Cryo-Aerosol Dust Collector

Preliminary Design Review
October 27th, 2017

Cryo Dust Collection and NSIDC

- Black carbon is derived from combustion of biomass and fossil fuels

- Black carbon deposition on snow reduces snow albedo (amount of reflected light), contributing to worldwide melting of ice

- Working with Alia Khan (NSIDC Postdoctoral Research Associate) to develop active dust collector to capable of linking dust deposition patterns to wind events and atmospheric patterns

Roberto Venturini, *European Environmental Agency*, 2016

BSNE Top View, *Soil Erosion Products*

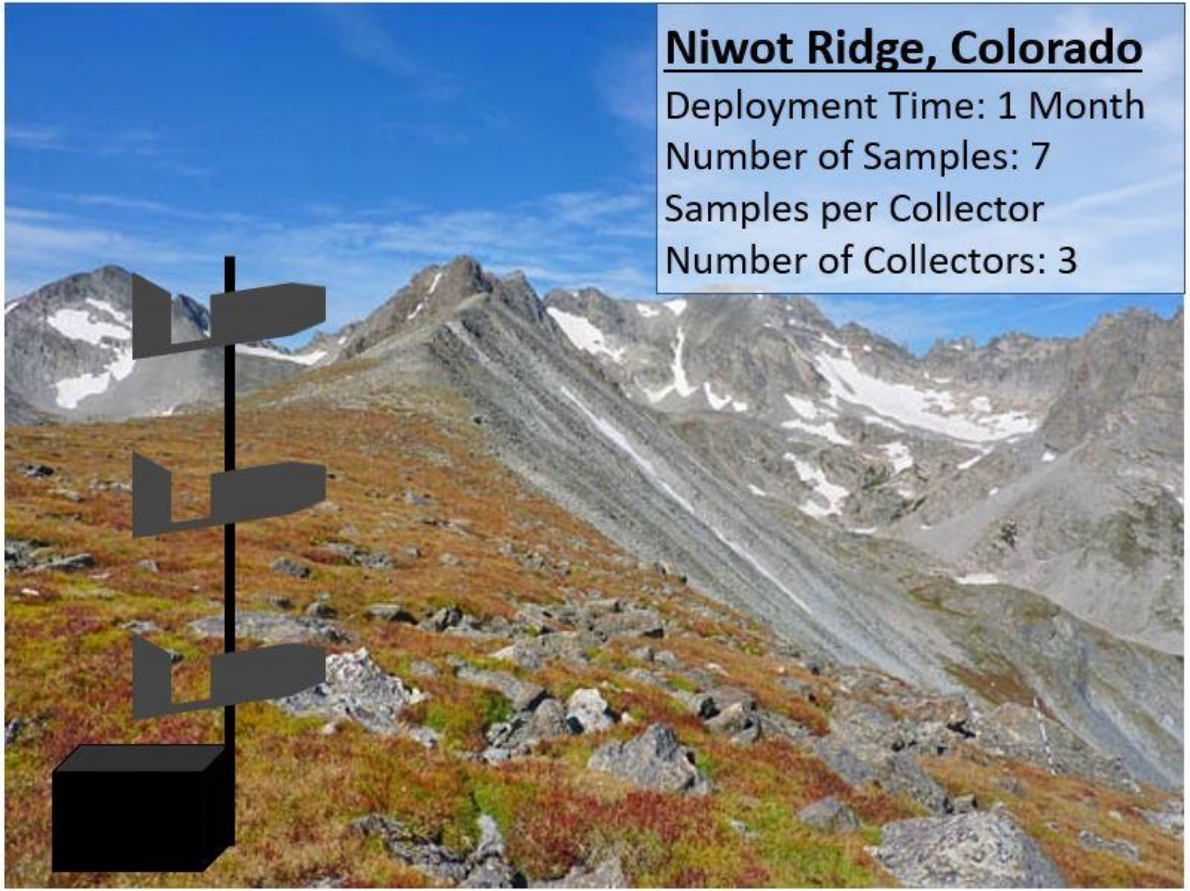
Mission Overview

The Cryo-Aerosol Dust Collection team shall build an aerosol auto-sampler that adds context and quantifiable data to the Cryospheric dust collection process.

Objectives:

- Deploy on the surface of icy and mountainous regions for extended amounts of time with minimal human interactions
- Provide environmental data linking dust deposition patterns to wind events and atmospheric patterns
- Collect dust samples that will be turned over to NSIDC for further analysis

Scope of Mission - Niwot Ridge, Colorado



Scope of Mission - Svalbard, Norway

Minimum Criteria For Success

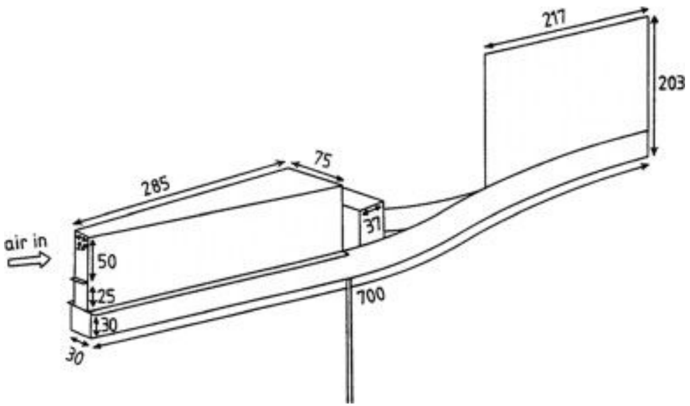
- Design a Dust Collector to be deployed on Niwot Ridge for one month
  - Design can be extended to Svalbard, Norway
- Collect black carbon and bioaerosols within the dust sample
  - Each dust sample will be a minimum of 0.5 grams of dust (on the top filter)
- Provide environmental data that corresponds with collected dust sample
- Dust collector is highly reliable in extreme environments, inexpensive, and portable

Systems

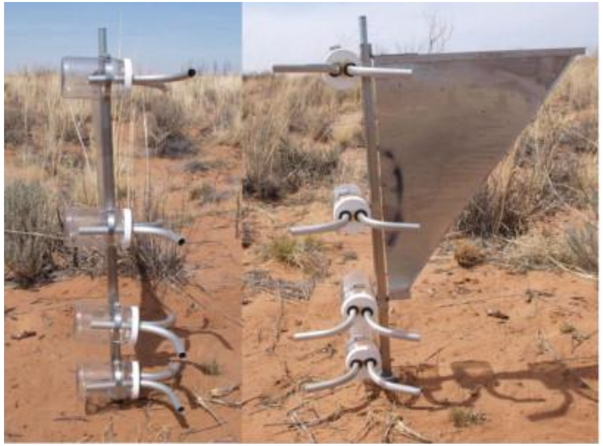
Will Butler, Bekah Haysley, Kathy Vega

Current Designs

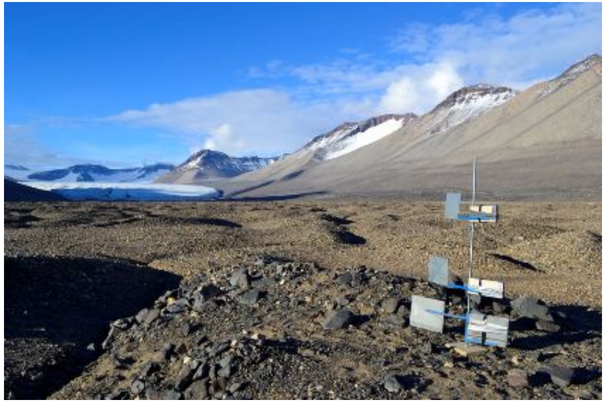
- BSNE - Big Spring Number Eight
  - Passive
  - Bulk Collector
  - Tend to break or wear
  - Simple
  - There *are* more specific black carbon collectors, but they are expensive



http://www.sciencedirect.com/science/article/pii/S1352231014006645



V. Acosta-Martínez et al., *Aeolian Research 18*, 2015



Courtesy of Alia Khan, 2017

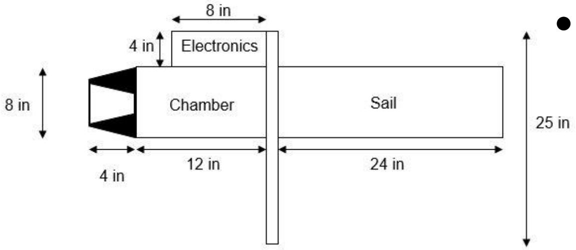
Proposed Improvements

Science Goal: Link dust **transportation**, **composition**, and **deposition** to snow melting

Design Improvements

- **Transportation**: Collect multiple samples that correspond to recorded wind events

- **Composition**: Collect on glass fiber filters with different pore sizes to separate particles



- **Deposition**: Robust and reliable design to allow transfer between varying environments and operate over long periods

Scientific Benefits

- Understand **transportation** patterns using sensors capable of linking environmental data to dust sample
- Dust sample is better representation of **composition** of dust in environment due to controlled sampling intervals and separation of chamber units
- Prolonged lifespan of mission via structural improvements in order to understand how dust is **deposited** over time

Requirements

Science Objective	Requirement	Design Traits
Investigate effect of black carbon **deposition** on snow albedo/melting in Cryospheric regions	**0.1**: Capable of deploying on surface of snow and ice across polar and mountainous regions for long periods of time with minimal human interactions ● Design is transferrable between Niwot Ridge, Colorado and Svalbard, Norway	● Easy to carry to remote locations (stacked design) ● Can be staked into ground, supported by stabilizing cords ● Powered by battery (and solar for extra boost) ● High reliability (slanted roof keeps snow and ice away from opening)
Understand how the dust (in particular, the black carbon) is **transported**	**0.2**: Link dust deposition patterns to wind events and atmospheric patterns	● Electronics and sensors located in each chamber system record environmental data and timestamp ● Control when dust collection happens using a rotating filter system ● Chamber openings face directly into the wind using a wind sail ● Minimum sampling time is determined using deployment time, number of snow days expected, and the sampling capacity (7 chamber units, 2 filters each) ● Dust samples are taken from 3 different heights from the ground, up to 6 feet ● Each of the three collection chambers is capable of collecting samples from 7 different wind events (2 filters per wind event)
Classify the **composition** of the dust deposited on the surface of snow and ice in Cryospheric Regions	0.3: Collect dust that can be turned over to NSIDC for analysis ● Collect a minimum of 0.5 g of dust per top filter per wind event	● Dust is collected on 47 mm diameter glass fiber filter ● Samples are stored in a sterile capsule ● Can collect micrograms to milligrams of dust

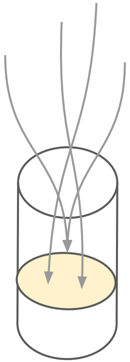
Dust Considerations

- Expected dust composition
  - **Black carbon**
  - Bioaerosols & Microbes
  - Mineral Dust

Gustafsson, *Stockholm University ACES*, 2015.

- Collection size
  - Anywhere from 2 nm - 2 microns sized dust particles

- Material for dust collection
  - Glass fiber (current for all dust)



- Require long enough sampling time to collect sufficient dust on filter (0.5 g minimum) for NSIDC to analyze
  - No pump/fan! Instead…..
  - Increased surface area of filter (47 mm, 1.85 inches)
  - Longer sampling time

Designing for the Environment

Antarctica (Chilean Research Station)

We may have opportunity to test initial prototype here in January!

Further snowfall research needed

- Precipitation: 44.5 mm in January
- Temp: Daily mean 1.5 ℃ in January

Niwot (CU Mountain Research Station)

Abundant snowfall → requires digging to stake central pole to ground

- Precipitation: 930 mm annual mean, with 80% occurring in winter and spring
- Temp: -13.2 ℃ average in January

Svalbard (Ny-Alesund Research Station)

Little snowfall → digging unnecessary to stake central pole to ground

- Precipitation: 385 mm annual mean
- 145 average snow days
- Temp: Annual mean -5 ℃

When do we change a filter?

Two options:

1. Change filter based on specified **minimum sampling time**. Spread sample collection evenly throughout deployment period
    - Minimum sampling time of 6 hours, with one sample taken every 3 days (Niwot) and every 47 days (Svalbard)
    - Approach discussed in CoDR and now PDR
2. Change filter based on the **direction of the wind**
    - Chamber Unit 1 is for 0-52 degrees, Chamber Unit 2 is for 53-105 degrees, and so on

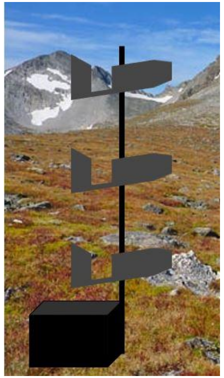
Options for Changing a Filter

Option 1: Minimum Sampling Time	Option 2: Direction of the Wind
• Dust collection only occurs for 6 hours (minimum) to 3 days (maximum, Niwot) • Sample is less specific with regards to “Wind Event” • Motor motion occurs only occasionally (at predicted intervals), so we are saving on power	• Must move motor more often, draws more power • Will not be able to predict how much motor will need to move • Riskier with regards to power and amount of motion required • Sampling is always “on”, except for cases of bad weather • Better separation of dust samples into “Wind Events”

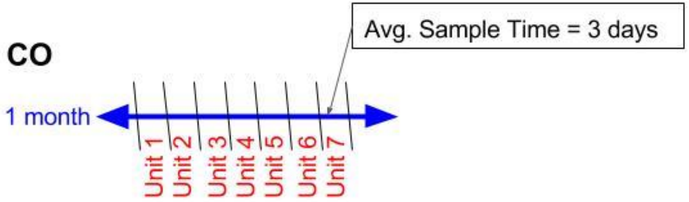
PDR Choice

Future Choice

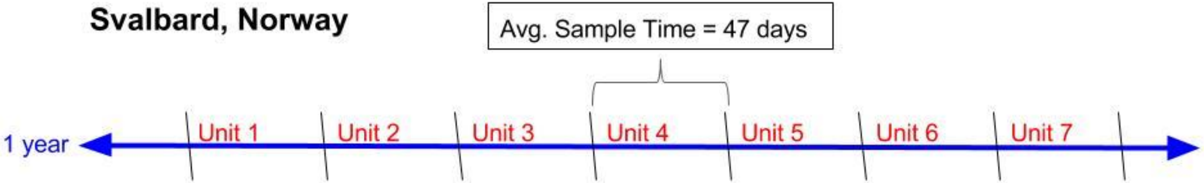
Timeline

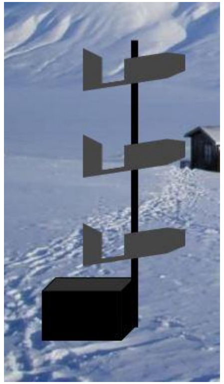


Niwot Ridge, CO



Svalbard, Norway





Sample Time = (Deployment Time - **S.F.**) / 7

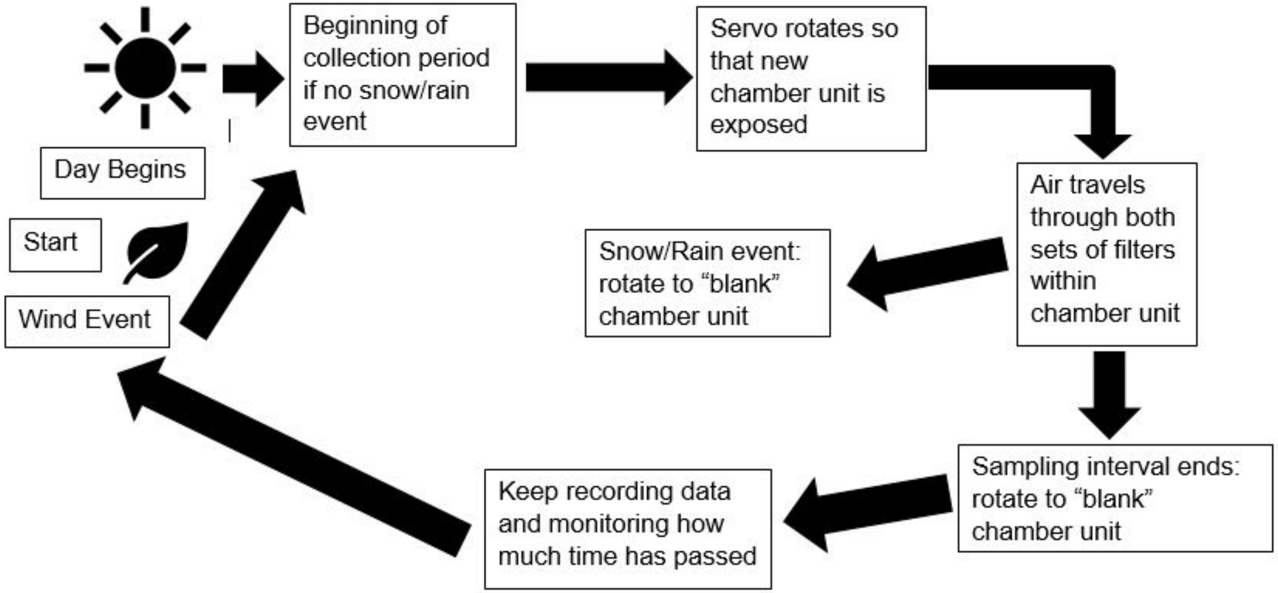
S.F. = Safety Factor (set based on number of "bad weather" days expected in each environment)

Niwot:	X "bad weather days" expected	S.F. = 9
Svalbard:	X "bad weather days" expected	S.F. = 36

FBD

A “Wind Event” triggers a sample change.

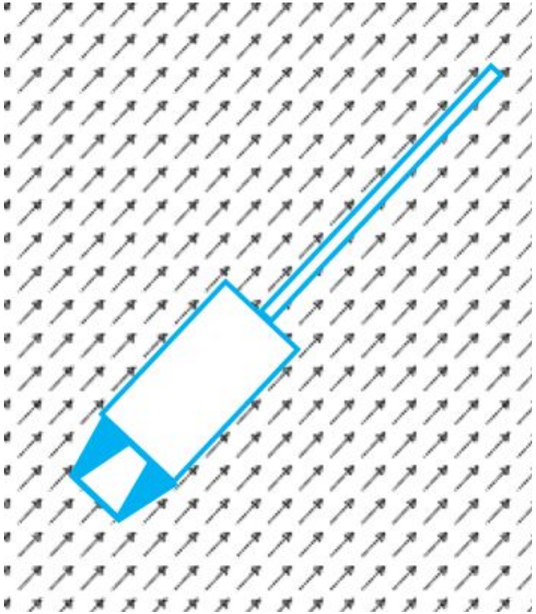
- Wind direction changes more than ***45 degrees***
- Wind speed speed changes by more than ***5 m/s***
- Limited to ***1 sample per 3 day period*** (Niwot), with ***minimum sampling time of 6 hours.***



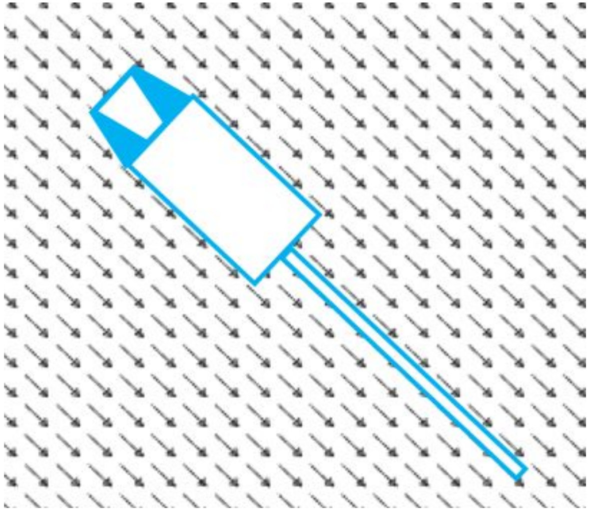
CONOPS

Dust collector swings to face the wind.

- To be determined:
    - Center of pressure
    - Ratio of sail size/weight to chamber and snout size/weight

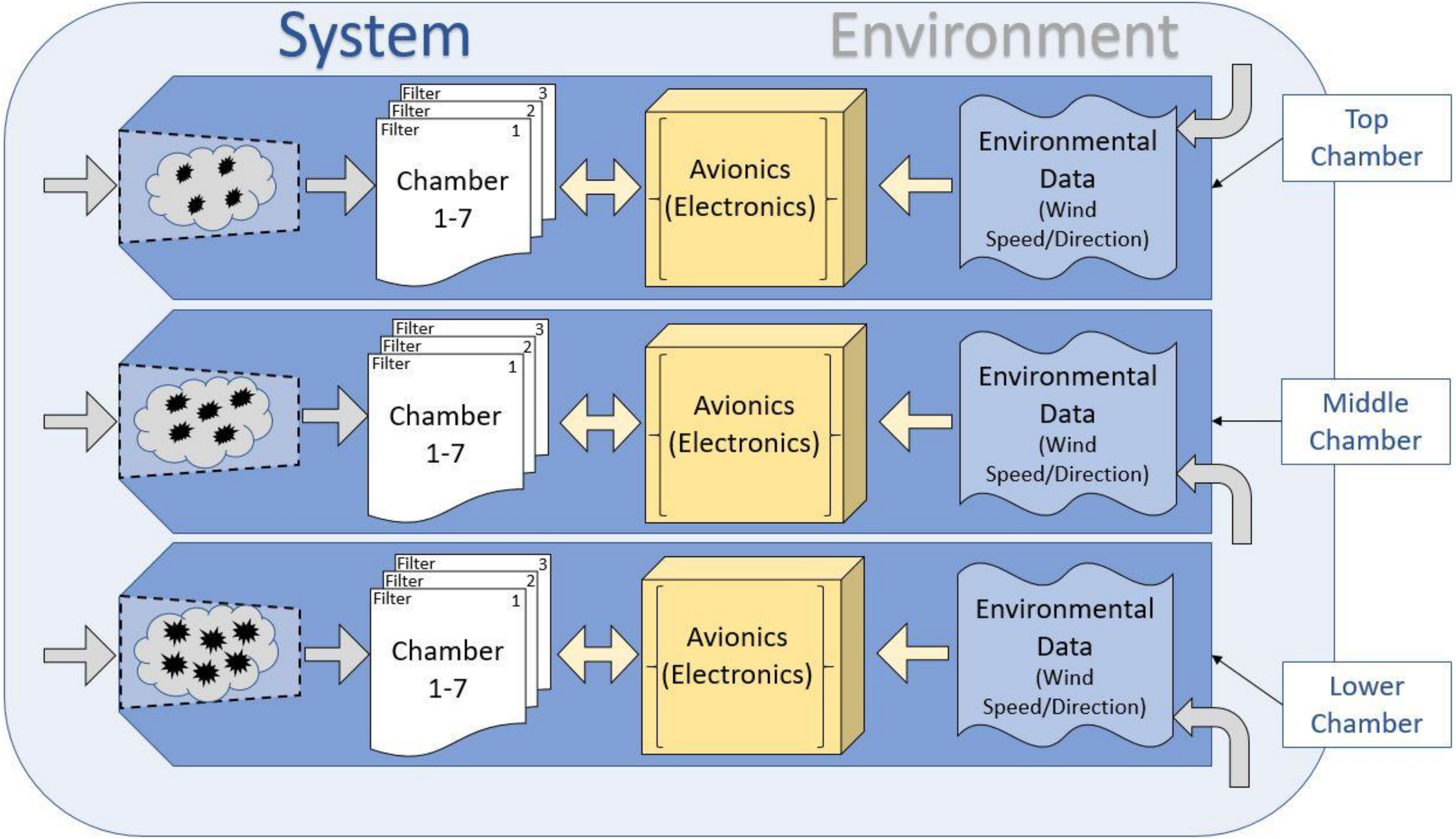


Time 1



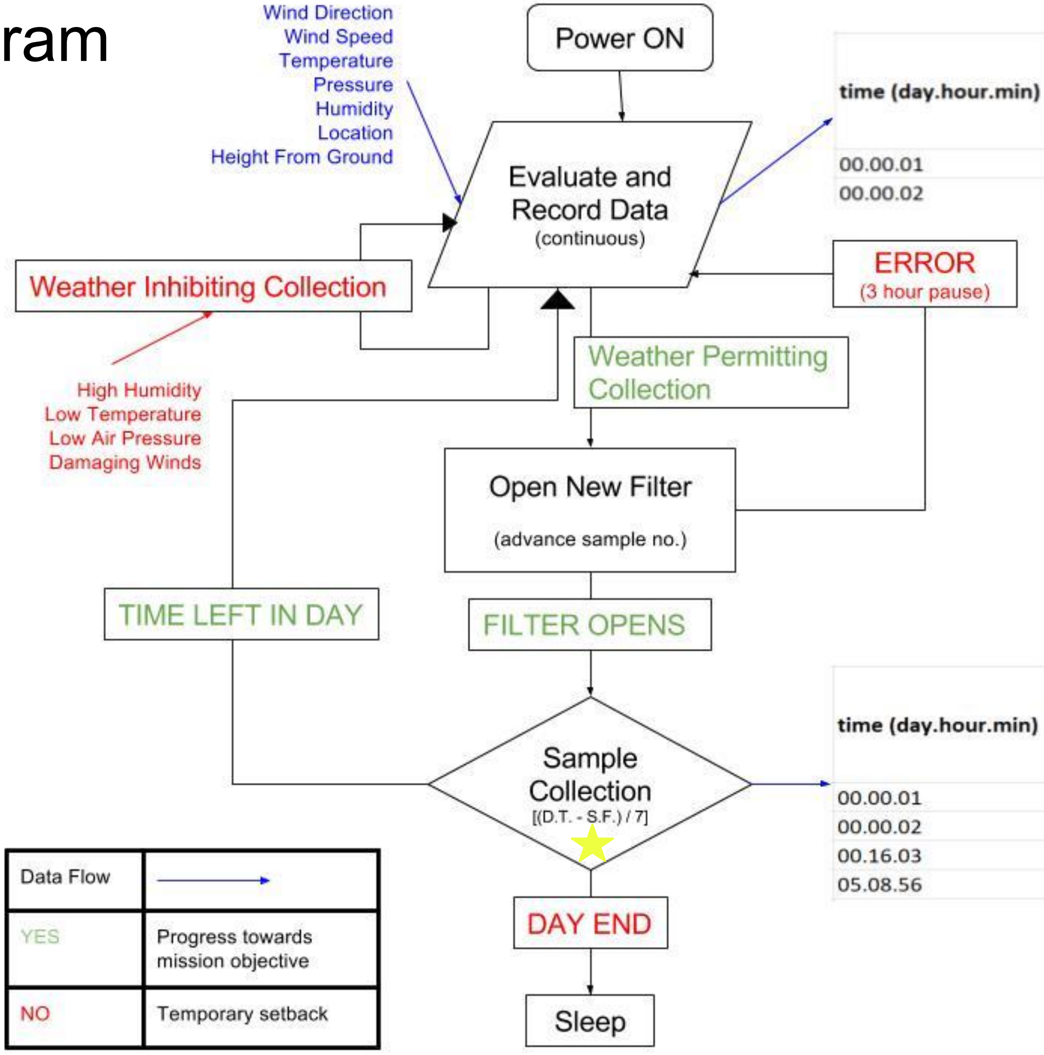
Time 2

CONOPS



System
Environment
Filter 3
Filter 2
Filter 1
Chamber
1-7
Avionics
(Electronics)
Environmental
Data
(Wind
Speed/Direction)
Filter 3
Filter 2
Filter 1
Chamber
1-7
Avionics
(Electronics)
Environmental
Data
(Wind
Speed/Direction)
Filter 3
Filter 2
Filter 1
Chamber
1-7
Avionics
(Electronics)
Environmental
Data
(Wind
Speed/Direction)
Top
Chamber
Middle
Chamber
Lower
Chamber

State Diagram



time (day.hour.min)	sample no.	data e.g. (location.height.direction.speed.temperature.pressure.humidity)
00.00.01	null	niwot.5.180.5.81.664.62
00.00.02	null	niwot.7.15.5.53.665.62

Periodic Cycle / State Diagram

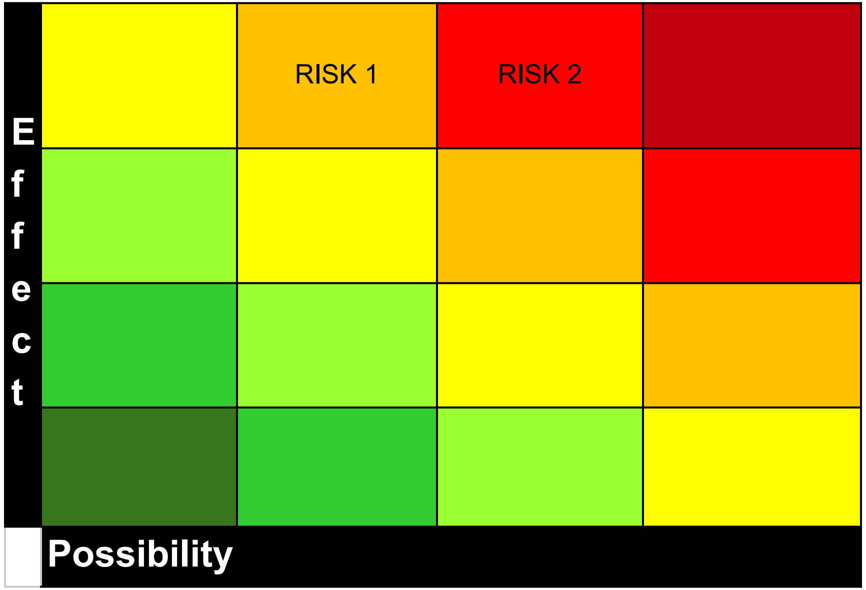
time (day.hour.min)	sample no.	data e.g. (location.height.direction.speed.temperature.pressure.humidity)
00.00.01	null	niwot.5.180.5.81.664.62
00.00.02	null	niwot.7.15.5.53.665.62
00.16.03	1	niwot.20.278.5.27.663.62
05.08.56	7	niwot.16.2.5.70.660.62

*Excel files are for example purposes only

Systems Risks/Worries

- Verifying our requirements through testing
  - The accuracy of the dust collector aligning with the wind
    - Flow analysis in SolidWorks
    - Testing prototype during windy day in Boulder
  - Collection chambers align correctly with air intake
  - Test snow or water drainage from angled roof
- Structural Failures
  - Dust collector or mounting pole failure
  - Dust collector intake fills with snow
  - Air intakes release from dust collector
- Electrical Failures
  - Cold weather drains battery
    - Thermal testing

Systems Risk Matrix



RISK 1: Data collection will fail IF snow and ice become trapped in the chamber units and around the motor.

RISK 2: Dust collection will fail IF the wind sail cannot orient the collector to face into the wind.

Systems Next Steps

- Cost analysis of the entire build
- Confirm Prototype can be built within its allowed budget
- Confirm test procedure for prototype and sensors
- Choose viable materials for the prototype
- Test the collection ability of the chamber
- Working towards CDR!

Structures

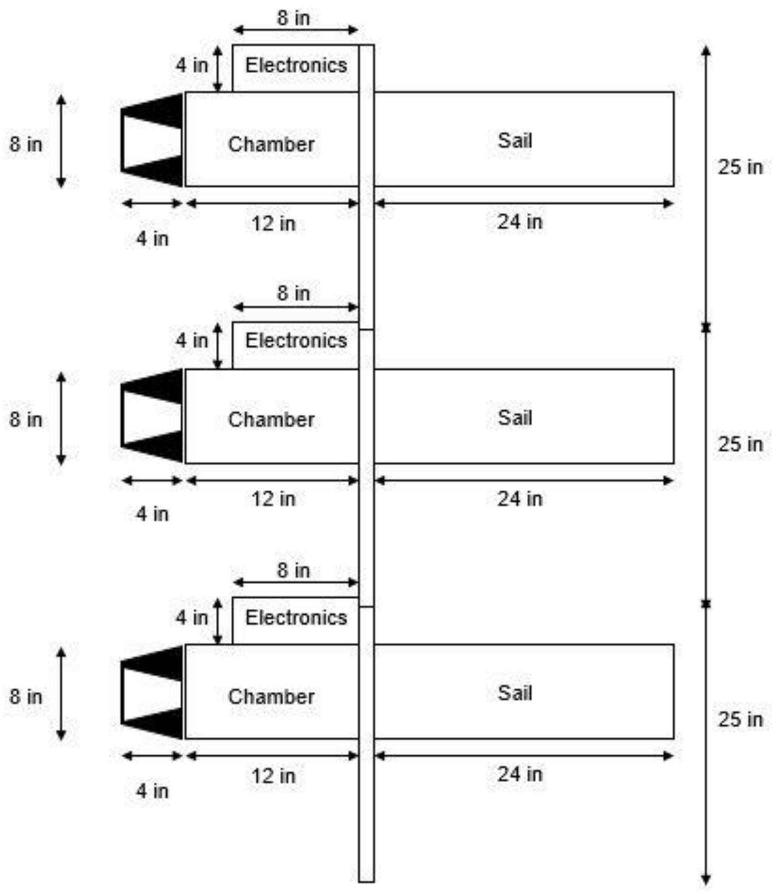
Sami Palma and Collin Doster

Requirements

Science Requirement	Mechanical Trait
0.1: Capable of deploying on surface of snow and ice across polar and mountainous regions	● Staked into ground, stabilizing cords ● Easy to carry to site (stacked design) ● High reliability (sails secured tightly, slanted roof) ● Transferability of design from Niwot to Svalbard (same number of collection chambers/capsules)
0.2: Link dust deposition patterns to wind events and atmospheric patterns	● Place to store electronics (not very worried about temperature) ● Sterile capsules so samples do not mix ● Rotating filter system for different samples ● Control when dust collection happens ● 3 chambers at different, adjustable heights up to 6 feet
0.3: Collect dust that can be turned over to NSIDC for analysis	● Opening facing directly into wind, in conjunction with sail ● Can collect micrograms to milligrams of dust ● Dust collected on glass fiber filters
Necessary amount of dust on filter = 0.5 g (minimum) to 1.0 g (goal)	● Size of filter = 1.85 in. ● Chamber shape and size

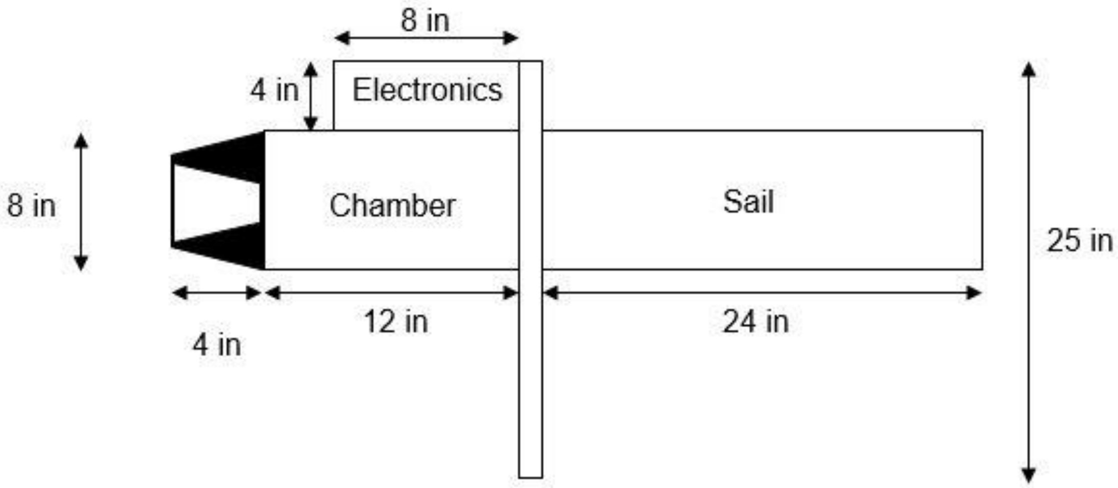
Proposed Design: Overview

- Total height: *6 feet*
- Chamber placement: *Adjustable*
- Chamber replication: *3 identical chambers*
- Opening faces into the wind: *Sails attached to each chamber*
- Solar Panel: *Backup option*
- Chamber weight: *10 lbs*
- Total weight: *30 lbs*



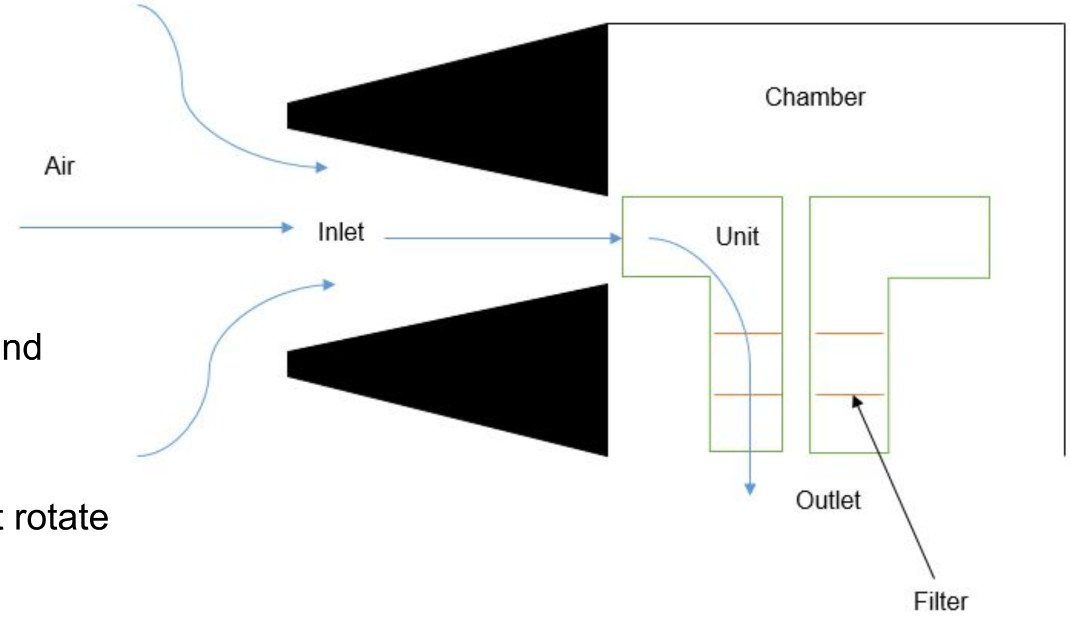
Transportation and Delivery to Site

- Stacked chamber design
- Electronics compartment
  - Easy to remove from collection chamber
  - Dimensions: 8 in x 4 in x 6 in
- Sails
  - Easy to remove from collection chamber
  - Material: Aluminum
  - Attachment: Bolts
  - Shape and exact size: TBD



Chamber Design

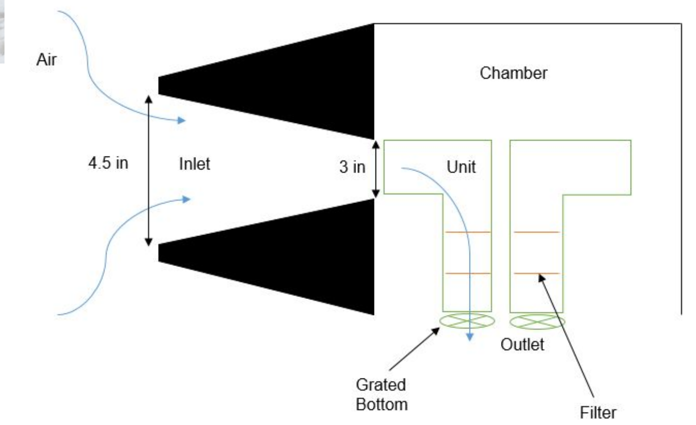
- No pump within each chamber
  - Reasoning:
    - Added complexity
    - Weight
    - Power draw
    - Cost
- Wind tunnel snout
  - Adds siphoning effect to push wind directly into filter system
- Capsules
  - 7 capsules in each chamber that rotate for dust collection
- Filter Scaffolding
  - Easy to insert and remove filters from collection units on site



Designing for Different Deployment Sites

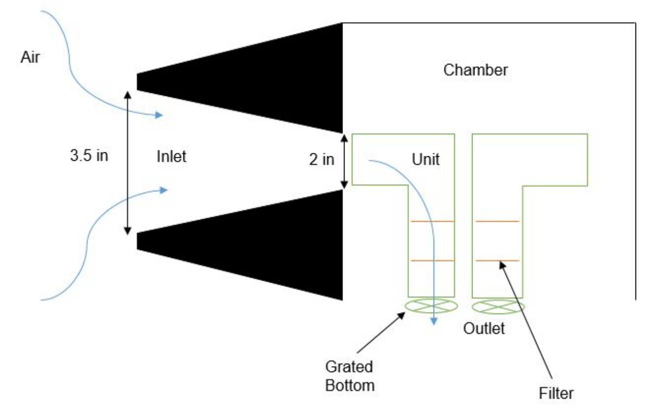
Niwot (Rocky Mountain Research Station)

- Short deployment time → Larger snout opening
  - Larger opening for more air flux → necessary due to shorter sampling time



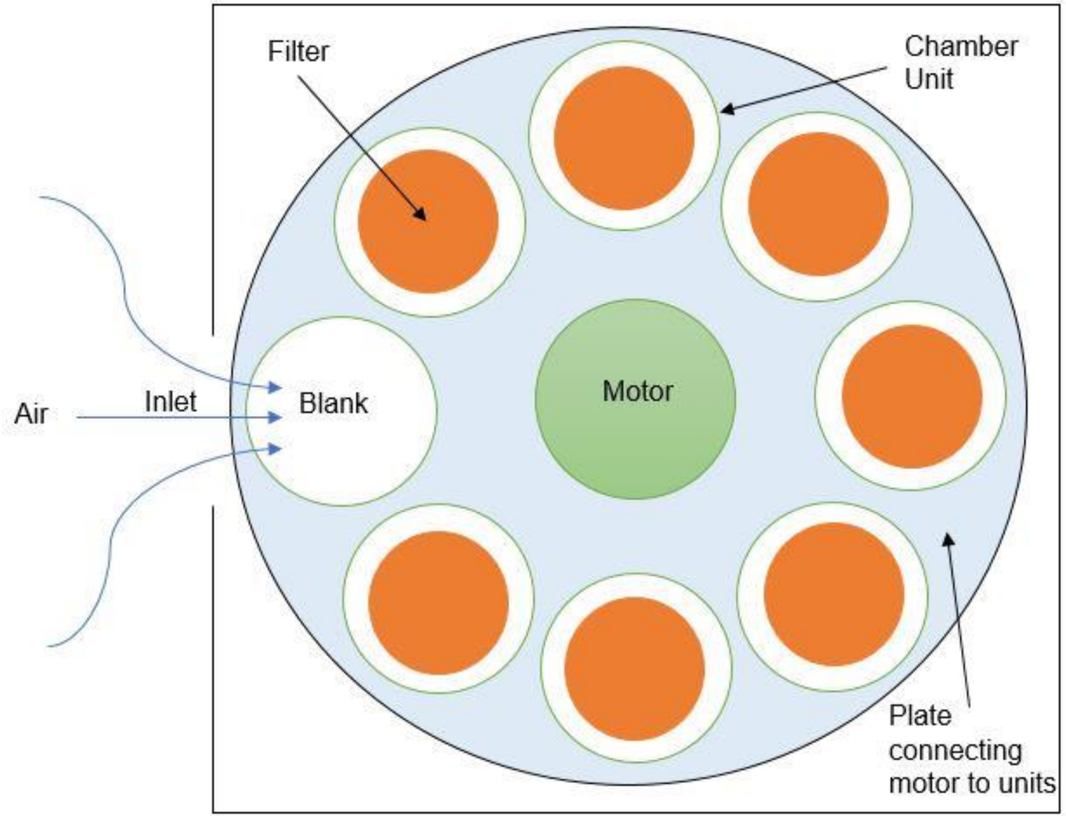
Svalbard (Ny-Alesund Research Station)

- Long deployment time → Smaller snout opening
  - Smaller opening for less air flux → longer sampling time



Filter Rotation and Dust Collection

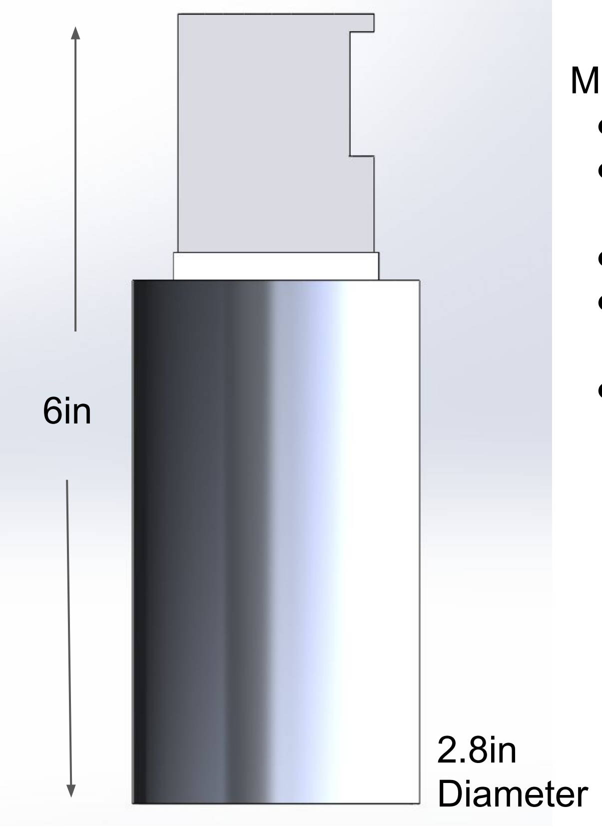
- 8 chamber collection units within one chamber
  - 7 containing filters, 1 “blank”
  - System resets to this “blank” when not collecting
- Each chamber independently rotates
  - Independent of snow accumulation
- Door within chamber about 4 inches, preventing moisture collection
- No doors opening/closing
  - No freezing doors shut



Motor Trade Study

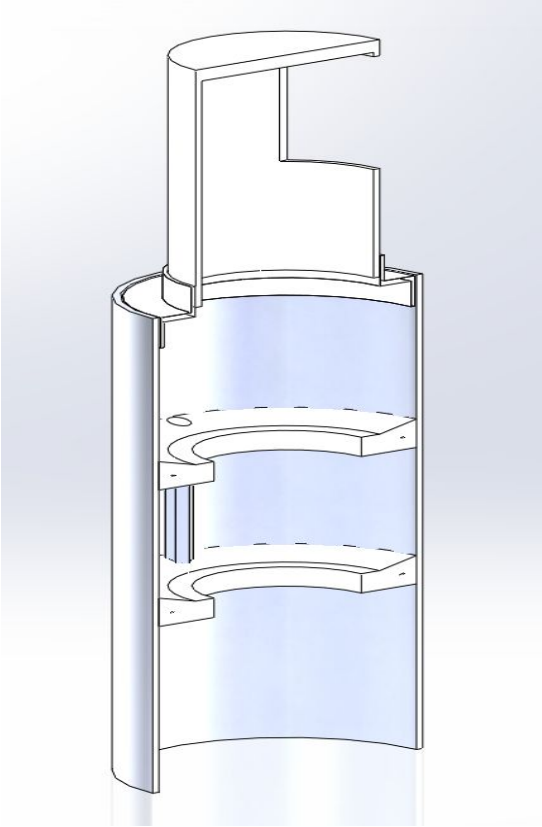
Gear Motor	Servo Motor
● Attached encoder ● Material: Steel ● Stall Torque: 593 oz-in. ● Solar panel needed ● Weight: 0.776 lbs ● Stall Current: 11.5 A ● Voltage: 12 V DC	● Voltage Range: 4.8 V - 8.4 V ● Stall Current: 2.65 A ● Stall Torque: 87 oz-in. ● Weight: 0.1323 lbs ● No solar panel needed ● Stripped gear boxes ● Torn wires ● Stripped heads ● Broken heads ● Attached with servo horns or wings

Capsule Design



Side Chamber View

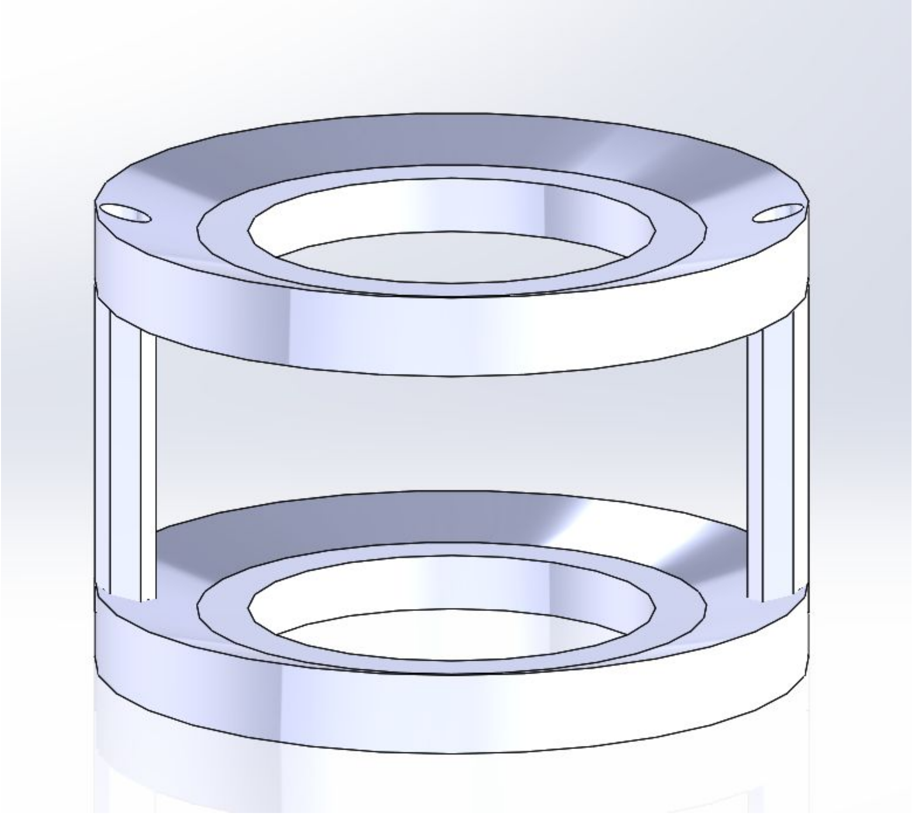
Materials
- PLA entrance
- Aluminum outer cylinder
- PLA scaffolding
- Aluminum standoffs
- PLA converter



Side Chamber Cut Away View

Filters - Ease of Access

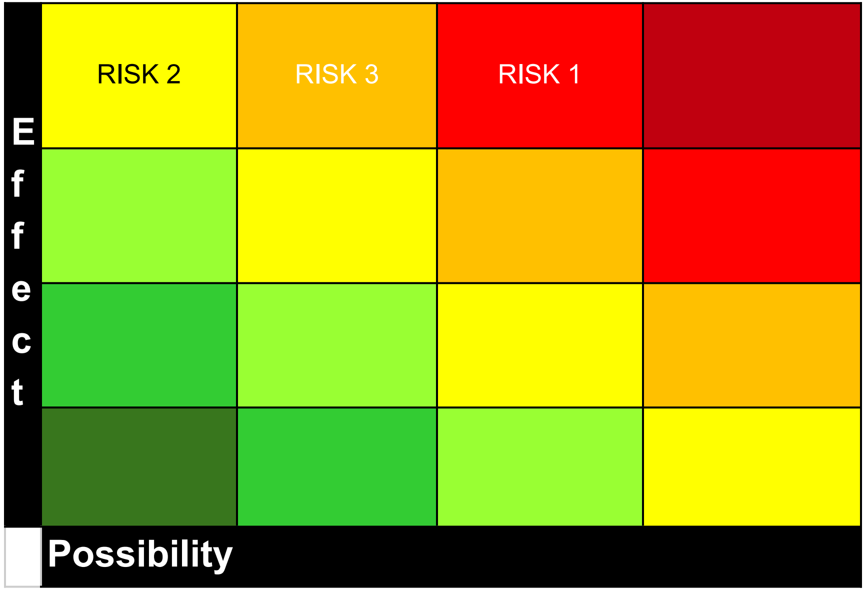
- Number of filters per chamber: 14 filters
- Number of units per chamber: 8 units (1 unit as a blank)
- Number of filters per chamber unit: 2 filters
- Filters rest on the ring in the middle
  - Bottom filter has smaller pore size to catch smaller dust particles
- Scaffolding/Standoffs:
  - 2 standoffs per filter tray



Structures Risks/Worries

- Securing sails
- Securing chambers to central pole
- Weight of structure
  - Rotation of chamber
- Directing airflow through chamber unit successfully
- Scaffolding structure
  - Airflow
  - Ease of removal

Structures Risk Matrix



RISK 1: Dust collection will stop IF chamber breaks off central pole.

RISK 2: Dust collection will stop IF sail is subject to structural failure.

RISK 3: Extraction of samples will fail IF scaffolding fails,

Structures Next Steps

- Finish SolidWorks parts
  - Make SolidWorks full assembly
  - Make SolidWorks drawings
- Finalize parts list
  - Finalize materials used in each chamber
- Make fabrication schedule
- Make assembly schedule

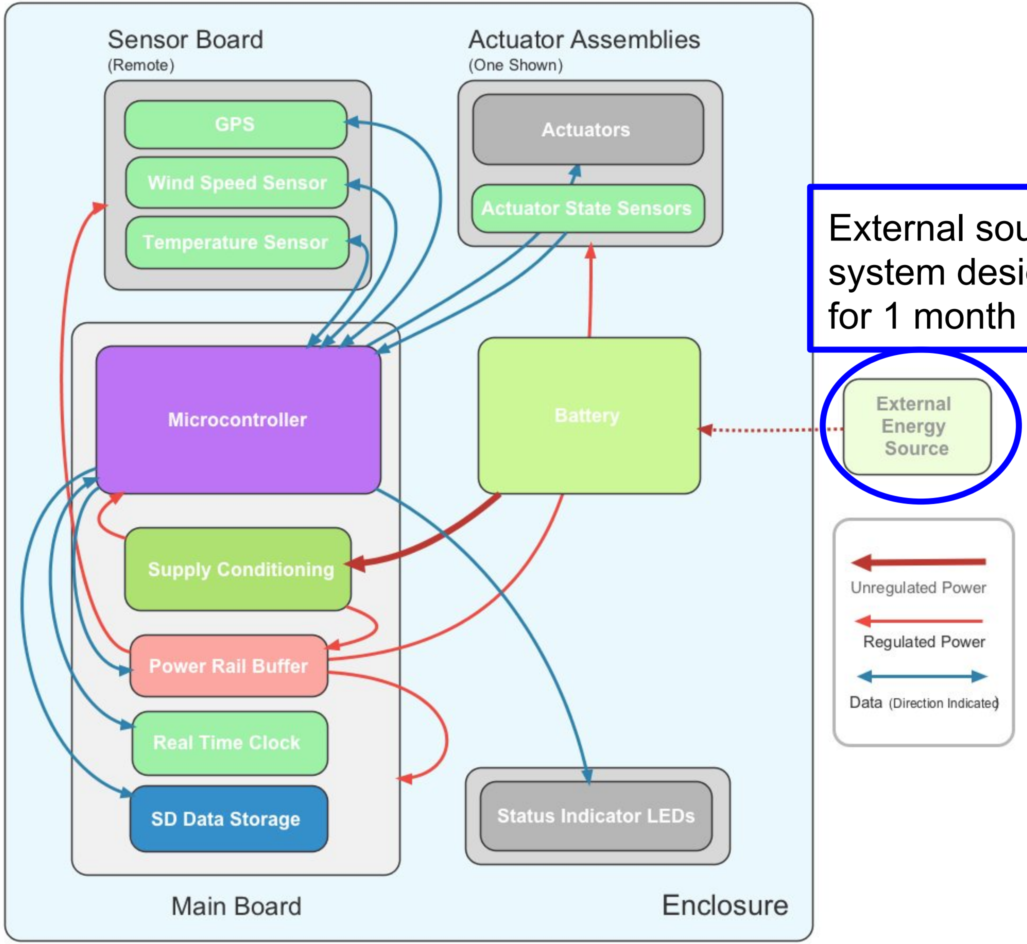
Electrical

Owen Lyke and Riley Hadjis

Requirements

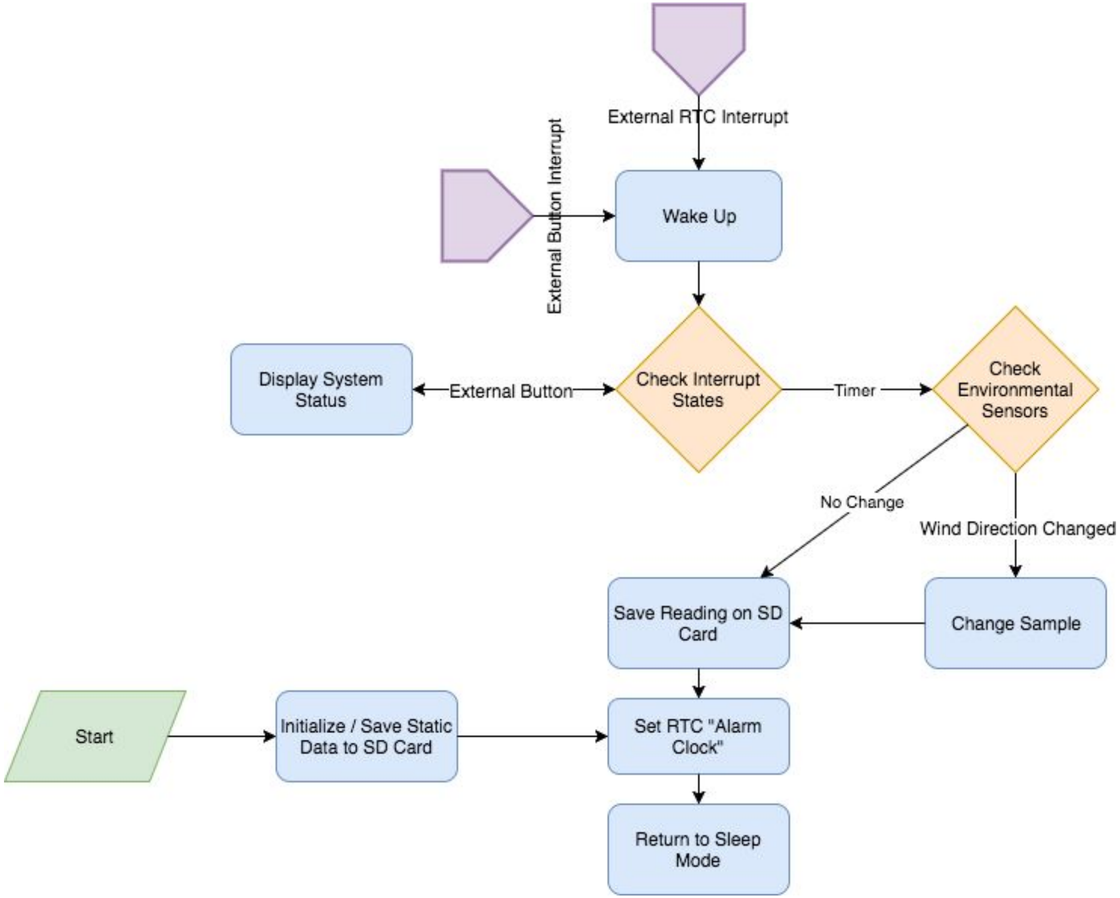
Category	Number	Description	Source
Level 0	0.2	The Cryo-Aerosol Dust Collector shall record data that will link dust deposition patterns to wind events and atmospheric patterns.	Mission Statement
Level 1	1.21	The Cryo-Aerosol Dust Collection Team shall record the time stamp, location, wind speed, wind direction, sample height from ground, temperature, and humidity.	0.2
Level 1	1.25	The Cryo-Aerosol Dust Collector shall have the ability to start and stop dust collection selectively.	0.2
Level 2	2.21.1	The Cryo-Aerosol Dust Collector shall record the sample interval for each of the environmental sensors.	1.21
Level 2	2.21.2	The Cryo-Aerosol Dust Collector team shall record wind speed as a function of height above the ground.	1.21
Level 2	2.22.1	The system shall have enough power to operate for a one month deployment period.	1.22

Functional Block Diagram



External source optional, system designed to operate for 1 month regardless

General Code Flow Chart

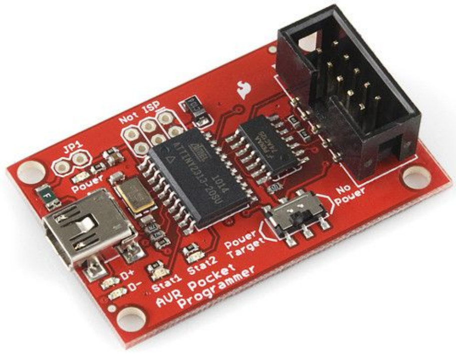


Microprocessor

The microprocessor chosen is the atmega 1284p.

The tool chain will include the following:

- Atmel studio IDE
- AVRDude for ISP programming
- Pocket AVR for the ISP interface
  https://learn.sparkfun.com/tutorials/pocket-avr-programmer-hookup-guide?_ga=2.54221032.1551731566.1508733595-1624392742.1506560341#device



Sensors

Measurement	Type	Name	Supply Voltage	Communication
Windspeed	Pitot tube	HSCMRRN060MDSA3	3-3.6 V	SPI
Wind Direction	Encoder	Custom built	3.3 V	Analog
Wind Direction	Magnetometer	TBD	3.3V	SPI
Humidity	IC	HDC1000YPAT	2.7-5.5 V	I2C
Time	RTC	AB0815-T3	1.5-3.6 V	SPI
Temperature	IC	G-NICO-018	2.2-3.6 V	SPI
Location and Sample Height	Static	This data will be stored at the time of deployment	N/A	N/A

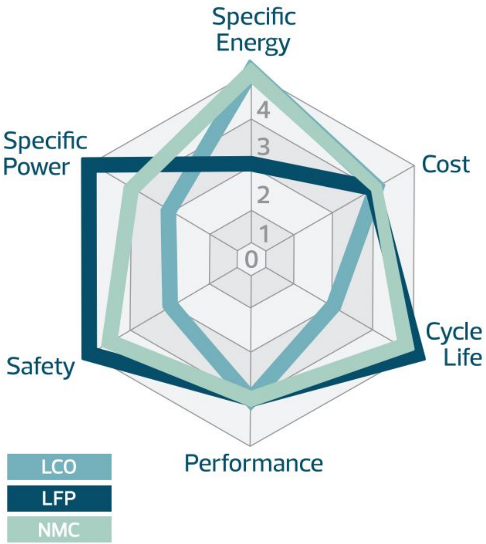
Power Budget

Results with 5 sec/15 minute sample period

	Results		
	Optimal Configuration	Optimal Configuration (No Fan)	Test Configuration (Sandbox)
Energy Used (J)	115024.4067	2630.10273	2772.468848
Required Capacity @ 3.3V (mAh)	9682.19	221.39	233.37

Results with half time spent sampling, uC always on

	Results		
	Optimal Configuration	Optimal Configuration (No Fan)	Test Configuration (Sandbox)
Energy Used (J)	129904.5873	17510.28327	154256.6865
Required Capacity @ 3.3V (mAh)	10934.73	1473.93	12984.57



Lithium Nickel Manganese Cobalt Oxide: $LiNiMnCoO_2$, Graphite anode, Since 2008 Short form: NMC (NCM, CMN, CNM, MNC, MCN are similar with different medal combination)	
Voltage, nominal	3.60V, 3.70V
Specific energy (capacity)	**150–220Wh/kg**
Charge (C-rate)	1C, 4.20V peak; 3h charge time
Discharge (C-rate)	2C continuous; 2.50V cut-off
Cycle life	**1000–2000** (related to depth of discharge, temperature)
Thermal runaway	**210°C** (410°F) typical. High charge promotes thermal runaway
Applications	E-bikes, medical devices, EVs, industrial
Comments	Provides high capacity and high power. Serves as Hybrid Cell. This chemistry is often used to enhance Li-manganese.

Lithium Iron Phosphate: $LiFePO_4$, Graphite anode, Since 1996 Short form: LFP or Li-phosphate	
Voltage, nominal	3.20V, 3.20V
Specific energy (capacity)	**90–120Wh/kg**
Charge (C-rate)	1C typical; 3.65V peak; 3h charge time
Discharge (C-rate)	**25–30C continuous**, 2V cut-off (lower that 2V causes damage)
Cycle life	**1000–2000 (related to depth of discharge, temperature)**
Thermal runaway	**270°C** (518°F) Very safe battery even if fully charged
Applications	Portable and stationary needing high load currents and endurance
Comments	Very flat voltage discharge curve but low capacity. One of safest Li-Ions. **Elevated self-discharge**

Your Price: $29.95

In Stock

Product ID # 8743
Part Number: LMN26650P2-8Ah

Lead Time: 5 Business Days!

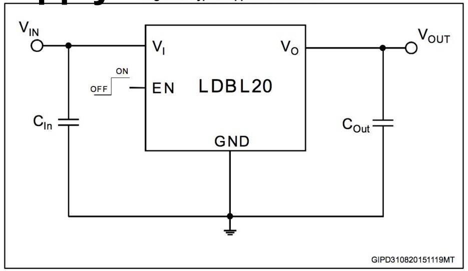
http://www.batteryspace.com/limnni-26650-battery-3-7v-8ah-29-6-wh-8a-rate-w-o-pcb.aspx

Dimensions(LxWxH)	58mm(2.3") x 30mm (1.2") x 85 mm (3.3") .

7400 mAh capacity leaves plenty of margin

Microcontroller, RTC, sensor, and SD supply:

Figure 3: Typical application circuits



https://www.digikey.com/product-detail/en/stmicroelectronics/ST1L08SPU33R/497-15508-1-ND/5244839

- Low dropout voltage
  - (100 mV @ 800 mA load)
- Low quiescent current (10 uA)
- 3.3V output suits sensors, SD, and uC
- Output voltage not suitable for motors

Motor supply

- Option 1: Higher voltage battery pack
  - Use simple “buck” regulator to reduce voltage (5-12V for stepper motor of choice)
  - Wastes more energy to get to 3.3V, but could potentially use a “center tap” for microcontroller
- Option 2: Use a “boost” converter
  - Only use when needed
  - Could reduce overhead of extra cells in battery
  - Options available for 12V or 5V

https://www.digikey.com/product-detail/en/texas-instruments/TPS63061DSCR/296-30205-1-ND/2834997

Data Format and Storage

Worst-case data budget:

- 5 sensors (assuming height and location are static)
- 12 standard ascii characters per sensor per sample
- 5*12 = 60 ascii characters per sample = 60 bytes per sample
- 16,000 samples per GB.
- Using a standard 8 GB SD card gives over 130,000 samples from each sensor with room to spare
    - Could sustain a 1 Hz sample frequency for 1 month

System Reliability

- There will be an external switch on the sensor as well as one RGB LED. When activated the LED will flash different colors to indicate different states as listed below
- Will coat the device in a polyurethane to repel moisture

System State	Color
On, batteries greater that 50%	Green
On, batteries below 50%	Yellow
On, batteries below 10%	Red
System Failure	Blue

Schematic

- Eagle will be used for PCB design
- A library of the components used in the project is being compiled
    - *Currently includes*
        - Microcontroller
        - SD card holder
        - Real Time Clock
        - Temperature Sensor
        - Pressure Sensor
        - Humidity Sensor

    - *To be added*
        - Magnetometer
        - Regulator
        - Button
        - Standardized passive components

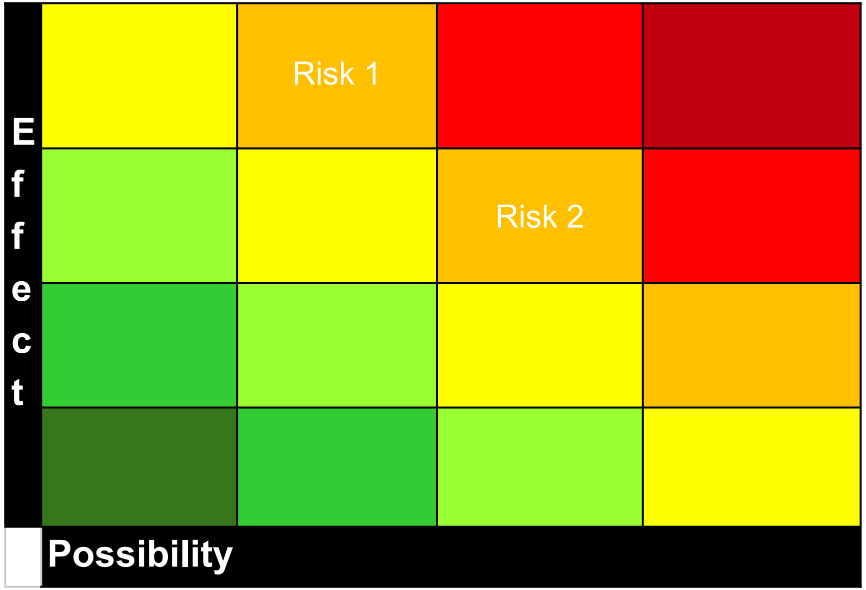
- Will specify design rules to follow before board design begins

Bill of Materials

CryoDust Electrical System BOM										
Purpose	Name	Manufacturer	Manufacturer ID	Source	Source ID	Lead Time	Price	Quantity	Total Cost	Link
Onboard Components										
Microcontroller	ATMEGA1284-PU	Microchip Technology	ATMEGA1284-PU	Digikey	ATMEGA1284-PU-	Immediate	5.25	1	5.25	https://www.digik
Temp Sensor	G-NICO-018	TE Connectivity Measurement Specialties	G-NICO-018	Digikey	223-1134-ND	Immediate	6.8	1	6.8	https://www.digik
Real Time Clock	AB0815-T3	Abracon LLC	AB0815-T3	Digikey	535-11930-1-ND	Immediate	1.81	1	1.81	https://www.digik
Pressure sensor (wind speec	HSCMRRN060MDSA	Honeywell Sensing and Productivity Solutior	HSCMRRN060MDSA3	Digikey	480-5429-ND	Immediate	35.58	1	35.58	https://www.digik
Humidity sensor	HDC1000YPAT	Texas Instruments	HDC1000YPAT	Digikey	296-38027-1-ND	Immediate	10.65	1	10.65	https://www.digik
Micro SD card holder	1051620001	Molex LLC	1051620001	Digikey	WM14405CT-ND	Immediate	0.88	1	0.88	https://www.digik
3.3V Regulator	ST1L08SPU33R	STM Microelectronics	ST1L08SPU33R	Digikey	497-15508-1-ND	Immediate	1.62	1	1.62	https://www.digik
									0	
									0	
									0	
									0	
									0	
									0	
									0	
LiNiMnCo Battery Cell	8743	AA Portable Power Corp.	8743	AA Portable Power Corp.	8743	5 Days	29.95	0.5	14.975	http://www.batter
Peripherals										
AVR Programmer	Pocket AVR	Sparkfun	PGM-09825	Sparkfun	PGM-09825		14.95	1	14.95	https://www.sparl
Micro SD Card									0	
									0	

- Current cost is $78
- Additional items needed
  - Magnetometer
  - Rotary resolver components
  - Servo
  - Battery
  - PCB fabrication

Electrical Risk Matrix



Note: Sensors stop operating at extremely low temperatures (pressure in particular)

- Pressure sensor operates to ~ -20C
- All other sensors operate to ~ -40C
- Alia expects down to -40C in winter in Svalbard

RISK 1: Electronic failure by low temperature

RISK 2: Rough estimate of mechanisms power usage

Electrical Next Steps

- Create detailed BOM
- Order prototyping parts
- Begin prototyping the microcontroller
- Start programming and laying out the first revision board

Management

Schedule

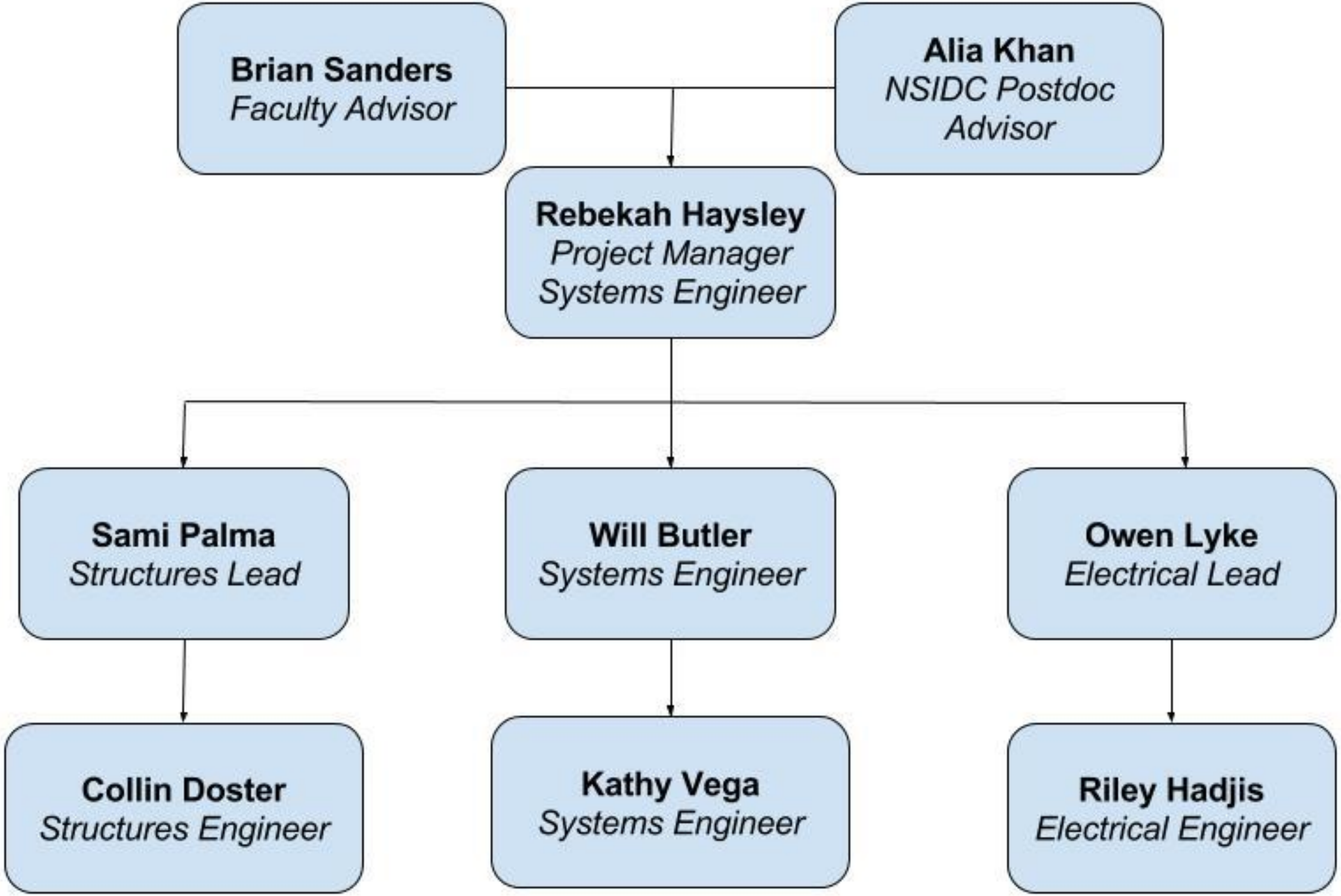
DATE	GOAL
8/29	Team Organization
9/12	Team forming and literature study
10/13	Conceptual Design Review
10/27	**Preliminary Design Review**
11/17	Critical Design Review
12/19	Prototype1
1/16	Winter Break
2/13	Prototype2
2/27	Final Build
3/27	End of Semester Report
4/10	Field Deployment

Budget Overview

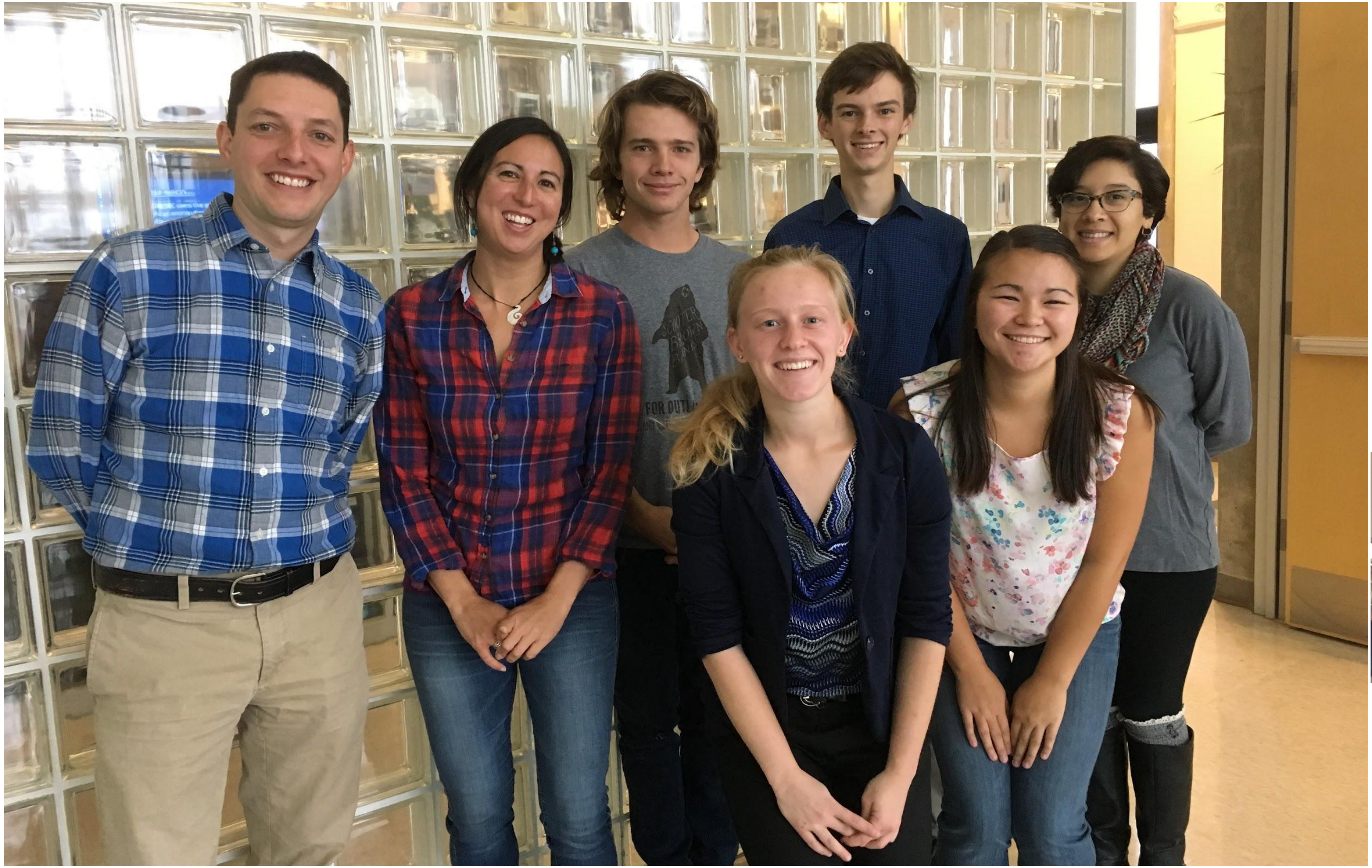
Component	Cost ($)
Structural Metal	600
Motors	200
Sensors & Microprocessor	300
Power (Battery)	200
Wiring and Hermetic Seals	200
Glass Fiber Filters	300
Pump	200
Margin	1000
Prototyping	1400
Total (w/o margin/proto)	2000
Total	4400

- Total Prototyping: $1400
- Total Margin: $1000
- Total Final Part: $2000
- Overall Total: $4400

Team Structure



Team Picture!



Thank you!

Questions?

Sources

Cryo Dust Collection and NSIDC

Khan, A. L., S. Wagner, R. Jaffe, P. Xian, M. Williams, R. Armstrong, and D. McKnight (2017), Dissolved black carbon in the global cryosphere: Concentrations and chemical signatures, Geophys. Res. Lett., 44, doi:10.1002/2017GL073485.

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Battery Chemistry Data
http://incellint.com/wp-content/uploads/2016/06/Comparison_Common-Lithium-Technologies_.pdf

SD Card Specifications
https://cdn-shop.adafruit.com/datasheets/TS16GUSDHC6.pdf