	$7.99
Active Heating Resistor	10	$0.50	$5.00	$0.00
Mounting tape (3ft)	**1**	**$4.35**	$4.35	$0.00
Temperature Sensor	**3**	**$1.95**	**$5.85**	$7.77
Descent Control Parts			$90.52	$9.49
Servo	4	$7.98	$31.92	$0.50
Sealing Valve	**1**	**$2.00**	**$2.00**	**$1.00**
Axial Fan	5	$11.32	$56.60	$7.99
Cut Away Mechanism Parts			$5.00	$0.10
Burning Resistor	10	$0.50	$5.00	$0.10
Balloon Attachment			$10.32	$4.10
Diffuser Neck Attatchment	1	$0.32	$0.32	$0.10
Balloon Neck Plastic Tube (5 cm)	**1**	**$4.00**	**$4.00**	**$2.00**
Balloon Neck Plastic Tube (8 cm)	**1**	**$6.00**	**$6.00**	**$2.00**
		Total	$388.36	$49.79

- Bolded Items are Pending Procurement
- Remaining Budget:
  - $4,141.79



Questions?

Resources

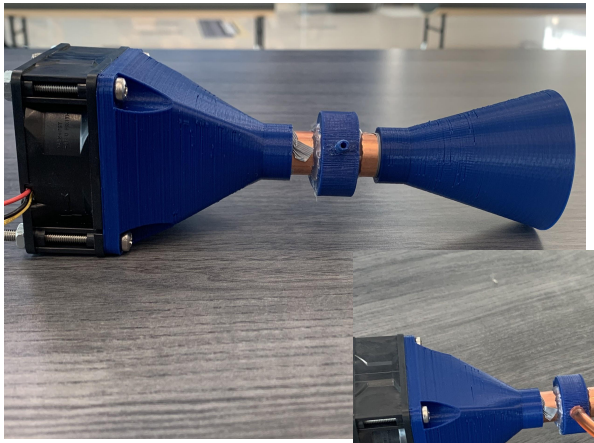
- Team ATOMIC 2019-2020 for presentation formatting
- Prof. Argrow's Customer Presentation Fall 2020
- Star CCM
- MATLAB
- SolidWorks
- Google Drive, Sheets, Drawing, Slides
- TeamGantt
- PAB Members
- Advisor, Prof. Akos
- Prof. Lawrence
- Prof. Argrow

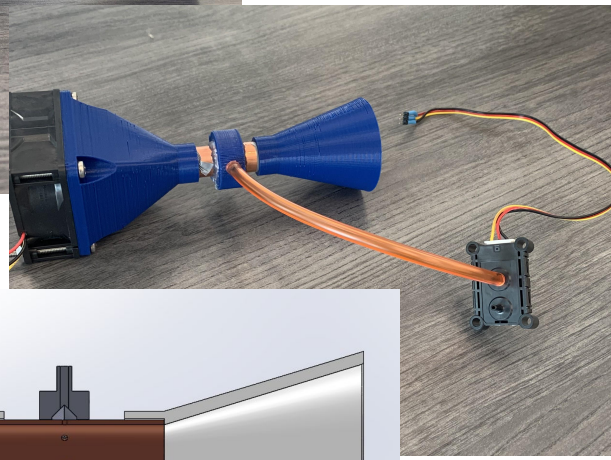
Appendix

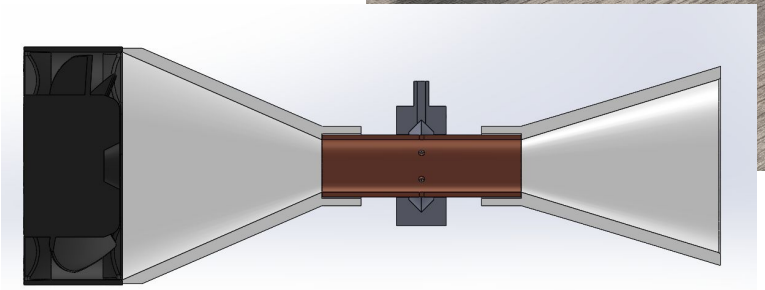
- Preliminary Pressure Testing - Hardware
- Preliminary Pressure Testing - Setup
- Preliminary Pressure Testing - Results
- Offramp: More Powerful Fan
- Offramp: Custom Fan
- 8cm Balloon ODDITY Design
- Alternative Valve options
- Offramp: Thermal Design
- Thermal Control of Fan
- Detailed Budget Breakdown
- Test Apparatus
- Balloon Filling
- Valve Construction
- Comms, Power, & Control - PCB Comparison
- Mass Budget

Preliminary Pressure Testing - Hardware

- Arduino with cape used in Gateway to Space
  - Recorded time, ambient temperature, ambient pressure, and differential pressure
- Fan & Venturi Tube
  - San Ace Fan attached to 3D printed diffuser connected to a copper venturi tube and 3D printed nozzle
  - Copper venturi tube had multiple holes drilled around the circumference
    - 3D printed collector ring around holes and connected to pressure sensor

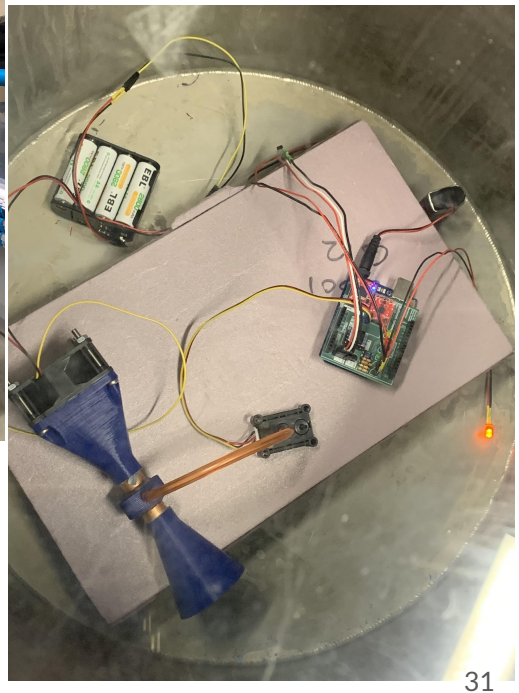






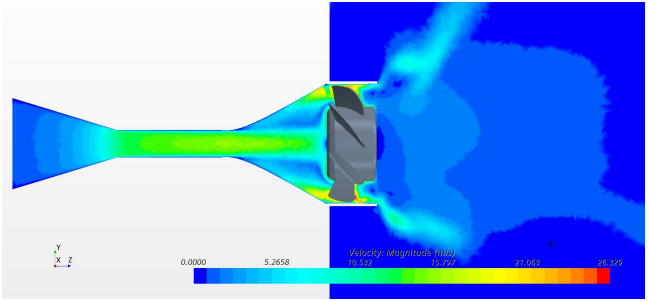
Preliminary Pressure Testing - Setup

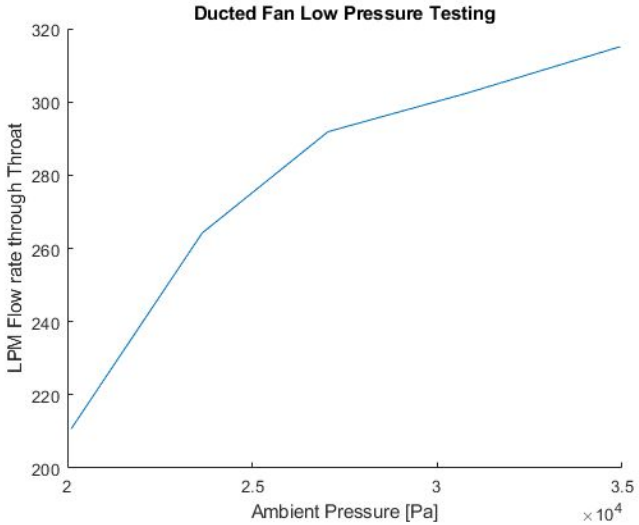
- Vacuum Chamber
  - Maximum differential pressure of 24 inHg
    - Allows us to reach ~18 kPa = 13 km
  - Slight vacuum leaks, not significant in testing
- Foam to prevent shorting on the Arduino
- Fan inlet and outlet spaced away from walls of chamber
- Differential pressure sensor placed flat on foam



Preliminary Pressure Testing - Results

- Severe flow rate drop off with decreasing pressure
  - Expected by group
- Volumetric flow rate was severely decreased by the Venturi system
  - Currently running CFD simulations of fan and venturi assembly to compare to test results





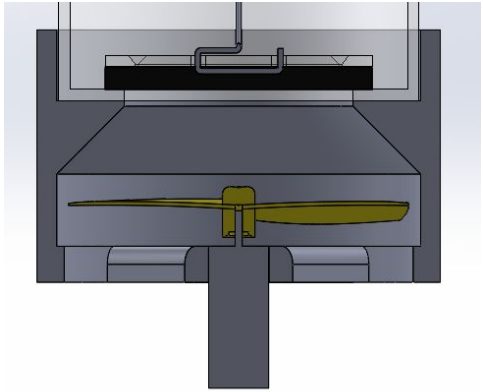
Offramp: More Powerful Fan

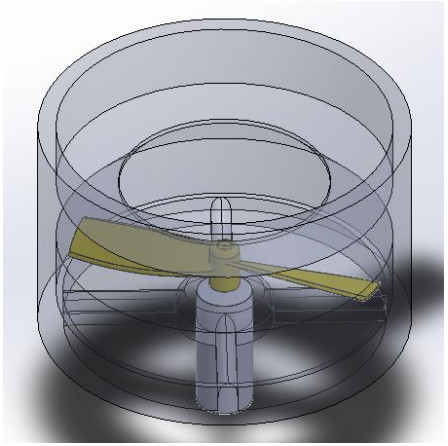
- Orion Fans: OD7025-12HHB10A
- Flow rate: 1444 LPM
  - ~40% higher than current fan
- Almost identical mass and power usage as current fan
- Slightly larger dimensions: 70 x 70 mm
- Features PWM control and a built-in tachometer
  - Would offer greater control and RPM measurement
- Only the 3D printed diffuser would have to be altered incorporate this fan
  - Might be an issue with fitting this fan in mass budget

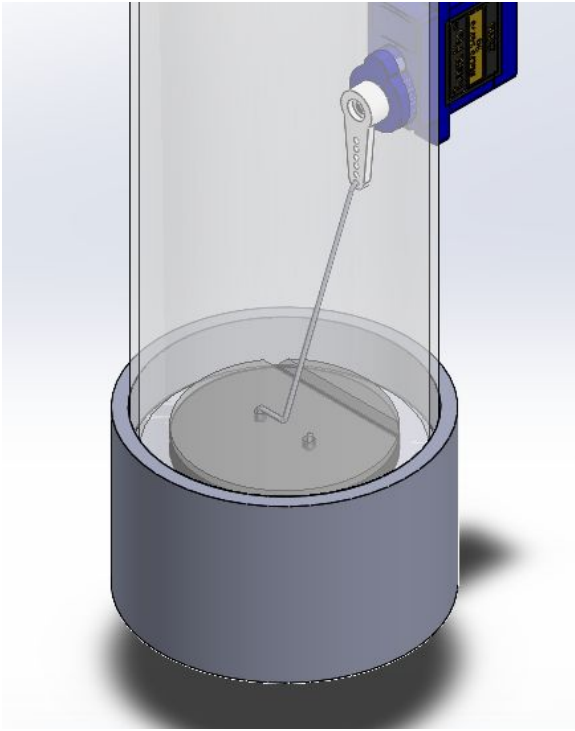
Offramp: Custom Fan

- Given mass/size constraints, the only remotely feasible option remains some sort of fan.

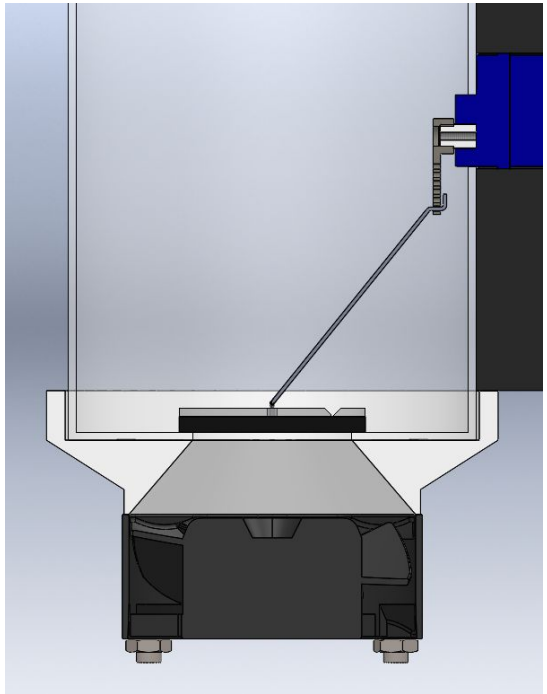
- Moving to quadcopter/RC motors as the actuator would open up the design space somewhat
  - Custom (Low Re) Propellers, Motor/Prop/Blade count, counter-rotating propellers, etc.

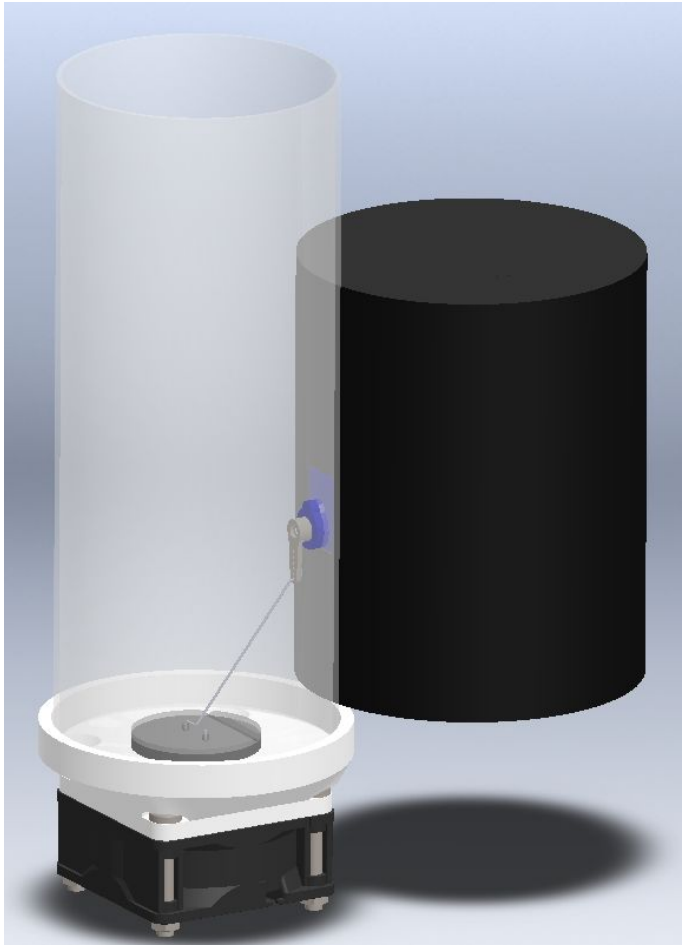






8cm Balloon ODDITY Design

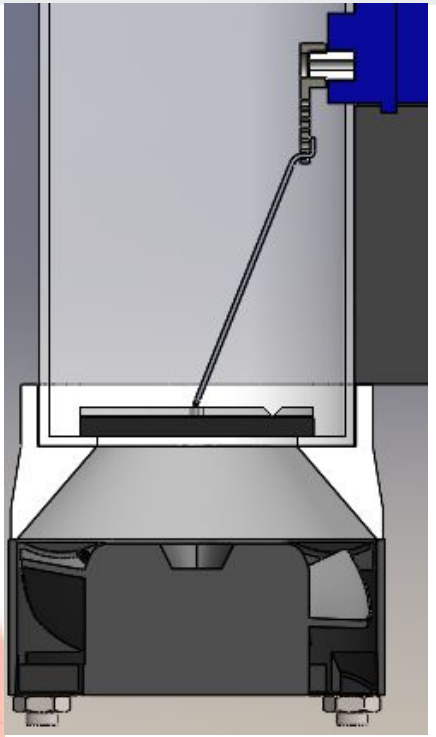




Alternative Valve options

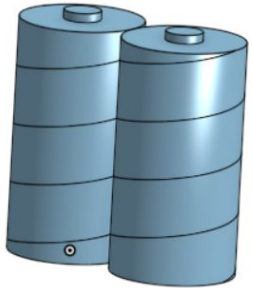
The Legacy system may obstruct the flow too much, reducing flow rate.

- Improved Legacy System
- Diaphragm Iris Valve
- Butterfly Valve



Offramp: Thermal Design

- Wrap batteries with Stainless Steel wire and bind with thermally conductive tape
  - Stainless Steel 304’
  - 4 Loops
  - Length: L = 0.9 m
    - Physically measured
  - Diameter: D = 0.004”

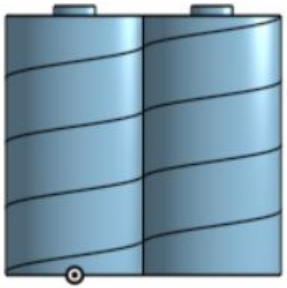


Power Needed: 1.5 W

Resistance: 82 Ohms

$$R = \frac{\rho L}{A}$$

ρ = resistivity
L = length
A = cross sectional area



Thermal Control of Fan

- Cold temperature testing of fan will be performed in 1-2 weeks
  - Will determine if thermal control is needed

Possible Solutions:

- Twitch Fan Motor On and Off
- Insulation
  - Attached to face of fan motor and sides of fan
  - Foam and Foil Insulation Tape
    - Thickness: 3.18 mm
  - Aerogel Blankets
    - Thermal Conductivity: ~ 15 mW/mK
    - Thickness 3.5 mm to 8 mm
- Heating:
  - Nichrome or Stainless Steel wire coiled on face of motor
    - Power available: ~1.49 Wh

Detailed Budget Breakdown

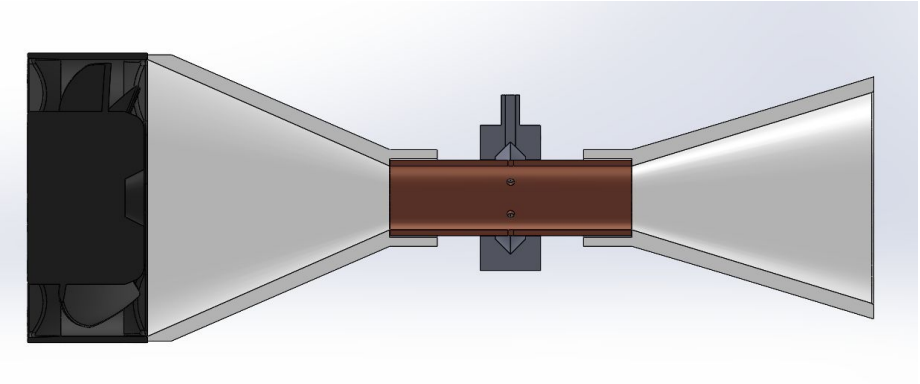
Future Materials	Quantity	Cost	Total
Dry Ice	1	$30.00	$30.00
Foam Cooler	1	$12.00	$12.00
Through Hole Xbee	1	$26.50	$26.50
Plastic Nuts & Bolts	1	$27.99	$27.99
		Total	$96.49

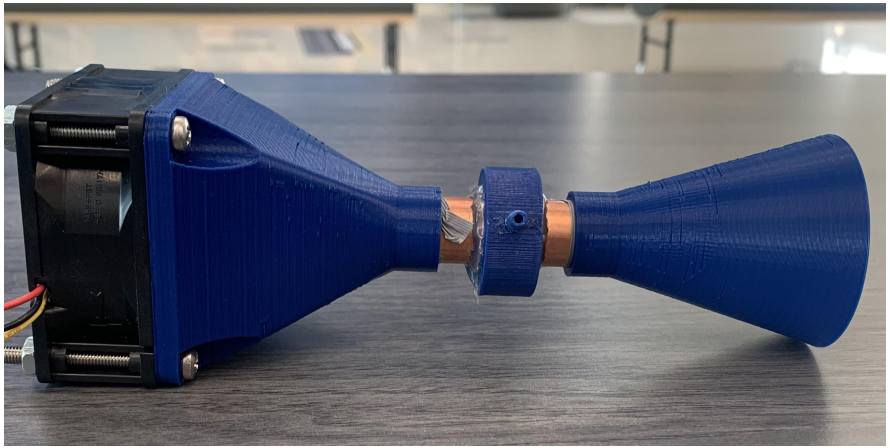
Testing Materials	Quantity	Cost	Total
Pressure Transducer	1	$220.00	$220.00
Copper Tubbing	1	$7.97	$7.97
Vinyl Fuel Line (10 ft)	1	$4.98	$4.98
PWM Fans	2	$12.79	$25.58
Connection Housing	1	$30.25	$30.25
Connection Socket	1	$0.10	$0.10
Xbee Dongle	1	$25.95	$25.95
		Total	$314.83

Budget Total	$5,000.00
Oddity Totals	$410.07
Testing Totals	$314.83
Future Totals	$96.49
Budget Remainder	$4,178.61

Test Apparatus

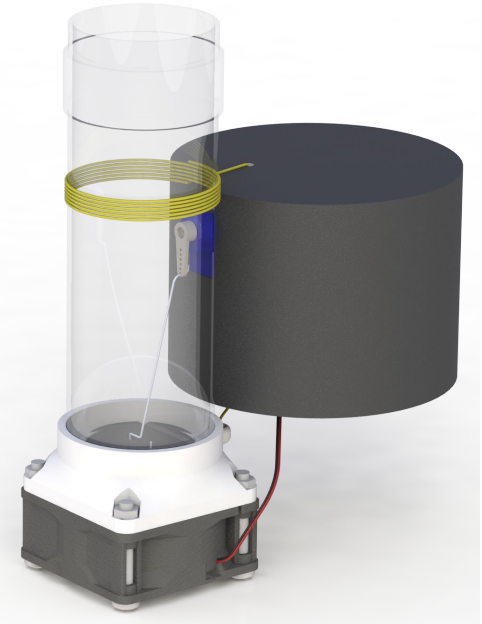
- 2” section of copper pipe
  - With 6, 1/16” holes drilled at equal intervals
- 3, 3D printed parts
  - Press fit connections with copper pipe
  - Connections are glued to provide airtight seal
  - Bolt connection to the fan
- System is designed to be easily adaptable both in dimensions and configurations
  - Variable pressure ports
  - Variable area ratios
- Later revisions may include smoother inner geometry and 1 piece construction

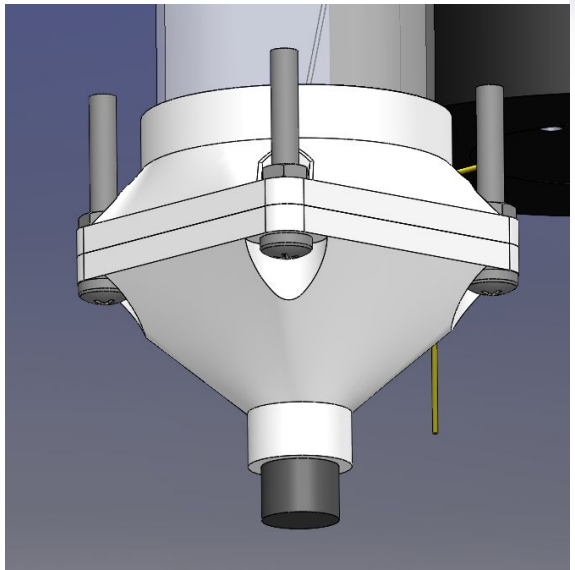


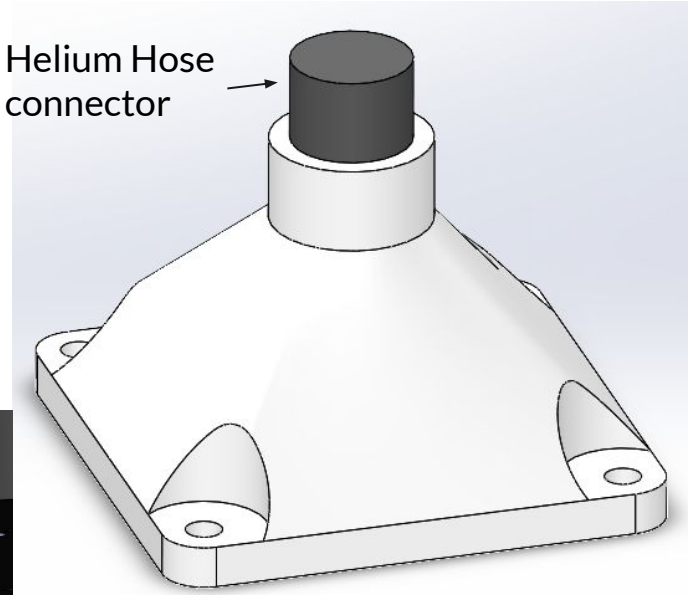


Balloon Filling

- Before the Fan is attached the fill adapter is bolted on
- The Valve is actuated and the balloon is filled
- The Valve is closed and the fill adapter is removed



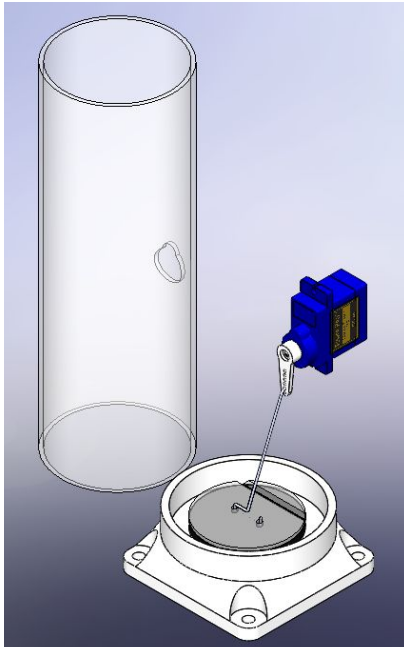




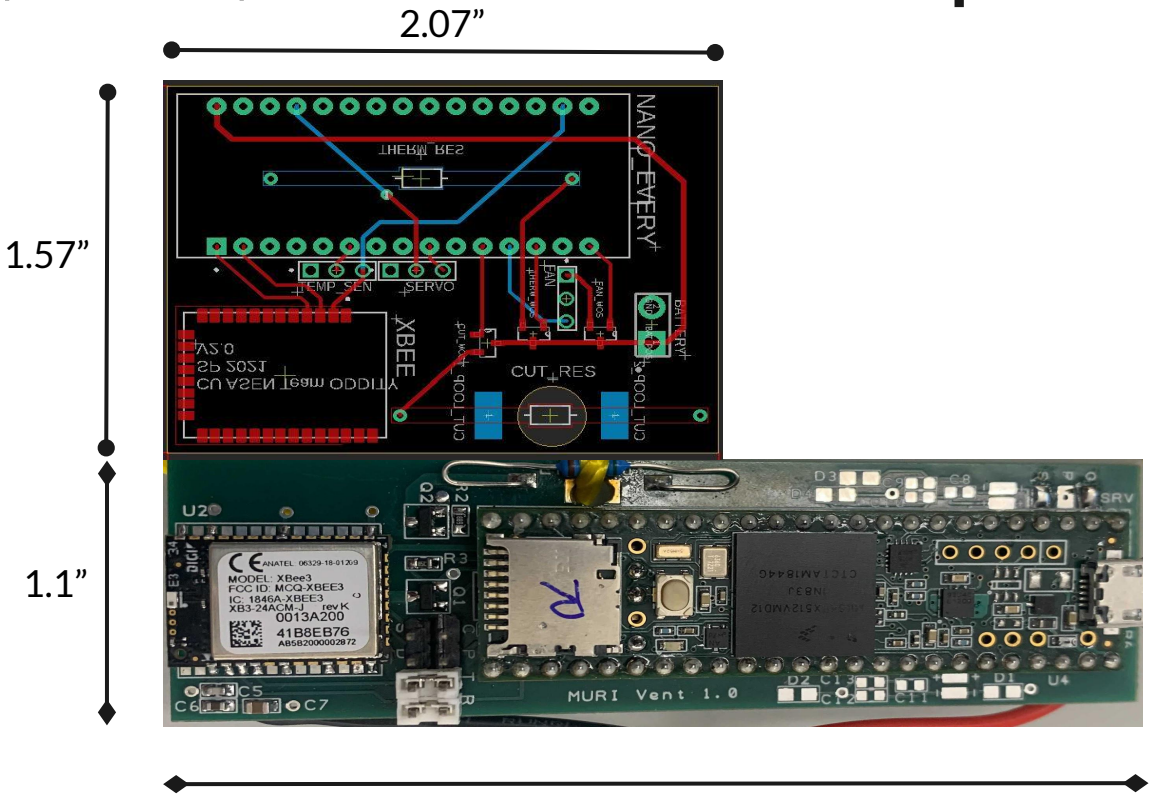
1/16 Rubber Sheet Gasket
- Cut with Exacto knife

Valve Construction

1. CNC cut the polycarbonate sheet to circles and split
2. Shape the music wire and attached to the valve holes
3. Glue both pieces of polycarbonate on to the foam
4. Connect the wire to the the servo through the tube
5. Glue the diffuser and servo to the plastic tube



Comms, Power, & Control - PCB Comparison



Mass Budget

Oddity Parts	Quantity	Mass (g)	Total (g)
Electronic Parts			
Arduino Nano	1	5.00	5.00
Xbee Zigbee 3	1	2.90	2.90
ASP CR123A Batteries	4	16.40	65.60
Miscellaneous Wiring and Solder	1	15.00	15.00
MOSFET	3	0.01	0.03
Printed Circuit Board	1	25.00	25.00
Thermal Control Parts			
Insulation	1	39.83	39.83
Active Heating Resistor	1	0.50	0.50
Temperature Sensor	1	1.00	1.00
Descent Control Parts			
Servo	1	2.72	2.72
Sealing Valve	1	5.00	5.00
Axial Fan	1	90.00	90.00
Cut Away Mechanism Parts			
Buring Resistor	1	0.50	0.50
Mechanical Hardware Parts			
Fan Attachement	1	18.00	18.00
Balloon Neck Plastic Tube	1	24.00	24.00
Fan Attachement Nylon Fasteners	4 (Screw & Nut Pairs)	0.91	3.63
		Total	298.71