SNOWCAT

System Naturally Observing Windborn Carbon & Aerosol Transportation

PC: Alia Khan

Test Readiness Review

April 5th, 2018

Mission Overview

Mission Statement:

SNOWCAT will gather environmental data and autonomously collect physical dust samples during its one month deployment in Svalbard, Norway.

Objectives:

1. Deploy on the surface of Svalbard for a month with minimal human interactions.

Model 1

2. Provide environmental data as a function of time.

3. Collect dust samples that are distinguished by time of collection.

Model 2

Presentation Overview

Purpose of TRR: To prove that we are ready to proceed to day-in-the-life testing.

- Prior subsystem testing and full system assembly → IN PROGRESS

Completed / Integrated Hardware:

- Sail
- Central pole and base
- Main chamber box, pullout tray, rear end cap
- Rack and pinion motor interface
- Collection box, 1 flute

Completed Electronics:

- Software flow and user specifications format
- Populated main board
- Preliminary testing / debugging

Completed Subsystem Testing:

- Sail testing
- Tube material testing
- Motor and tube movement testing
- Motor torque testing

In Progress Hardware:

- CNC of flutes, blank
- CNC of front cap
- Motor interface
- Nozzle attachment
- Integration of electronic components

In Progress Electronics:

- Prove programmability
- Write low-level APIs
- Write / test sensor drivers
- Write / test main program
- DITL testing ?
- Mission life estimation

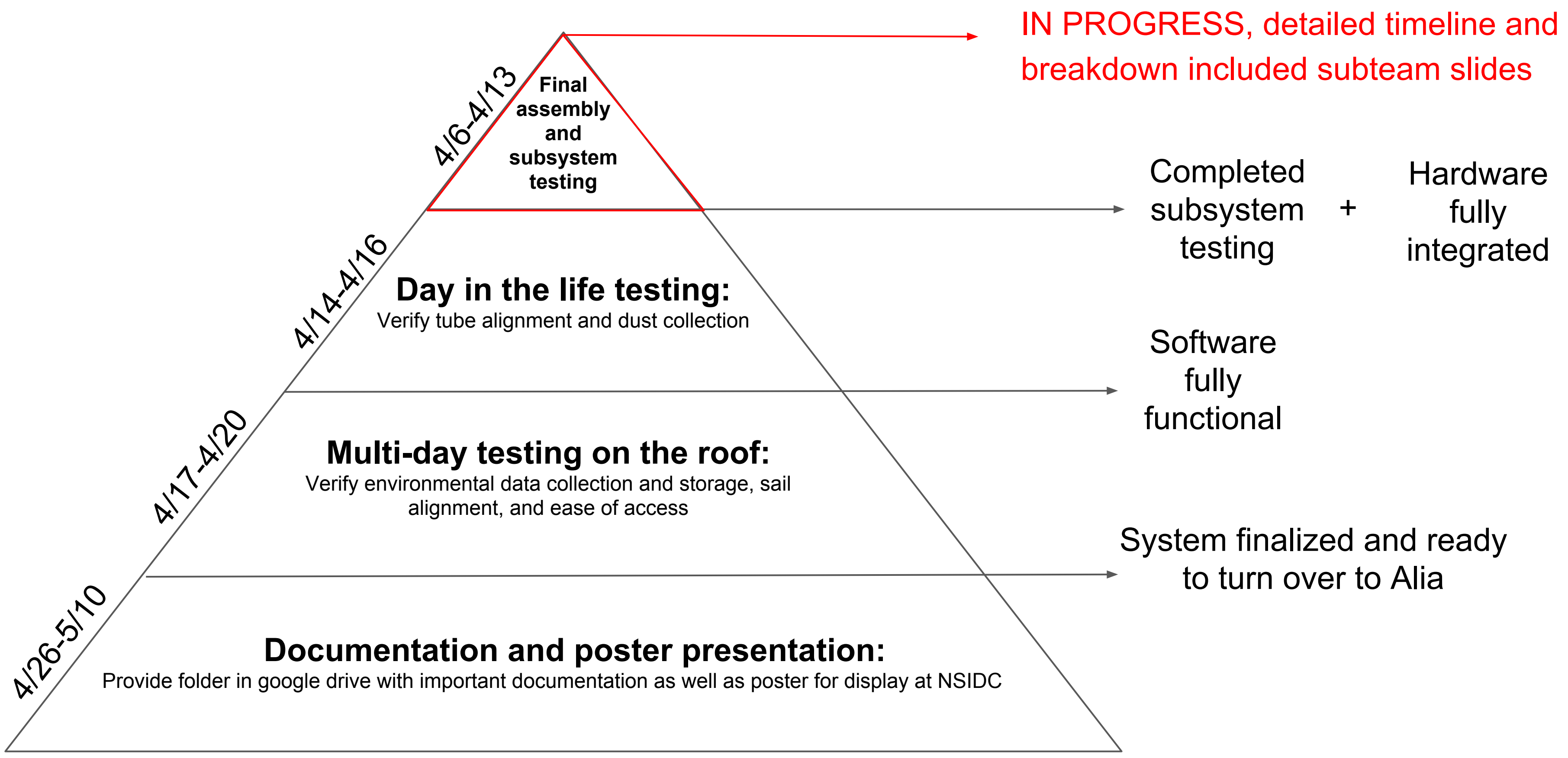
Future SubSystem Testing:

- Quantify tube to motor alignment

Future System Testing:

- Day-in-the-life testing
- Multi-day test on roof

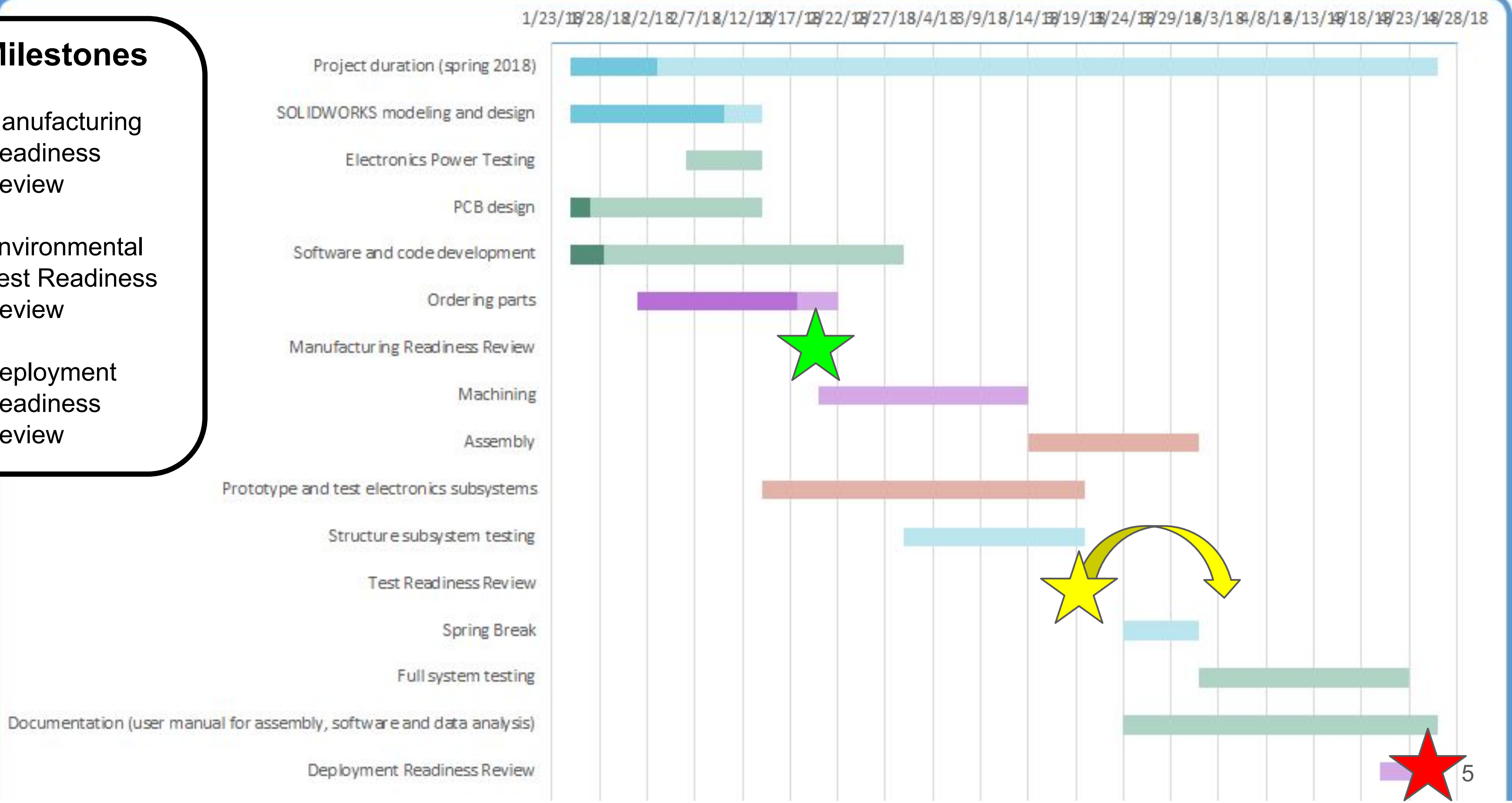
Moving Forward



Team Timeline

Milestones

- Manufacturing Readiness Review
- Environmental Test Readiness Review
- Deployment Readiness Review



Systems

Bekah Haysley and Will Butler

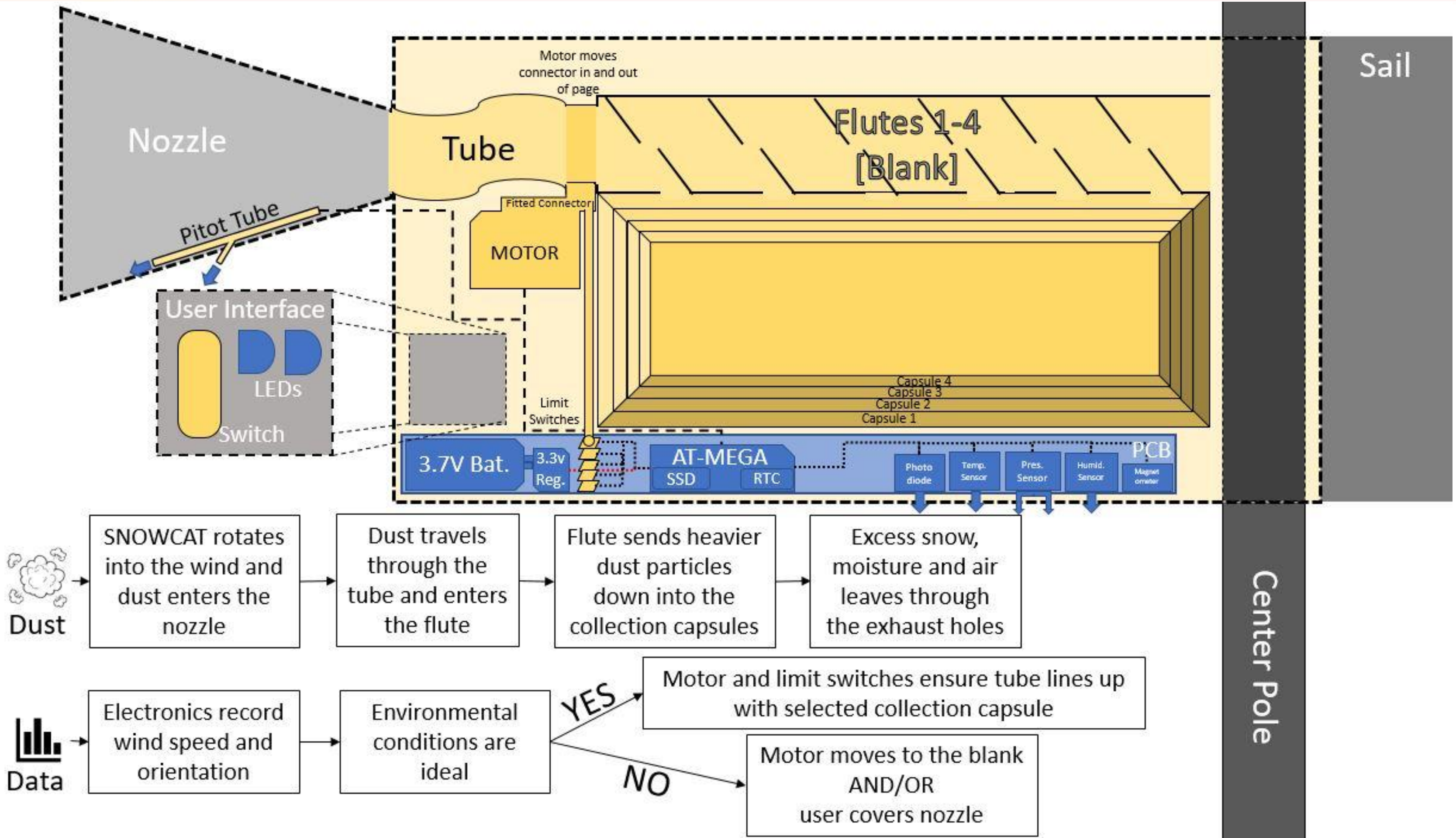
Requirements

Science Objective	Requirement
Investigate effect of black carbon deposition on snow albedo/melting in cryospheric regions	0.1: Deploy on the surface of Svalbard for a month with minimal human interaction
Understand how the dust (in particular, the black carbon) is transported	0.2: Provide environmental data as a function of time
Classify the composition of the dust deposited on the surface of snow and ice in cryospheric regions	0.3: Collect dust samples that are distinguished by time of collection

Minimum Criteria For Success (Model 2)

	Success Criteria	Pre-Deployment Verification
1	Collection chamber rotates to face the wind.	Multi-day environmental testing. Sail subsystem testing.
2	Able to power the system for a full month.	Power testing.
3	Collect 4 different dust samples that are distinguished by time of collection.	Day-in-the-life testing. Motor and software testing. Tube testing.
4	Record environmental data as a function of time.	Multi-day environmental testing. Sensor and software testing.
5	Dust collector remains structurally sound for the duration of the mission.	Multi-day environmental testing. Success of Model 1.

Functional Block Diagram



Sail Testing

- System Response Time (Settling Time)
  - 4-5 Seconds for system response
  - Good for negating the effects of gusts that are not aligned with the general wind direction
- SNOWCAT shall have an opening facing directly into the wind whenever wind speeds exceed 2.5 m/s.
  - System responds to wind exceeding 2.5 m/s (5 mph) as shown in video, however, system response cannot be measured using the ITLL Wind Tunnel*
  - * It was learned that the wind tunnel exhaust exits in a torus shape, deeming it unusable for our larger model
  - Average wind speed for day tested 7 mph

- Plan to use multi-day testing to quantify systems sensitivity
  - This can be measured by filming the system and a known weather vane in an overhead fashion
    - Measuring the System’s response time and pointing angle to the true wind heading
    - Further sensitivity may be found through the day in the life testing by using the magnetometer
    - Want to prove 15 degrees accuracy in system alignment with wind

Tube Material Testing

Requirements:
- SNOWCAT shall have the ability to start and stop dust collection for each capsule.
- SNOWCAT shall collect dust with particle sizes ranging from micrograms to milligrams.

Flexible 1/16” Thickness Blue Tube

- Not Static Dissipative
  - Dust sticks to walls due to silicon material properties
- Deflection at room temperature: 7.94 mm
- Deflection at freezer temperature (8℉): 6.00mm

Carbon Impregnated 1/8” Thickness Black Tube

- Static Dissipative
- Larger diameter means larger volumetric flow rate
- Rated for temperature down to -40℃
  - Expect same reduction in deflection distance
- Decreased Flexibility due to 1/8" thickness

Carbon Impregnated 1/16” Thickness Black Tube

- Static Dissipative
- Smaller diameter means smaller volumetric flow rate
- Rated for temperature down to -40℃
  - Expect same reduction in deflection distance
- Increased Flexibility due to 1/16” thickness

Future Testing

Day in the life

Scheduled: April 14th - 16th
Duration: 1 hour
Location: SG Patio

Goals:

- Verify tube alignment and dust collection by isolating other variables
- Simulate dust blowing in using fan or leaf blower

Flute 1 (15 min)	Flute 2 (15 min)	Flute 3 (15 min)	Flute 4 (15 min)
Rock Chalk	Coffee Grounds	Rock Chalk	Coffee Grounds

✓	Chalk and coffee are contained to desired capsule

Multi-day testing

Scheduled: April 17th - 20th
Duration: 3 days
Location: Roof

Goals:

- Verify environmental data collection and storage over time
- Verify sail alignment and ease of access
- Single capsule open, allowing natural dust collection

✓	Sail aligned directly into the wind to within 15 degrees whenever wind speed > 2.5 m/s
✓	Environmental data stored to SD card

Systems Next Steps

Task	Date Start	Amount of Time	Projected Finish Date
Final assembly and subsystem testing	April 6	7 days	April 13
Day-in-the-life testing	April 14	2 days	April 16
Multi-day testing on roof	April 17	3 days	April 20
Hardware finalized	April 21	5 days	April 26
Documentation and poster presentation	April 27	13 days	May 10

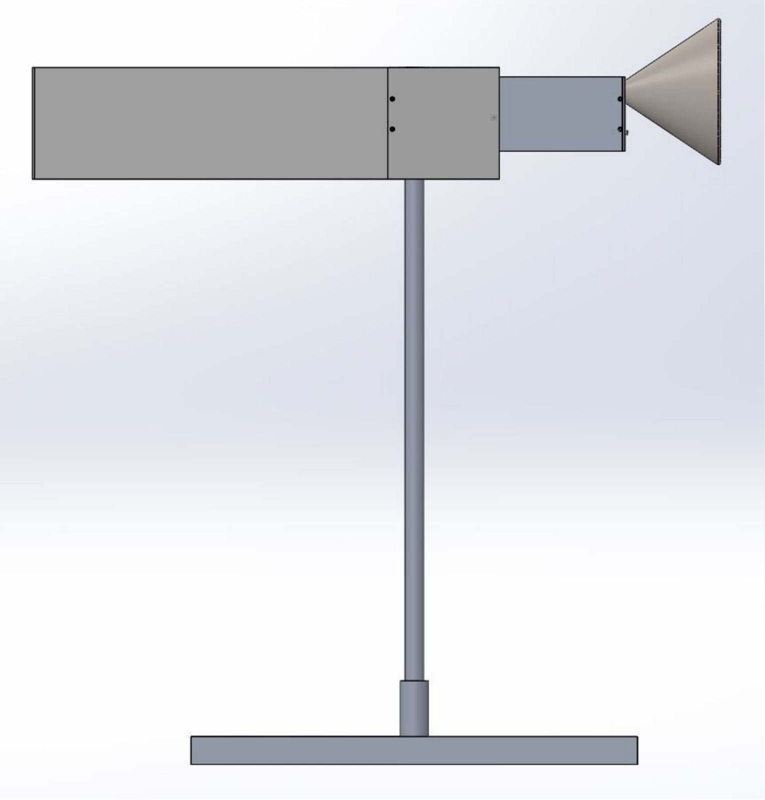
Structures

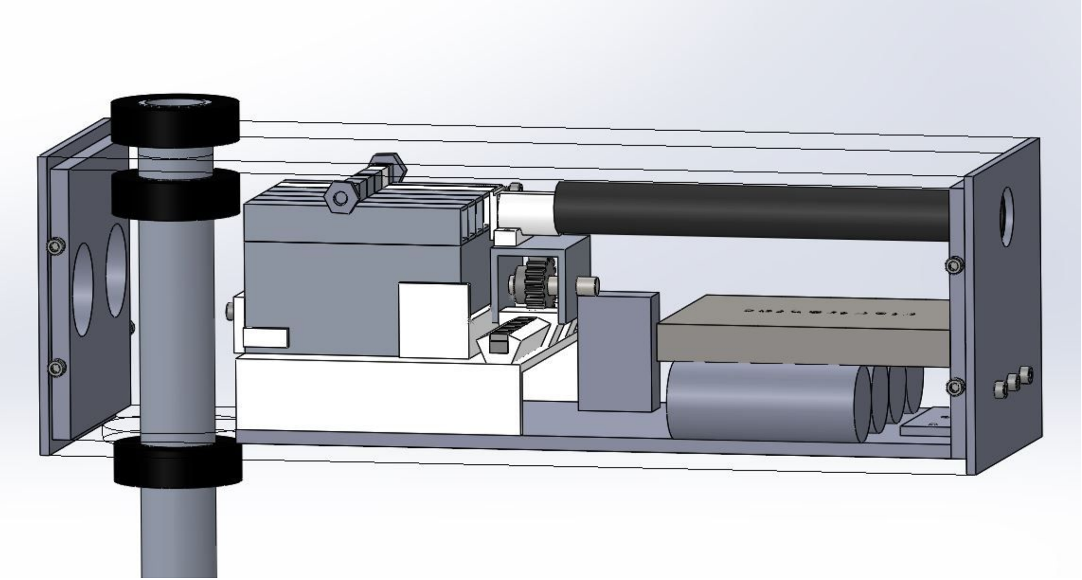
Sami Palma and Collin Doster

Requirements

Science Requirement	Mechanical Trait
0.1: Deploy on the surface of Svalbard for a month with minimal human interaction	• Base solution: extruded aluminum • Blank capsule for harsh environmental conditions • End product easily separable for ease of transport
0.2: Provide environmental data as a function of time	• Provide a space for electronics, sensors, and batteries • Electronics easily accessible with removable front cap • Sensors incorporated into structure for necessary environmental data
0.3: Collect dust samples that are distinguished by time of collection	• Provide a collection box with separable samples • Provide a motor to translate along x-axis to collect at different periods • Incorporate a flute system in order to collect dust ranging from micrograms to milligrams • Provide a chamber nozzle to allow air to flow through chamber

Hardware Demonstration





Motor and Tube Movement Testing

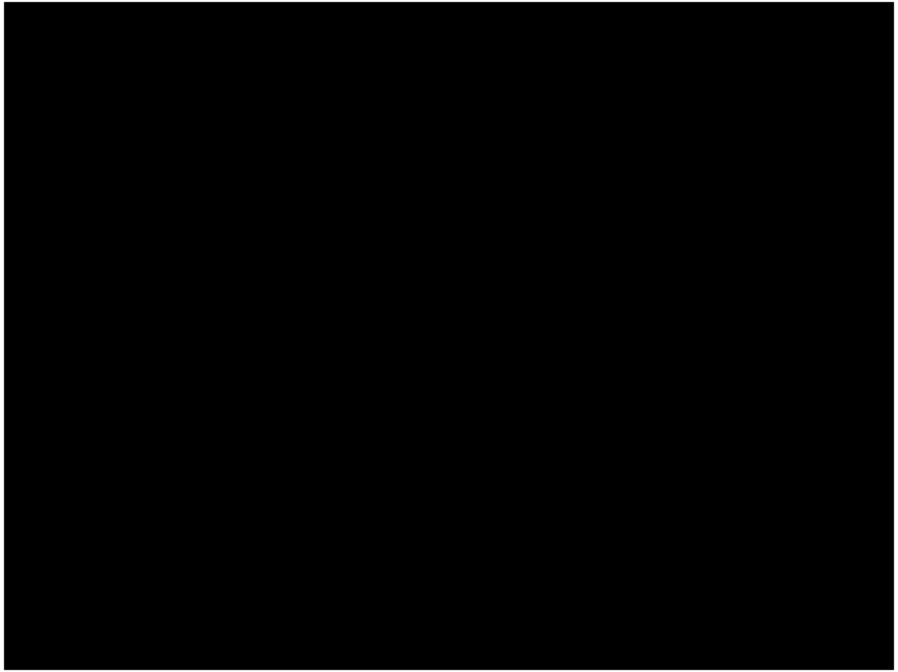
Purpose: To verify that the chosen motor would be able to provide enough torque to enable motion of tube between flutes

Results:

- Tube to flow alignment: To be determined
- Torque draw with smaller diameter tube (9.5 mm ID): 1.059 N·mm

Conclusions:

- The motor will be able to provide enough torque to enable motion of the tube between flutes



Structures Next Steps

Task	Date Start	Amount of Time	Projected Finish Date
Motor interface assembly	4/4/2018	3 days	4/7/2018
Back of chamber housing stop	4/4/2018	3 days	4/7/2018
Nozzle and electronic components assembly	4/4/2018	3 days	4/7/2018
Front cap CNC’d and assembled	4/9/2018	5 days	4/14/2018
Flutes CNC’d and assembled	4/9/2018	5 days	4/14/2018
Day in the life testing	4/14/2018	2 weeks	4/16/2018

Electrical

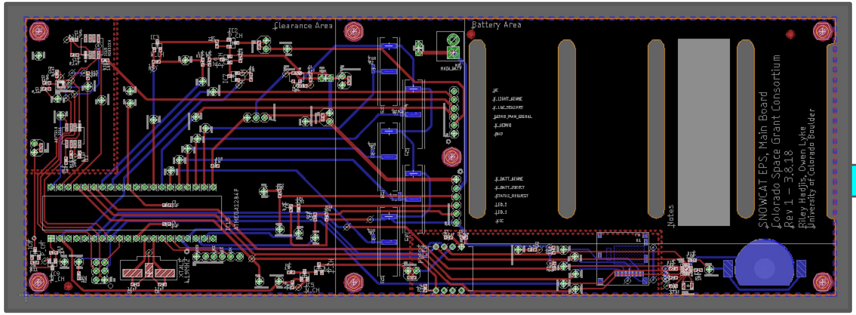
Owen Lyke and Riley Hadjis

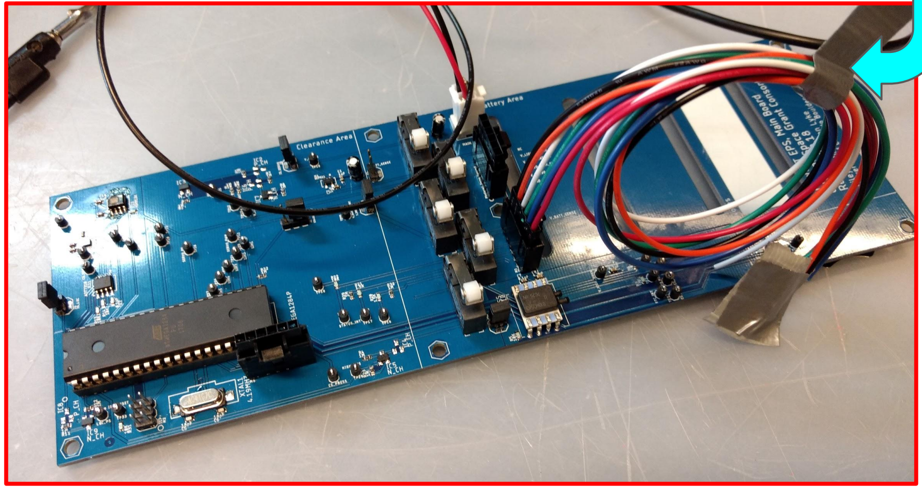
Electrical Requirements

Science Objective	Requirement	Design Traits
Quantify correlation of dust collection data to environmental conditions.	**0.2:** The Cryo-Aerosol Dust Collector shall record data that will link dust deposition patterns to wind events and atmospheric patterns.	Onboard microcontroller to sample sensors, record data, and control dust collection.
Record environmental conditions.	**1.21:** The Cryo-Aerosol Dust Collection Team shall record the time stamp, location, wind speed, wind direction, sample height from ground, temperature, and humidity.	Real time clock, differential pressure sensor, magnetometer, temperature sensor, and humidity sensor.
Control dust collection period.	**1.25:** The Cryo-Aerosol Dust Collector shall have the ability to start and stop dust collection selectively.	Collector selecting mechanism controlled by microcontroller, function determined by program loaded by the user.
Improve temporal resolution of dust collector.	**2.21.1:** The Cryo-Aerosol Dust Collector shall record the sample interval for each of the environmental sensors.	Real time clock will record the sample interval along with each measurement.
Characterize dust transport in different heights.	**2.21.2:** The Cryo-Aerosol Dust Collector team shall record wind speed as a function of height above the ground.	Wind speed will be recorded at each module, each module will be pre-programmed with its deployment height.
Enable long term data collection.	**2.22.1:** The system shall have enough power to operate for a one month deployment period.	A $LiNiMnCoO_2$ rechargeable battery will provide reliable long-term performance in an antarctic environment.

Recent Progress

Hardware





Software

- Defined users options in mission specification
- Defined how users specify options
- Finalized software flow

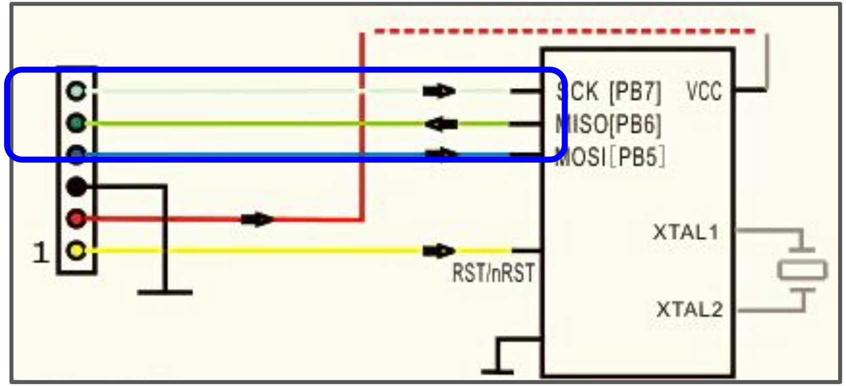
Hardware Complication / Debugging

Problem: Can’t program the uC in main board

Cause:

- Confirmed programmability of new microcontroller on the old board
- ISP lines should be isolated at all times, but they appear to connect to VCC when system energized

Next steps: Test programmability with only essential parts on the board, then add parts incrementally to find the fault



The ISP connections for programming, affected lines shown in blue

Software Design

Completed:

- Final flowchart and data storage specification
- Identified minimum set of functions and their location in the file system.
- Created Github Repository for code with file system

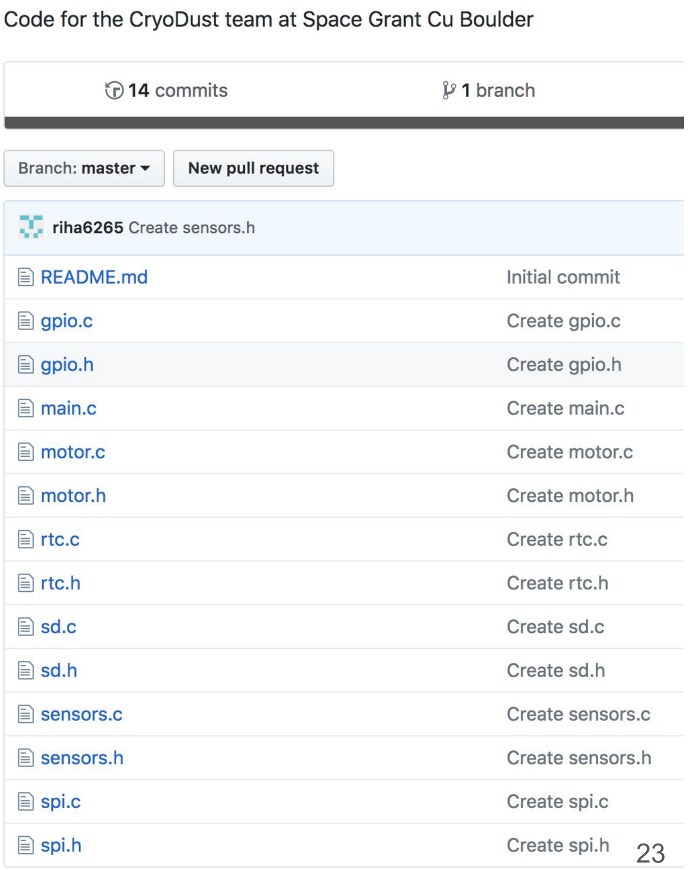
General functionality:

- Read/Write SD card
- wake/sleep on exact times
- Gather the following data: direction, temperature, humidity, time, pressure
- Move and align motor.

Next Steps:

Begin filling out the file system following the overview.

- Begin with low level drivers like gpio, spi, and pwm
- Then complete sensor drivers



File Structure / User Options

[SNOWCAT Data Specification](#)

Name

- SD_Card
  - LOG0
    - S#XXXX_INFO_SNOWCAT.txt
    - S#XXXX_LOG_SNOWCAT.csv
    - S#XXXX_PARAMS_SNOWCAT.txt
  - LOG1
  - LOG2
  - LOGNNNN
  - S#XXXX_INFO_SNOWCAT.txt
  - S#XXXX_PARAMS_SNOWCAT.txt

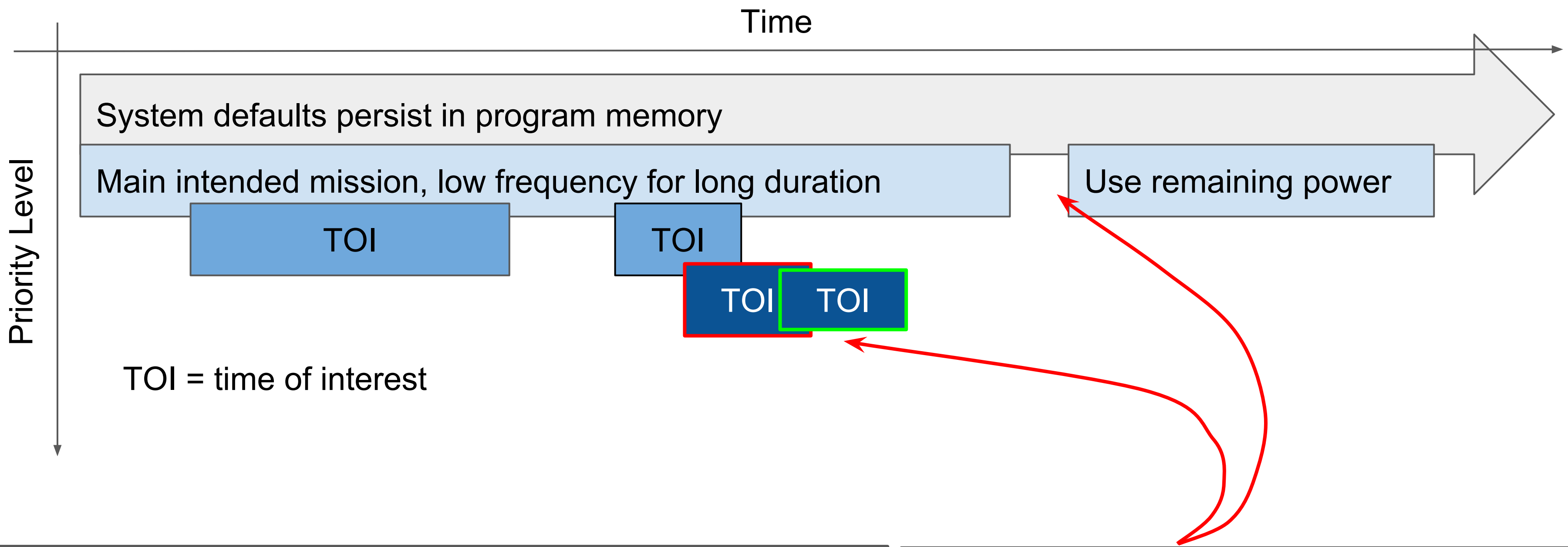
Enables portable, free-standing records of all pertinent information for robust data post-processing

User mission specification options

Variable	**Range**	**Description**
HDSR	[1,16777216]	High-draw sample rate in centi-seconds
LDSR	[1,16777216]	Low-draw sample rate in centi-seconds
POS	[0,4]	Chamber position, 0 is ‘blank’
STMOUT	[0,255]	Servo timeout in seconds
CHNGLVL	[0,65535]	Change battery warning level in mV
HBNTLVL	[0,65535]	Hibernate battery level in mV

Gives the user flexibility to adapt the mission profile in general, based on the current time as shown on next slide

Mission Specification ‘Blocks’



Mission Specification File

1: **STRT1,END1,PRI1**,HDSR1,LDSR1,POS1,STMOUT1,CHNGLVL1,HBNTLVL1 # first spec
2: **STRT2,END2,PRI2**,HDSR2,LDSR2,POS2,STMOUT2,CHNGLVL2,HBNTLVL2 # second
...
n: **STRTn,ENDn,PRIn**,HDSRn,LDSRn,POSn,STMOUTn,CHNGLVLn,HBNTLVLn #nth spec

- Tolerant of gaps, overlaps, and partial settings
- Specification does not require careful attention to stop/start boundaries or other conflicts.
- Makes for simple general specification method

PCB and Sensor Functionality Testing

PCB Functionality:

- *Power regulation:* confirmed
- *Limit switch action:* confirmed
- *Power zone switching:* to-do
- *Programmability:* to-do

Test Sensors Regardless of Programming Status:

- Jack in an external microcontroller on the SPI bus and use pre-existing SPI libraries. Use our own C sensor drivers except modified to use the existing SPI library for the other sensor (Teensy most likely)

Servo Testing

- Demonstrated torque capability
- Loaded current draw within acceptable bounds for hardware
- Idle current of 4 mA will be switched off when not in use
- Problematic behavior: stalling
  - Stalls mean servo does not start moving when commanded off-center
  - Stalls seemed to occur in particular conditions, but not always
  - Notd that small shaft movement kickstarts servo into movement
  - Mechanical problem likely, causes may include:
    - Pinching of the drivetrain by the case
    - Poor lubrication of drivetrain
  - Electrical problems unlikely - checked signal with DLA and mechanical symptoms
  - Need additional testing in a more final mounting situation
  - Could potentially provide a software solution: jerk-start or increased start torque

Power Testing

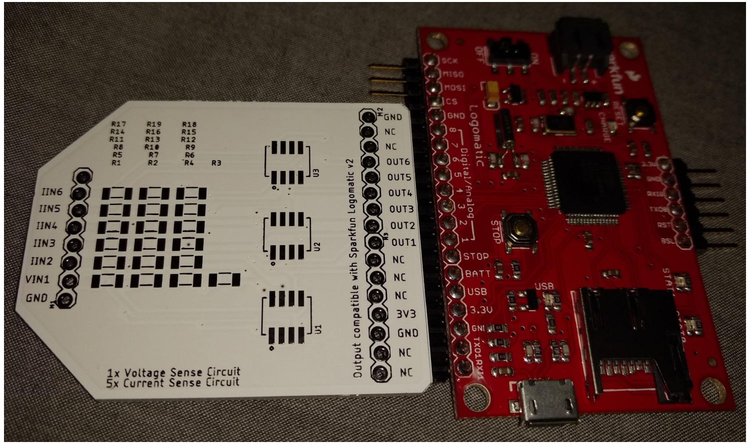
Initial Testing:

~500 uA standby current, no code execution and no low-power options

~200 mA servo movement current, OK for small duty cycles

Future testing plans:

- Time record of current draw using Logomatic V2 and custom amplifier circuit
- Demonstrate current saving from:
  - Power zone switching
  - Microcontroller sleep

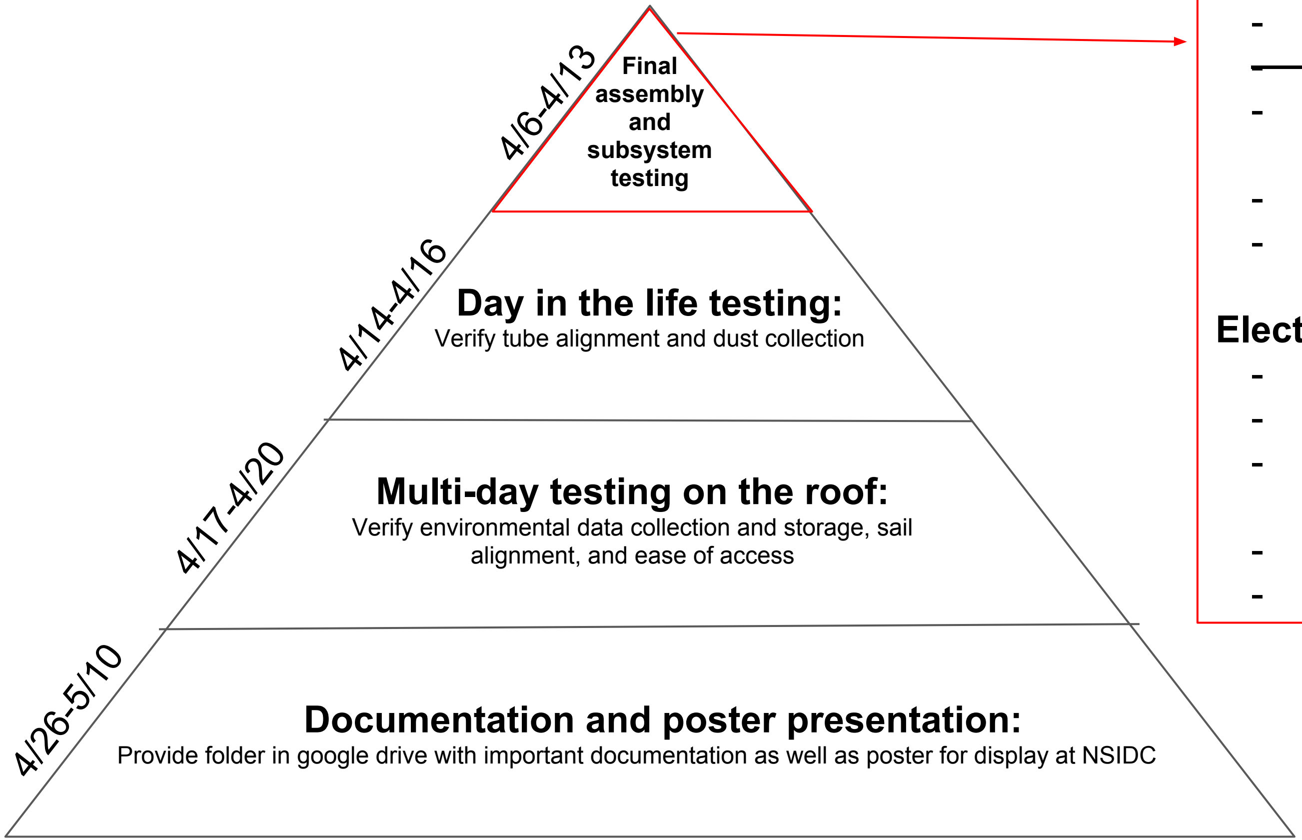


Electronics Next Steps

Task	Date Start	Amount of Time	Projected Finish Date
Prove programmability	4/4/18	1 week	4/11/18
Write low-level drivers	4/6/18	4 days	4/10/18
Write sensor + sd + servo drivers	4/10/18	4 days	4/14/18
Write main program	4/14/18	4 days	4/18/18
Prove EPS	4/18/18	2 days	4/20/18

Conclusions

Moving Forward



Structures:
- Motor interface assembly
- ~~Back of chamber housing stop~~
- Nozzle and electronic components assembly
- CNC and assemble front cap
- CNC and assemble flutes

Electronics:
- Prove programmability
- Write low-level drivers
- Write sensor + sd + servo drivers
- Write main program
- Prove EPS

Deliverables

Assembled hardware (due April 26th):

- **Electronics Subsystem**:
  - SD card, battery pack, temperature sensor, pressure sensor, humidity sensor, RTC, anemometer, magnetometer, limit switches, indicator system
- **Structure Subsystem**:
  - Sail, central pole and base, nozzle to tube interface, main chamber box, pull out tray, collection box, 1 flute, rack & pinion motor interface, rear and front end cap, motor interface
- **Dust Collection Subsystem**:
  - Tube, 5 Capsules, 4 Flute and 1 Blank, Motor Subsystem

Designated Google Drive Documentation Folder (due May 10th):

- Table of Contents with links to documents below
- Testing manuals and results
- Integration, hardware, and software user manuals
- PCB design and schematics
- Solidworks files

Thank you!

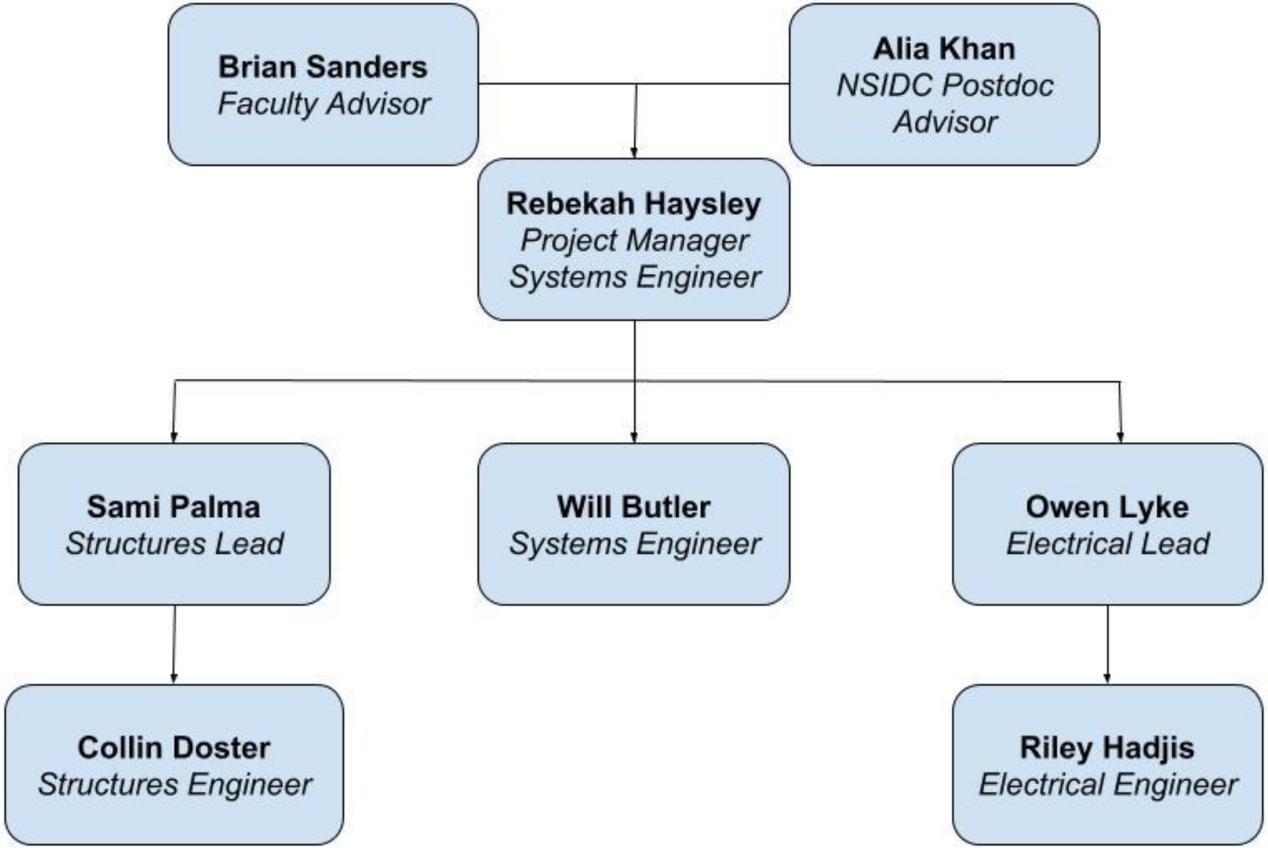
Questions?

Appendix

Appendix A: Budget Overview

Model 2 Budget Overview							
Electronics Component	Amount ($)		Structures Component	Amount ($)		Overall Budget	Amount ($)
Order E1	64.7		Order S1	51.82		Total	1011.59
Order E2	359.13		Order S2	29.2		Overall Budget	1150
Order E3	64.31		Order S3	19.1			
			Order S4	274.86		Margin	Amount ($)
			Order S5	40.5			
			Order S6	25.86			
			Order S7	24.47		Total	0
			Order S8	15.95		Allowed	50
			Order S9	13.44			
			Order S10	28.25			
Total	488.14		Total	523.45			
Allowed	500		Allowed	600			

Appendix B: Team Structure



Appendix C: Team Picture!