Cryo-Aerosol Dust Collector

Conceptual Design Review
October 13th, 2017

Cryo Dust Collection and NSIDC

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

- It reduces snow albedo (amount of reflected light), contributing to worldwide melting of ice

- Current dust collector design passively collects samples without recording useful environmental data to track dust transport

- 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

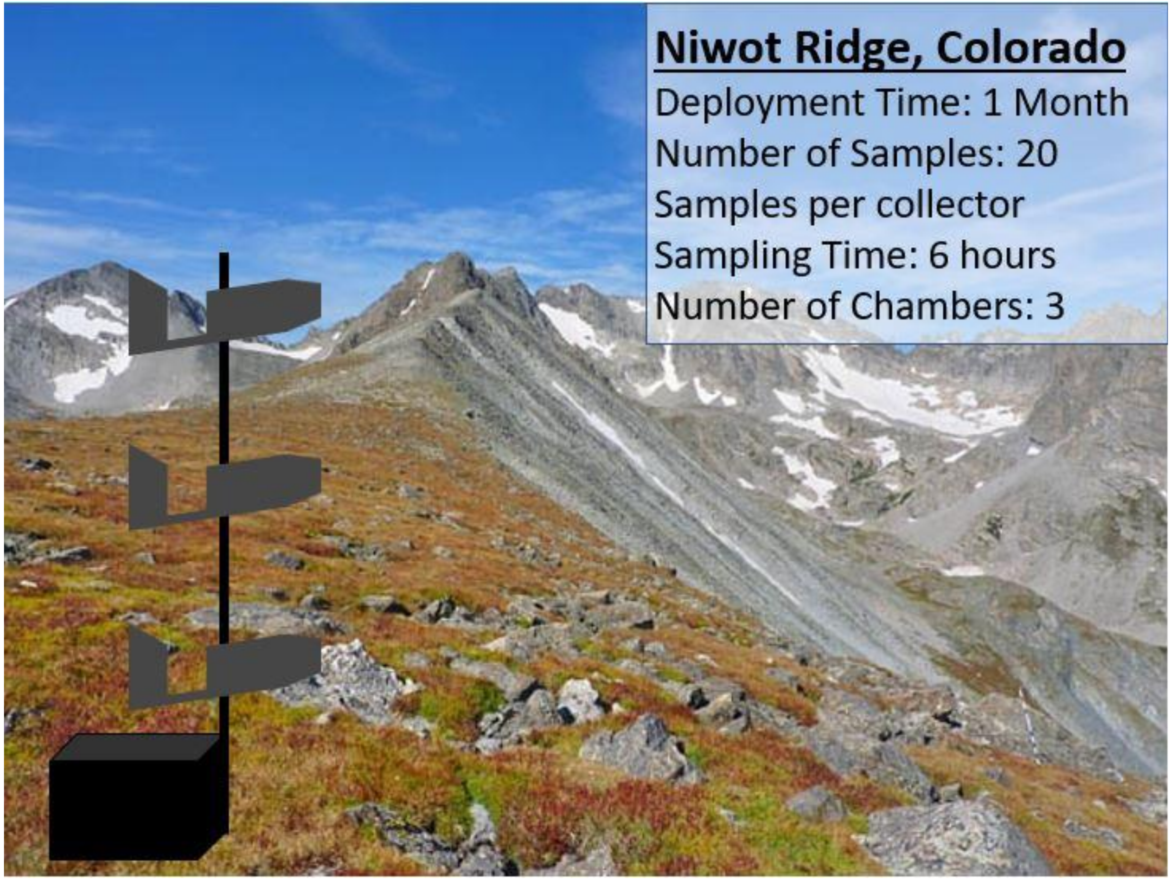
Mission Overview

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:

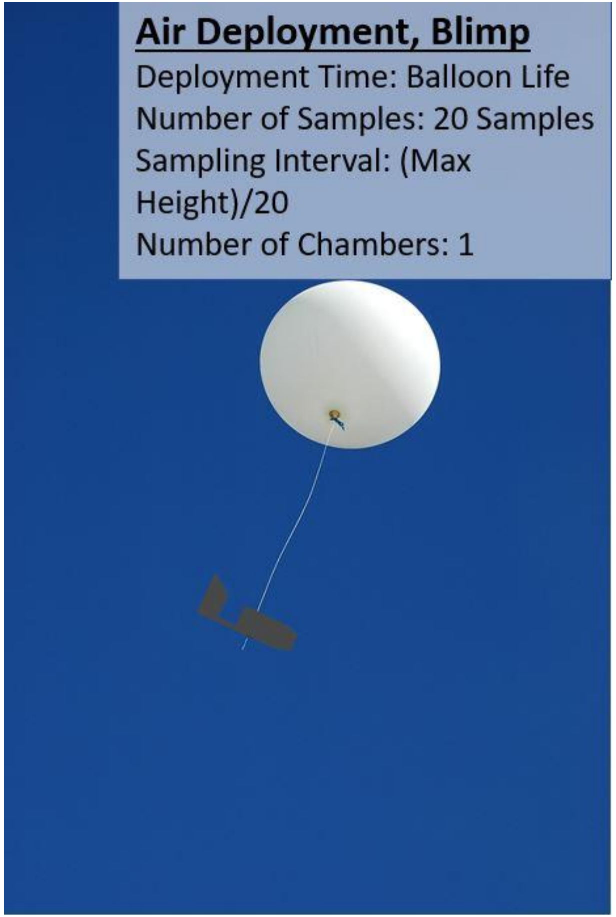
- Deploy on the surface of icy and mountainous regions for extended amounts of time with minimal human interactions
- Provide environmental data linking dust deposition patterns to wind events and atmospheric patterns
- Collect dust samples that will be turned over to NSIDC for further analysis

Scope of Mission - Niwot Ridge, Colorado



Scope of Mission - Svalbard, Norway

Scope of Mission - Blimp



- Blimp would help us investigate dust composition at different altitudes within the boundary layer
  - Local dust effects
- HOWEVER, blimp introduces design challenges of stability and weight
  - Would need complete redesign of chamber
- We are not designing for the blimp
  - Hope to pass on chamber design to a freshman projects group

Minimum Criteria For Success

- Design a Dust Collector that will be deployed on Niwot Ridge for a month
  - Design can be extended to Svalbard, Norway
- Ability to collect black carbon and bioaerosols within the dust sample
- Provide environmental data that corresponds with a particular dust sample
- Dust collector is highly reliable in extreme environments, inexpensive, and portable

Systems

Will Butler, Bekah Haysley, Kathy Vega

Requirements

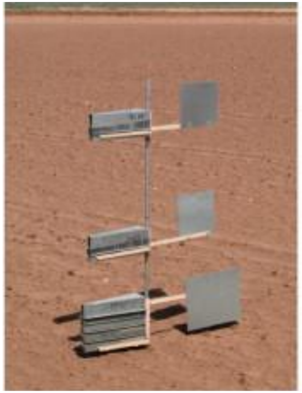
Category	Number	Description	Source
Level 0	0.1	The Cryo-Aerosol Dust Collector shall be capable of deploying on the surface of snow and ice across polar and mountainous regions (specifically, Niwot Ridge) for a month with minimal human interactions.	Mission Statement
Level 0	0.2	**The Cryo-Aerosol Dust Collector shall record data that will link dust deposition patterns to wind events and atmospheric patterns.**	Mission Statement
Level 0	0.3	The Cryo-Aerosol Dust Collector shall gather dust that will be turned over to NSIDC for analysis.	Mission Statement
Level 1	1.11	The Cryo-Aerosol Dust Collector shall be inexpensive, lightweight, portable, and robust.	0.1
Level 1	1.12	**The Cryo-Aerosol Dust Collector shall maintain high reliability in high winds and in low temperature environments.**	0.1
Level 1	1.14	The Cryo-Aerosol Dust Collector shall prove the capability of extending deployment time to a period of one year at Svalbard, Norway.	0.1

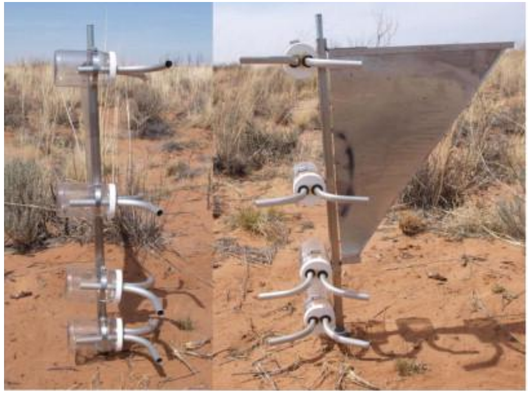
Requirements Cont.

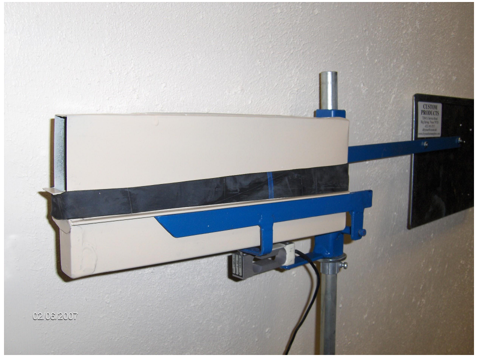
Category	Number	Description	Source
Level 1	1.13	The Cryo-Aerosol Dust Collector shall protect its electronics from damage due to the extreme environment.	0.1
Level 1	1.22	**The Cryo-Aerosol Dust Collection Team shall collect 20 dust samples over the period of a month.**	0.2
Level 1	1.33	The dust shall be collected in such a way that it is easy to hand over to NSIDC for analyzation.	0.3
Level 1	1.34	The Cryo-Aerosol Dust Collector shall have the ability to collect black carbon and bioaerosols.	0.3
Level 2	2.21.2	The Cryo-Aerosol Dust Collector team shall calculate the average volumetric flow rate of wind entering the collector over a sample period*	1.21
Level 2	2.22.1	**Each sample shall be collected over roughly the period of one day, with a minimum sampling time of 6 hours.**	1.22

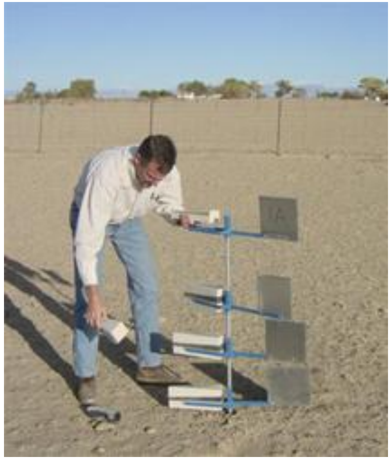
Current Designs

- BSNE - Big Spring Number Eight
- Passive
  - The system is left for months at a time to collect
- No filters - just collection reservoirs
- Tend to break or wear
- Strength - they are simple and reliable in their use









Proposed Improvements

- Link environmental data to the collected dust sample
  - Wind speed, wind direction, duration of collection, temperature, humidity, location, height from ground, etc.
- Collect on loaded filters
  - Glass Fiber Filter
  - Aerosols (*future* possibility)
- Design is robust and reliable in its build
  - Can be successfully transferred between varying environments and continue operation
    - Niwot Ridge, Rocky Mountains
    - Svalbard, Norway
    - Chamber design could be downscaled for *future* blimp deployment

Environmental Considerations

Niwot Ridge	
Mean Temperature	Annual: -2.2 ℃ (28 ℉), Jan: -13.2 ℃ (8 ℉), Jul: 8.2 ℃ (47 ℉)
Climate	Mean annual precipitation: 980 mm (36 in)
Duration of Collection	30 days
Power Needs	Pump/fan(1.2-3.6 kW), sensors(100 µA), SD card (100 mA), motors (12V), servos (5V)

Svalbard	
Mean Temperature	Annual: -4.6 ℃ (32 ℉), Winter: -11.7 ℃ (11 ℉), Summer: 5.2 ℃ (41 ℉)
Climate	Mean annual precipitation: 400 mm (15.7 in) in Western Spitsbergen
Duration of Collection	365 days
Power Needs	Sensors(100 µA), SD card (100 mA), motors (12V), servos (5V)

Designing for Different Environments

Niwot

- Abundant snowfall → sacrifice lower chambers/solar panels
    - Concern: parts icing over
- Short sampling time → pump or fan to ensure sufficient samples
    - Concern: benefits vs. risk of failure, extra weight, and additional power costs

Svalbard

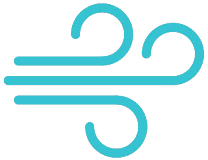
- Little snowfall → solar panels are more useful & unnecessary to sacrifice chambers
- Long sampling time → pump unnecessary
    - Concern: More difficult to distinguish wind events within the 8 day collection time frame

Dust Considerations

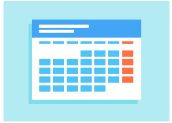
- Collection sample types expected in each filter
  - **Black carbon**
  - Bioaerosols
  - Microbes
- Collection size
  - Anywhere from 2 nm - 2 microns sized dust particles
- Material for dust collection
  - Glass fiber (current for all dust)
  - Aerogel (future consideration for bioaerosols)
- Need a long enough sampling time to make sure we get a good sample for NSIDC

Current Uncertanties

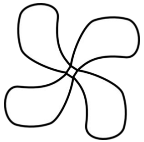
- Necessary air flux to collect samples and support each design

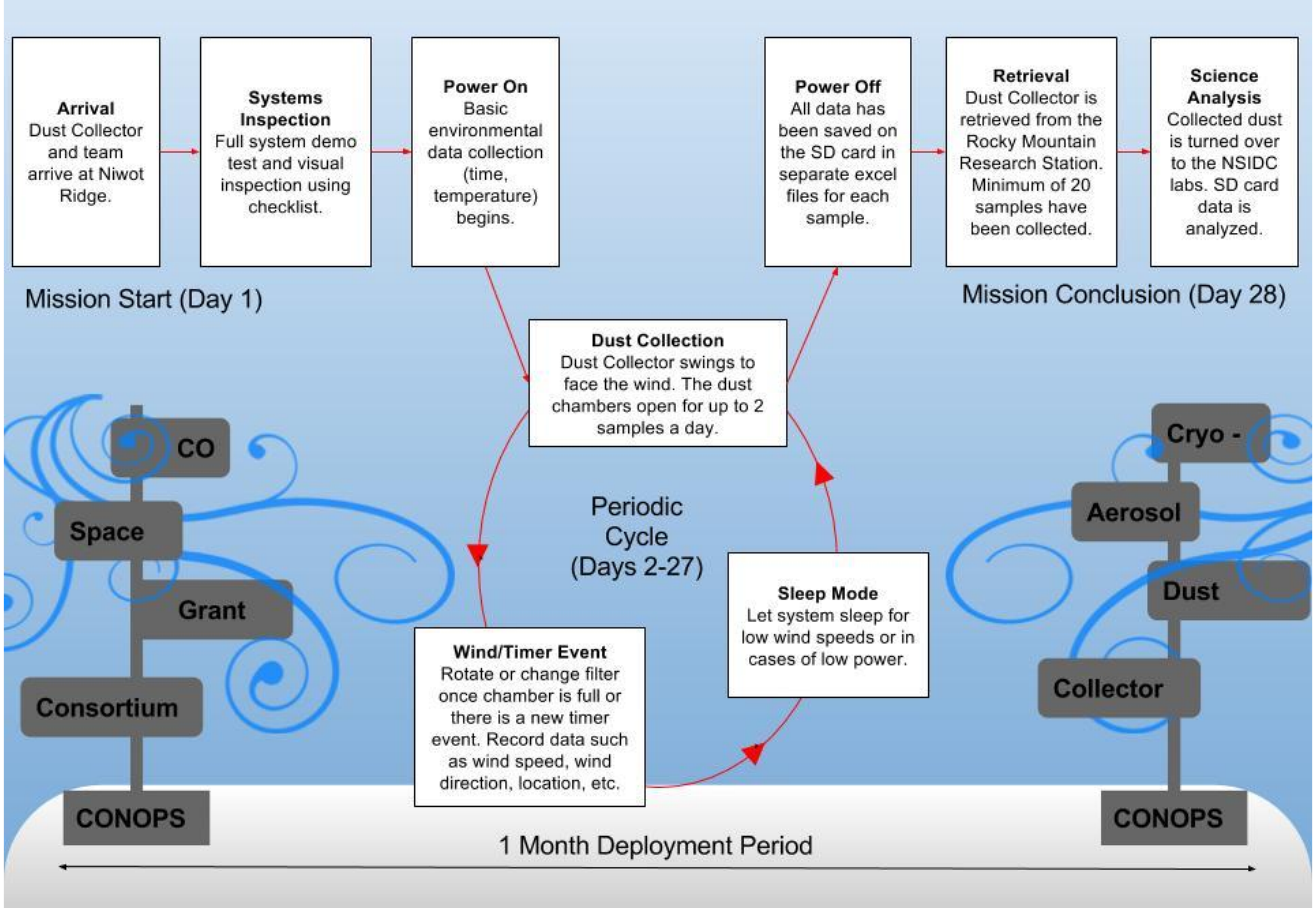


- Sampling periods
    - We are currently using our best approximation for the sampling time (6 hours on Niwot Ridge) to generate enough dust sample on filter



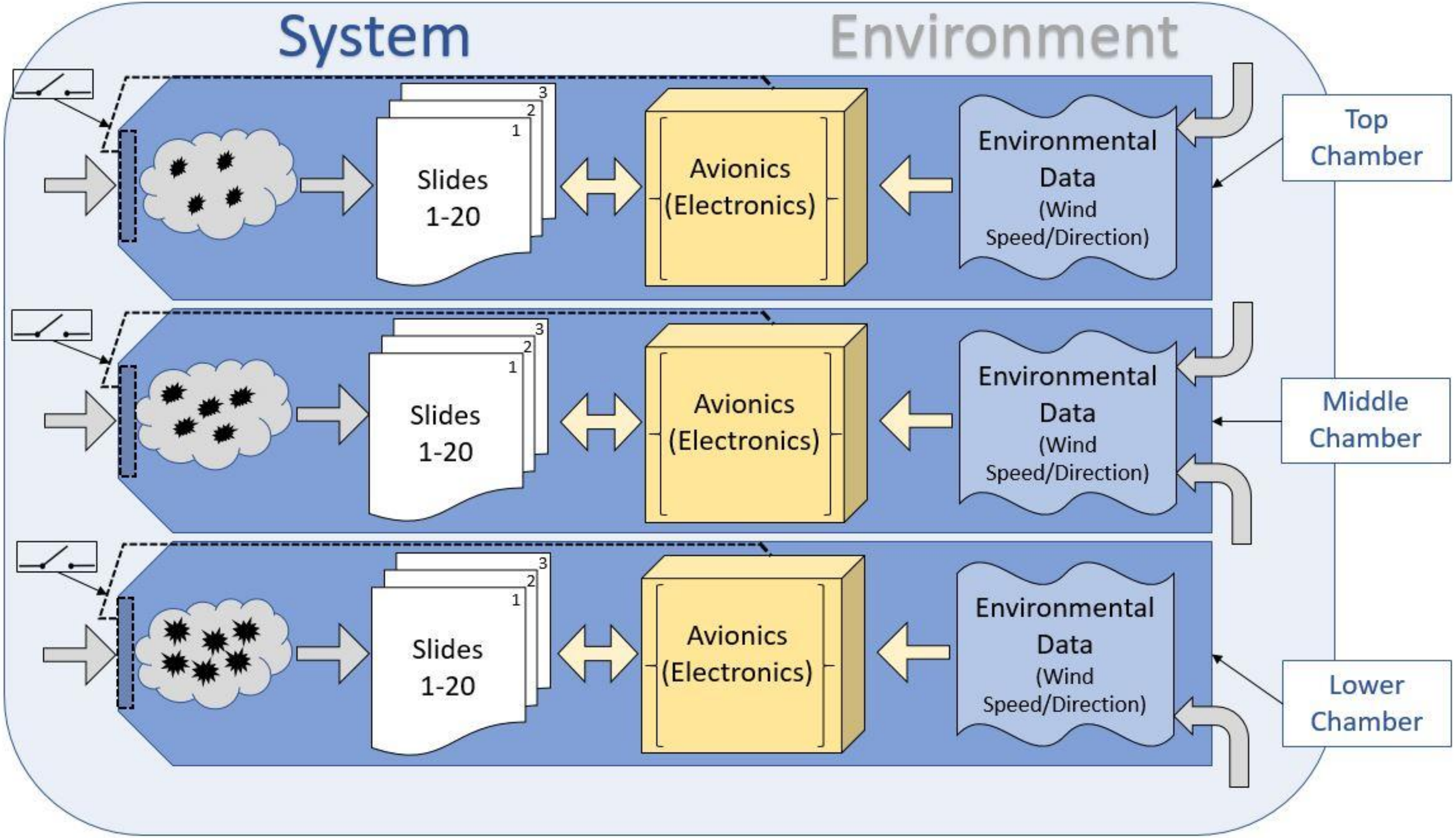
- Need/benefits of using a pump or fan for moments of low/no wind
    - Greater complexity → greater risk of design malfunction and/or instability
    - Subteams will present trade studies in upcoming slides



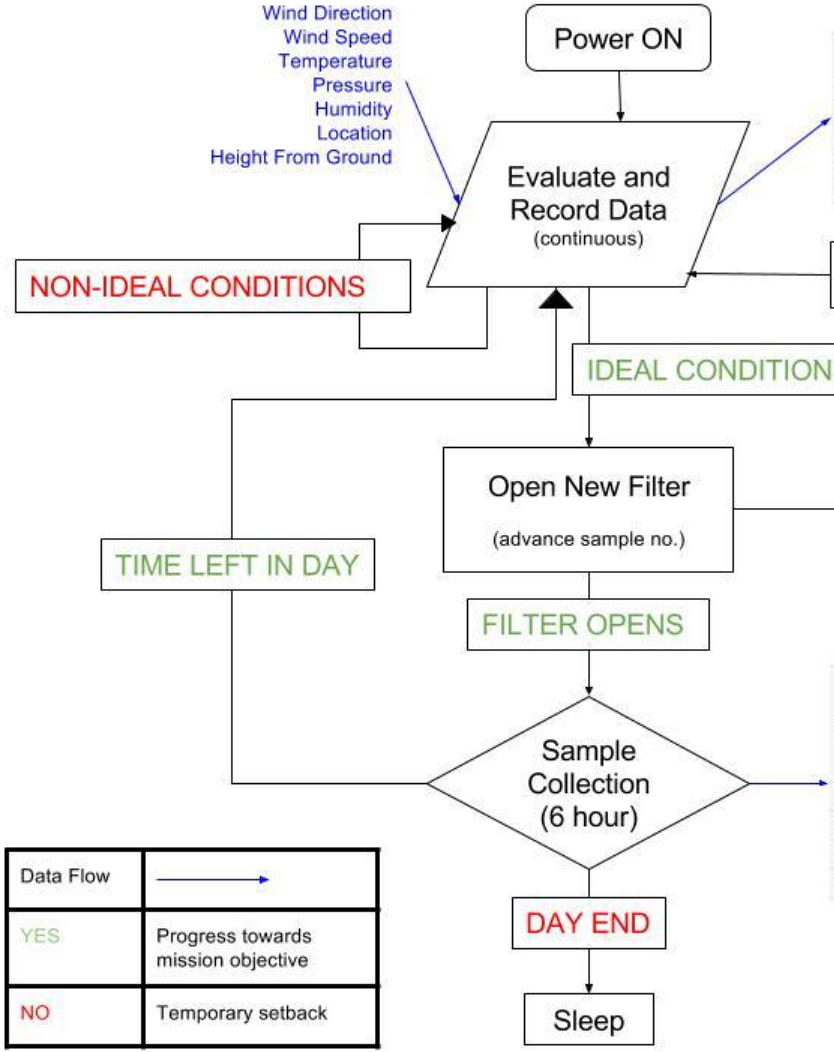


Niwot Ridge CONOPS

FBD


System
Environment
3
2
1
Slides 1-20
Avionics (Electronics)
Environmental Data (Wind Speed/Direction)
Top Chamber
Middle Chamber
Lower Chamber

Periodic Cycle / State Diagram



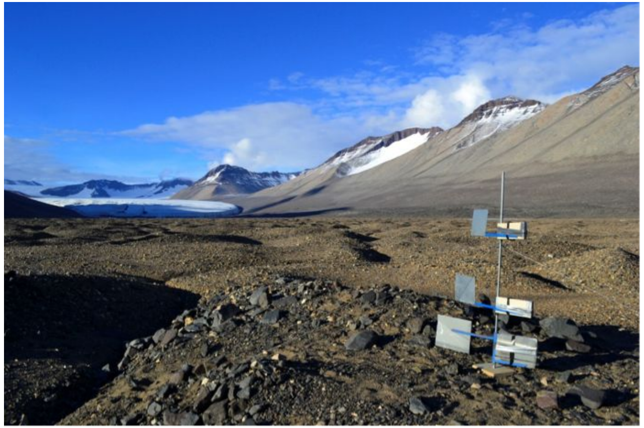
time (day.hour.min)	sample no.	data e.g. (location.height.direction.speed.temperature.pressure.humidity)
00.00.01	null	niwot.5.180.5.81.664.62
00.00.02	null	niwot.7.15.5.53.665.62

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

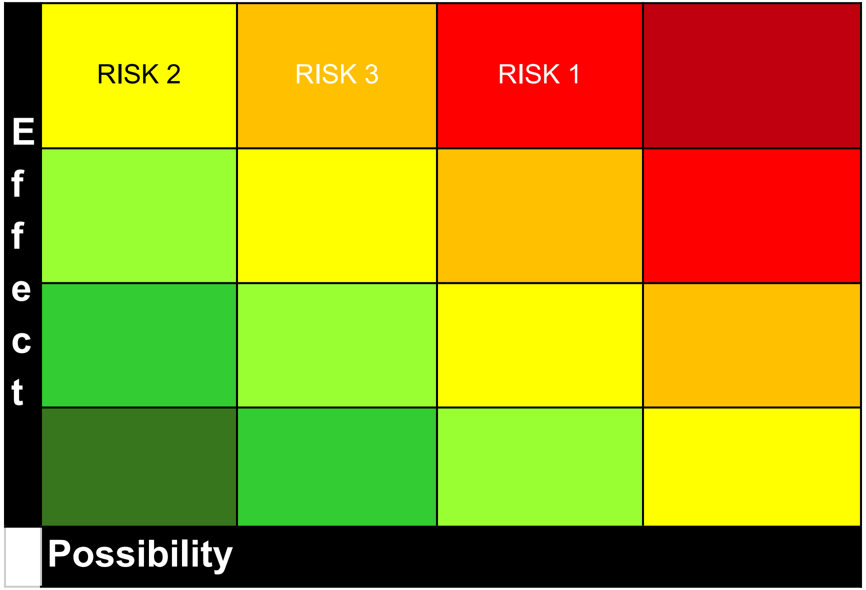
*Excel files are for example purposes only

Systems Risks/Worries

- Verifying our requirements through testing
  - We can calculate the effect of high wind, but where can we test it?
  - We can simulate snow coverage of equipment, but how can test Colorado snow pack?
- Structural Failures
  - Ice covers ports for dust collection or sensor data
    - Heaters?
    - Suggestions?
  - Dust Collector is unable to face wind direction due to environmental effects (ice, snow, water)
    - Design a mount to protect the swinging motion
- Electrical Failures
  - Cold weather drains battery
    - Insulation, material testing, structural design to protect electrical systems
  - Climate/Environmental conditions threaten sensors



Systems Risk Matrix



RISK 1: Dust collection and data recording will stop IF pump/fan fails.

RISK 2: Data recording will stop IF electronics become too cold.

RISK 3: Dust collection will stop IF chambers become frozen shut or covered with snow.

Systems Next Steps

- Confirm that the Dust Collector will be inexpensive, lightweight, and robust in design
- Write test procedure for design and sensor testing
- Gain an understanding of usable materials versus cost
- Clearly map out a detailed plan for the collection process and method
- Gain an understanding of sampling interval versus allotted memory
    - Sampling interval versus power draw
- Working towards the PDR!

Structures

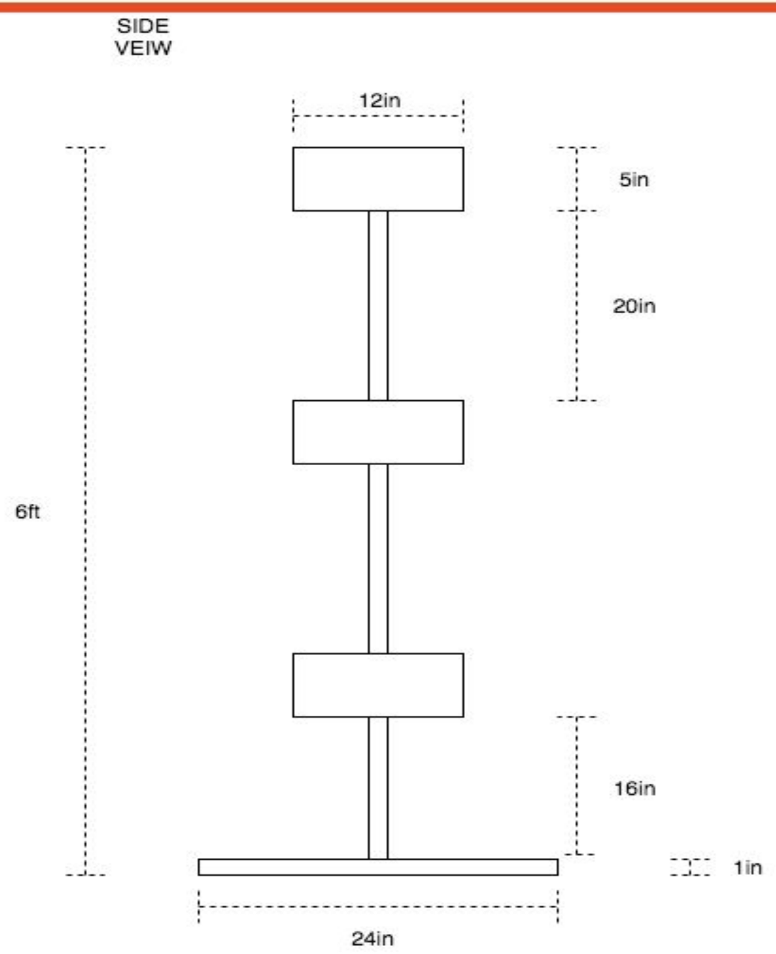
Sami Palma and Collin Doster

Requirements

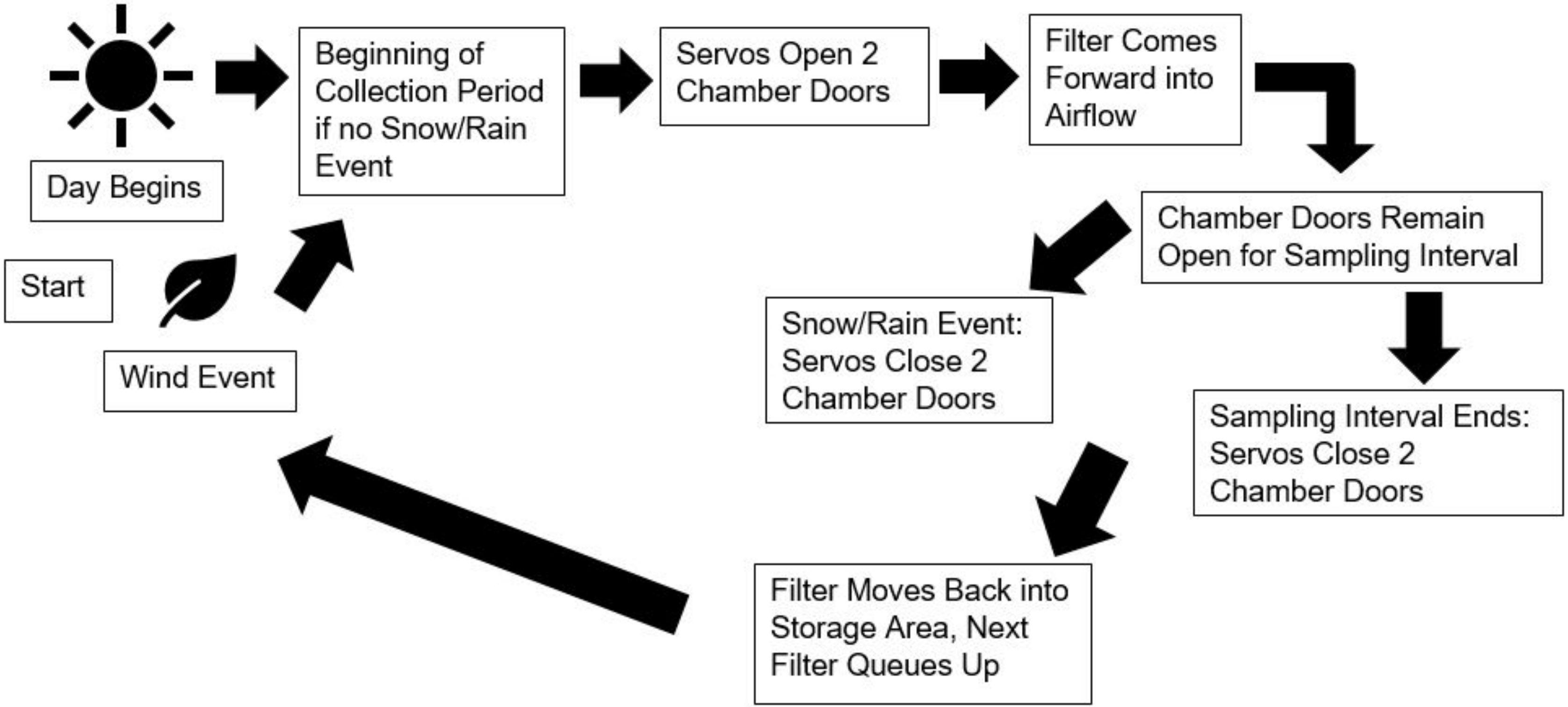
Category	Number	Description	Source
Level 0	0.1	The Cryo-Aerosol Dust Collector shall be capable of deploying on the surface of snow and ice across polar and mountainous regions (specifically, Niwot Ridge) for a month with minimal human interactions.	Mission Statement
Level 0	0.3	The Cryo-Aerosol Dust Collector shall gather dust that will be turned over to NSIDC for analysis.	Mission Statement
Level 1	**1.31**	**The Cryo-Aerosol Dust Collection Team shall collect each dust sample on a glass fiber filter and the area of the collections needs to be roughly quarter sized.**	**0.3**
Level 1	**1.23**	**The Cryo-Aerosol Dust Collector shall collect samples from different heights from the ground, up to 6 feet.**	**0.2**
Level 1	**1.24**	**The Cryo-Aerosol Dust Collector shall have an opening facing directly into the wind for dust collection.**	**0.2**
Level 1	**1.32**	**The Cryo-Aerosol Dust Collector shall maintain a sterile collection environment.**	**0.3**
Level 2	2.31.1	The Cryo-Aerosol Dust Collector shall be able to collect micrograms of aerosols to milligrams of dust.	1.31

Proposed Design: Overview

- Chambers:
  - 3 chambers stacked to a total height range of 6 feet
  - Two circular openings in each chamber to allow airflow and dust collection
  - Filter rotation and collection area
- Weight:
  - On ground: 15 kg = 33 lbs
    - No limit, but needs to be able to carried/skied to collection area
  - On blimp (*future*): 2 kg = 4.4 lbs



Structures FBD



Changes from BSNE Model

Current Design	Proposed Design Change	Reason
Metal Sails	1. Change of material - carbon fiber, or a similar one of increased flexibility & change of securement of sails 2. Lengthen sails	1. Sails have been seen to break off when left unattended for long periods of time due to faulty screws 2. Lengthening them to get more accurate wind direction
Open collection bin	Closed & sealed bin	Keep samples sterile, have filter in collection chamber, air flow through chamber (two openings)
No pitot tube	Pitot tube	Measure wind speed.
No filters	Adding glass fiber filters and/or rotating filter	To collect dust samples with multiple samples being collected a day for further analysis

Design Option 1 (Recommended Design)

Magazine design:

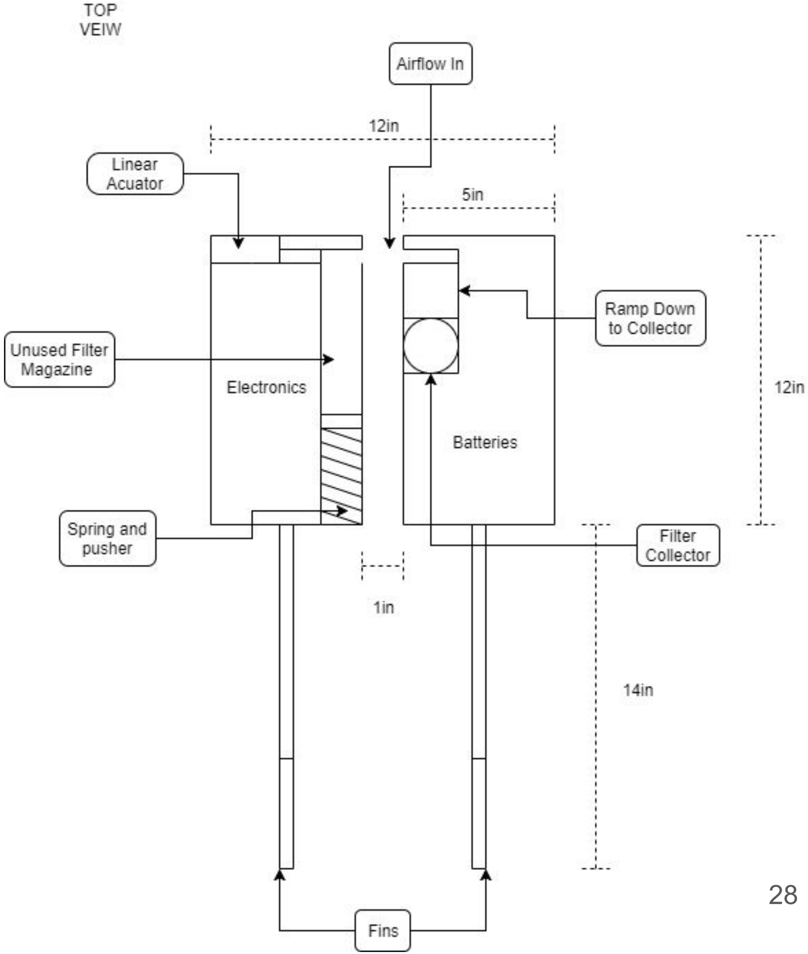
- Uses individually stacked fiber filters fit inside small 3D printed covers
- Up to 50 filters are fit into a “magazine” and pushed forward with a spring
- Solenoid pushes a filter into the airflow.
- Once a new filter is pushed into the airflow the used one falls away into a collection cylinder

Pros:

- Small
- Light
- Simple

Cons:

- Potential problems with the spring



Design Option 2

Spool Design:

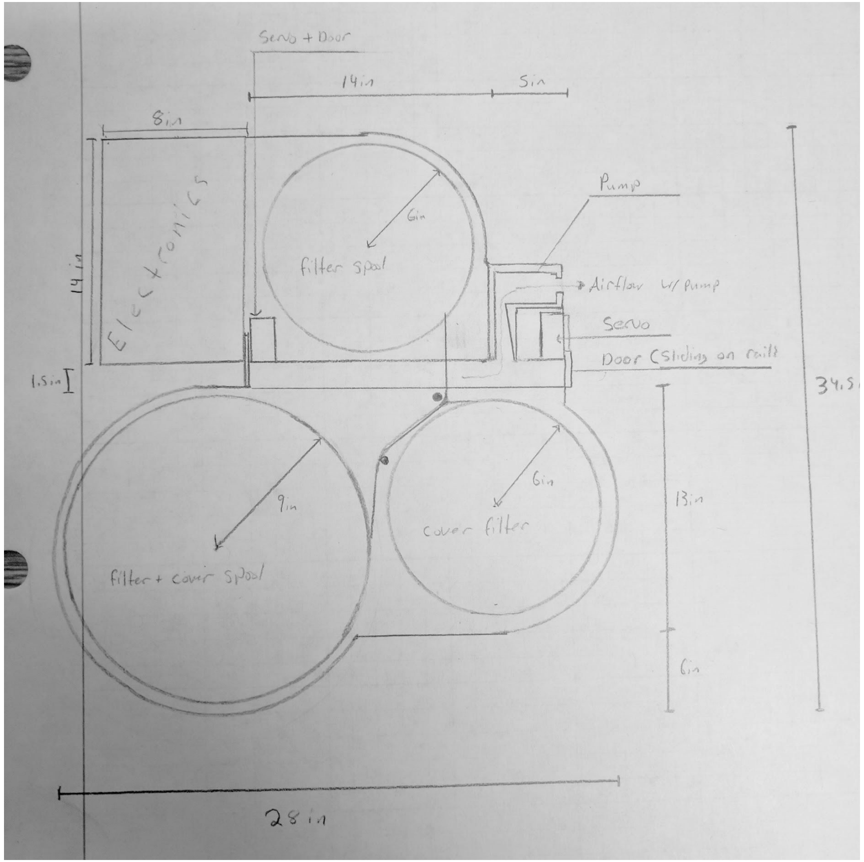
- Use three separate spools to collect, wrap, and then store filters

Pros:

- Very high filter capacity

Cons:

- Mechanically complex
- Large
- Heavy
- High power draw (2 motors, 2 servos)



Controlling Dust Collection

- Two openings in each chamber allowing for airflow in and airflow out
- Use of 2 Servos to open and close the openings
- Open at the point where collection is set to begin or when a wind event happens
- Keep open for collection period time: 6 hours, or duration of wind event
- Close at the point where collection ends in each scenario
- Use of pump to increase airflow (Case Study)

Inclusion of a Pump System

<table>
<tr><th>Pros</th><th>Cons</th></tr>
<tr><td>

Steady airflow throughout chamber during all collection periods
Would allow for dust collection when there is no wind present
Increases dust collection
Increases amount of samples
Increases viability of science mission

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Adds weight to the structure
Adds complexity and expense to existing design and structure

Depending on final design, could block airflow
Need to design around the pump

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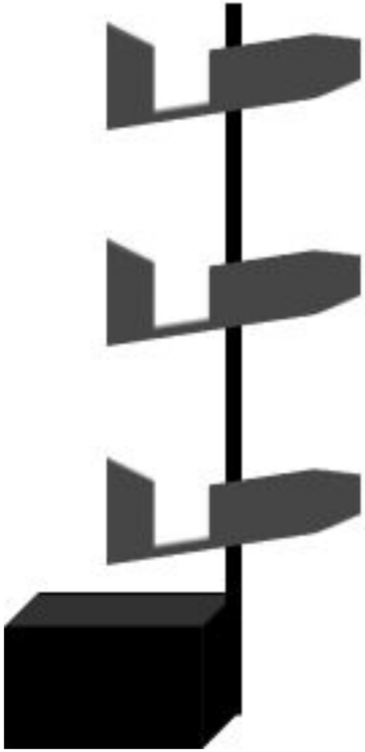
Electronics Placement and Management

- Each chamber will have its own complete electronics set mounted with standoffs
  - Depending on the design, the electronics chamber will be about 14 in x 8 in x 4 in
- Batteries may be in separate chamber, dependent on which design we decide
  - Batteries generating the most heat - placed near the structural components which are most at risk of freezing
- Insulation around electronics set - arrangement dependent on which filter rotation we decide on
  - MLI, Foam Core
  - Able to keep the electronics above critical temperature so they do not lose function

Replication of Chambers

- 3 Chambers will be exact replicates of each other
- Chambers will have the ability to be extracted from each other, or stacked on one another
  - Stackability feature
  - Provides benefits when transferring a system from Niwot to Svalbard to a blimp
  - Meets the requirement of being portable
- Niwot and Svalbard will require some assembly, “stacking”
- Each chamber able to rotate independently
  - Provides benefits in case of a major snow event



Structures Risks/Worries

- Filter Rotation
  - Sealing the samples to keep sterile
  - Need to define our definition of sterile
  - Steps for troubleshooting when something goes wrong
- Thermal Aspect
  - Chambers open for collecting dust, electronics need to be insulated
  - If something freezes, how do we fix it?
- Weight
  - Being able to carry dust collector out to deployment site
  - Hanging from a blimp - limit of 2 kilograms
- Blimp System
  - Weight issue, stability issue

Structures Next Steps

- Begin Solidworks of design
- Start making a more thorough parts list
- Start researching different materials
  - Finalize what each component is going to be made of
- Finalize filter rotation method
  - Speak with advisers/professors for general advice
- Finalize chamber opening method
- Finalize pump decision

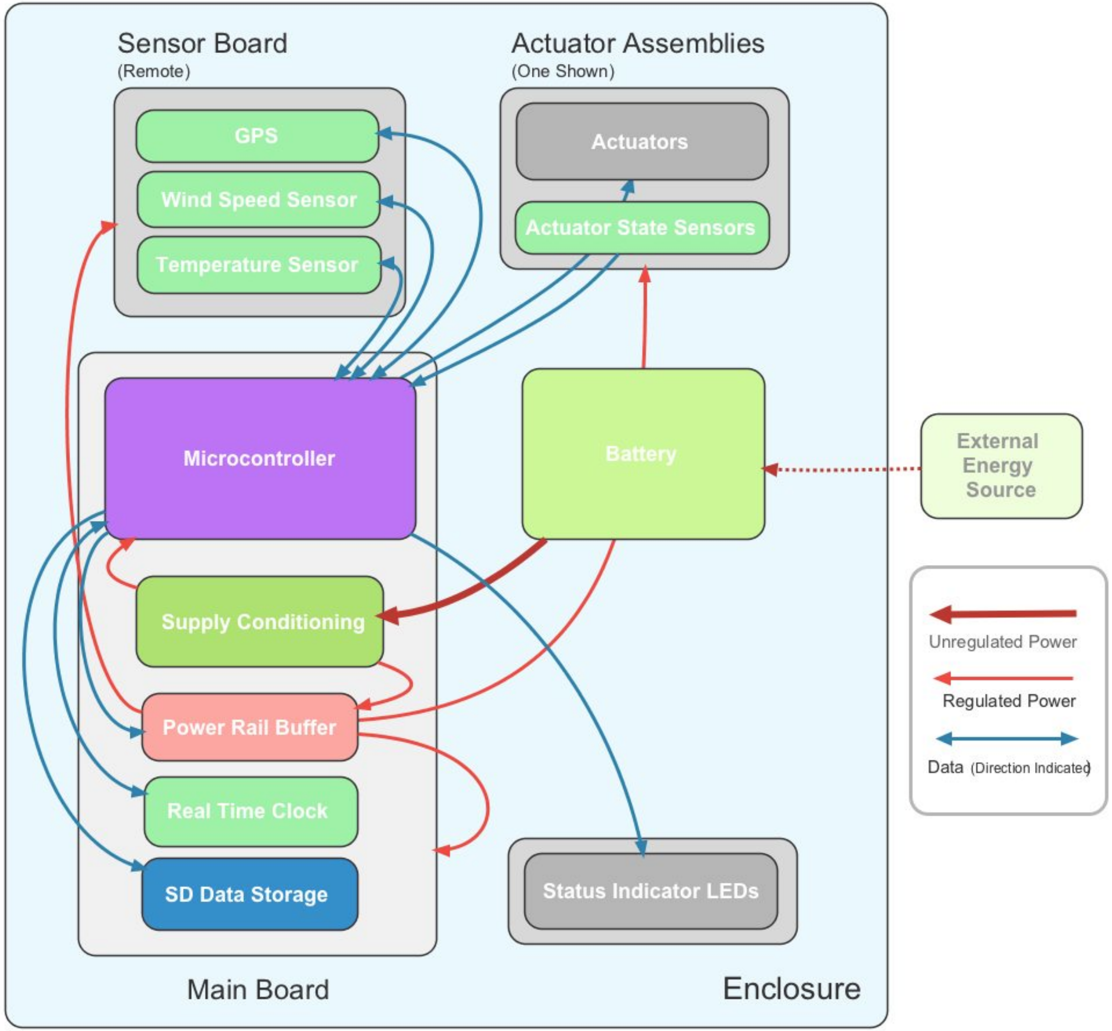
Electrical

Owen Lyke and Riley Hadjis

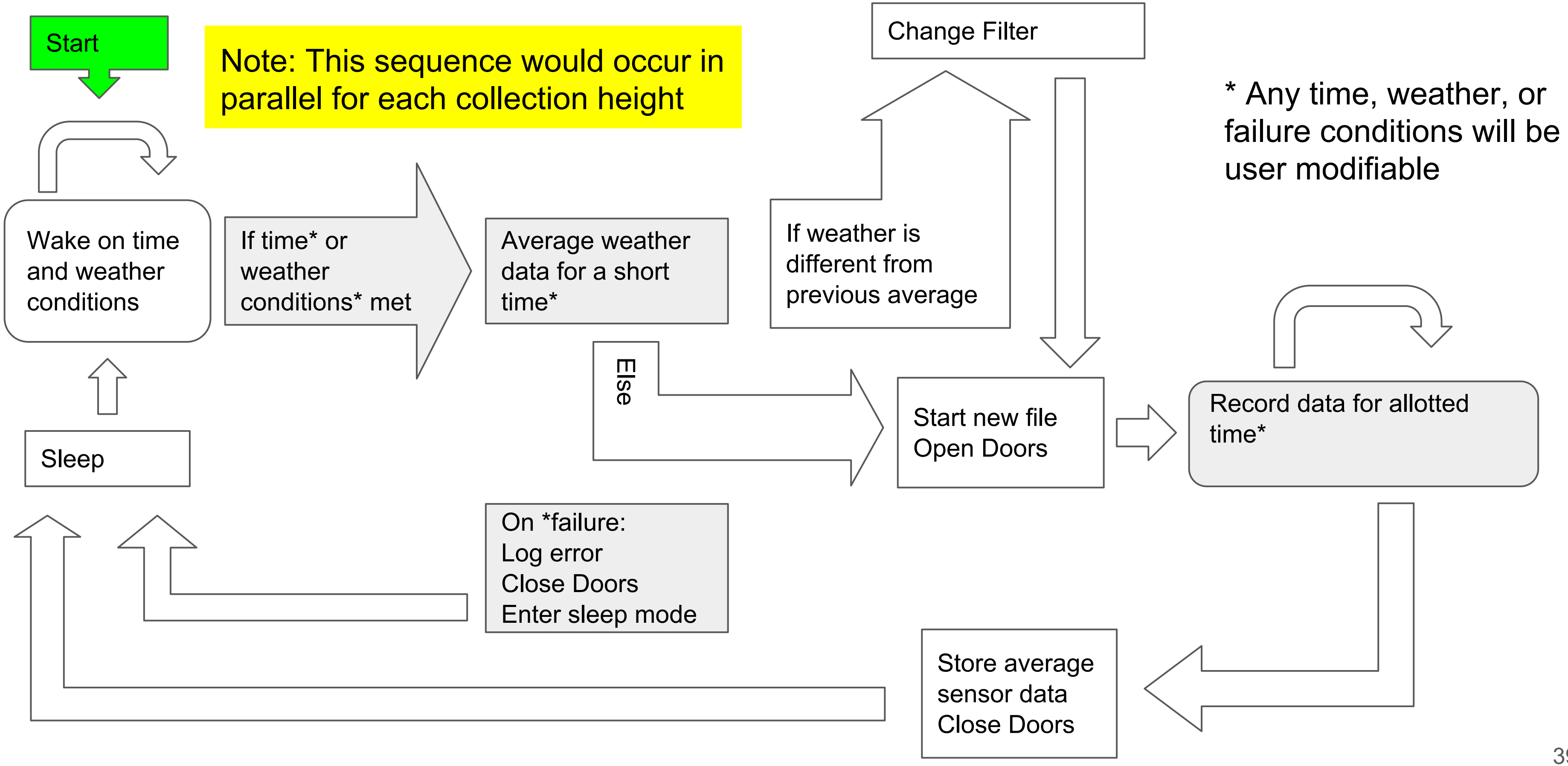
Requirements

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



General Code Flow Chart



User-Specification of Mission Profile

Actions:

- Log sensor readings to the file
- Open/close dust chambers (individually)
- Change filters (individually)
- Set fan speed (on, off, etc..)

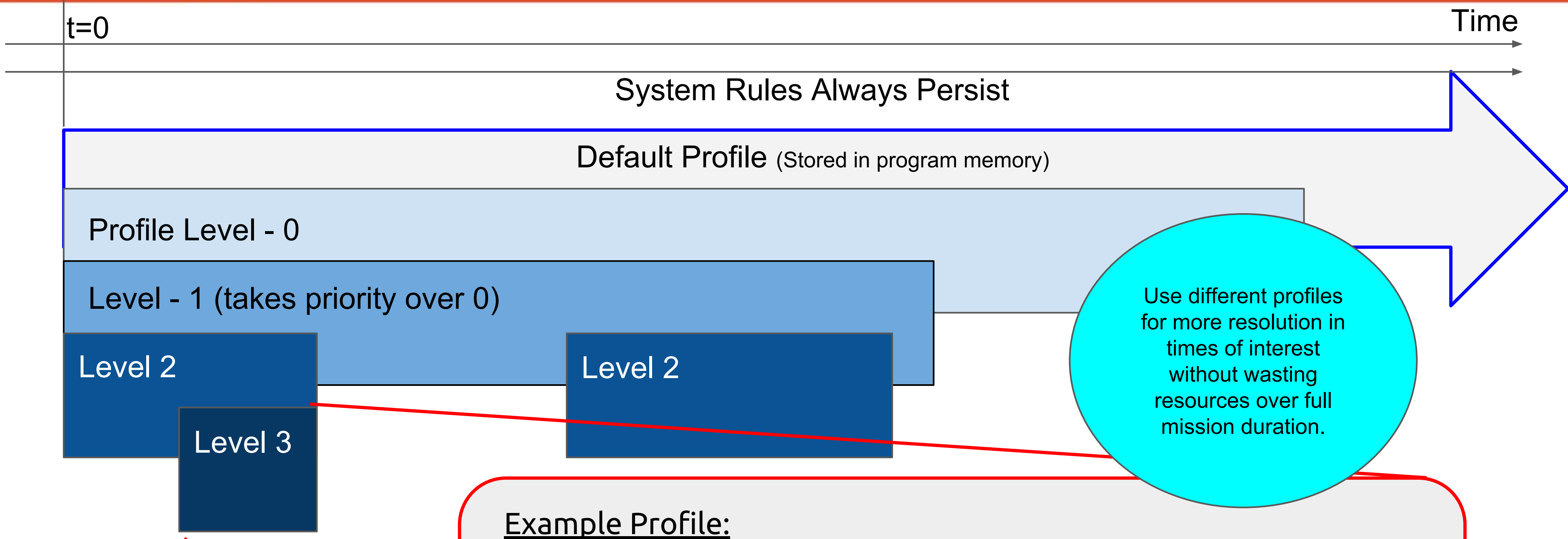
User Provided Info:

- Height of openings
- Deployment location
- Battery properties (nominal voltage, capacity, external, etc.)
- Minimum filter life

Possible Triggers:

- Failure checking
- Time Events
- Weather Events
- Also specify which, if any, to ignore in a “mode”

Customizing for Mission Scope



Example Profile:
Time Events: 2 x per day, not after 7:00p
Weather Events: wind > 10 mph or pressure change > 500 Pa
Environmental Sample Rate: 1 per hour
Fan Speed: 3.5
Failsafe: Close Doors, enter low power for 3 hours then check

Microprocessor Trade Study

Micro	Pre made	Power Voltage	Average power	sleep power	Processor	Clock	Non Volatile Memory	RAM	Flash	Language	On Board Sensors	IO Channels	PWM Channels	SPI Channels	UART Channels	I2C	Other	Price ($)	Link
Uno R3	yes	7-12v	19.9mA	3.14mA	ATmega328p	16 MHz	1kb EEPROM	2kb	32kb	Arduino C	none	14	6	1	1	1	6 analog	25	https://www.sparkfun.com/products/11021
MSP342P	yes	5v	3.84mA	660 nA	ARM Cortex M4F	48MHz	none	64kb	256kb	Embedded c	none	40	(configurable)	8	4	4		16	http://www.ti.com/tool/msp-exp432p401r
Cyclone 10 lp	yes	5-12v	NA	NA	NA	NA	multiple 9kb blocks	NA	NA	Verilog	none	176	(configurable)	(configurable)	(configurable)	(configurable)		60	https://www.altera.com/products/fpga/cyclone-series/cyclone-10.html
Atmega	no	1.27-5.5v	0.4mA	0.1uA	Atmega1284p	1MHz or higher	4kb EEPROM	16Kb	128Kb	Assembly	RTC, ADC	32	6	1	2	1	6 sleep modes	5	https://www.digikey.com/product-detail/en/microchip-technology/ATMEGA1284-PU/ATMEGA1284-PU-ND/2271218
MSP340	no	1.8v to 3.6v	270uA	1uA	MSP430	32kHz	8,16,32Kb	512,1Kb	256b	Assembly	ADC	16,32,64	(configruable)	1	1	1		3	http://www.ti.com/lsds/ti/microcontrollers-16-bit-32-bit/msp/products.page

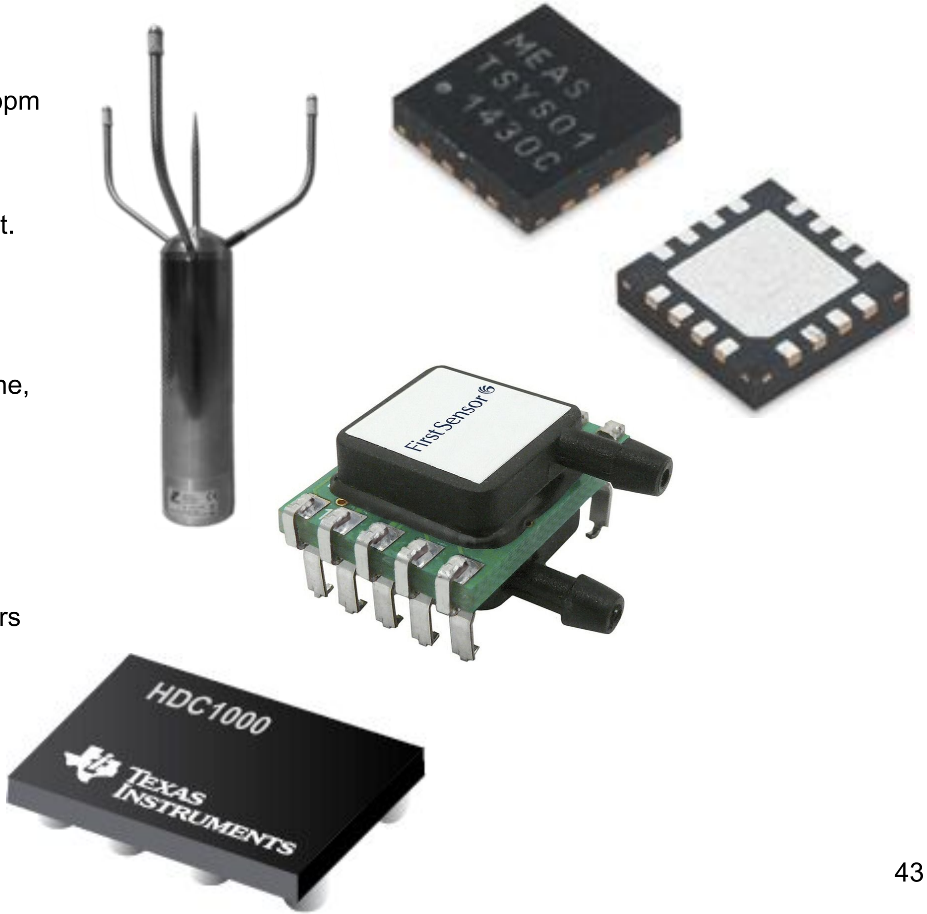
Recommended Microprocessor: ATmega1284p

Advantages:

- Ultra low power, and 6 sleep settings
- Familiarity with the AVR instruction set
- Ease of use
- Customizable hardware around the Atmega

Sensors

- Time Stamp:
  - Some µC options include a real time clock.
  - If more accuracy is required external chips offer as low as 2 ppm drift rates and low current.
- Location:
  - If location stays static then it could be recorded at deployment.
  - If measurement is required then GPS can also provide time synchronization.
- Wind Speed / Direction:
  - Options include differential pressure as well as ultrasonic, vane, and hot wire anemometers.
  - Scalar measurements could be used in combination to find direction
- Sample Height:
  - Could be recorded as static data.
  - If measurement is required then ultrasonic or lidar rangefinders could be used, not optimal.
- Temperature:
  - Options include ICs, thermistors, and thermocouples.
- Humidity
  - Again, ICs represent a very reliable solution to this need.



Sensor Trade Study

Temperature sensors		Name	Source	Overall Rating	Accuracy	Resolution	Range	Current Draw	Sleep Current Draw	Supply Voltage	Cost	Size	Ease of use	Communication	Link
	Given Weight				8	9	4	7	10	2	5	2	5	6	
	Calculated Weight				0.1379310345	0.1551724138									
	IC Type	TMP116NAIDRVT	Digikey	2	±0.3°C (±0.5°C)	16 b	-55°C ~ 125°C	3.5 µA	0.250 uA	1.9 V ~ 5.5 V	2.73	Smol	Easy	I²C/SMBus	https://www.digik
		S-5855ADDB-I4T1U	Digikey		±0.3°C	-	-40°C ~ 125°C	50 µA	-	1.65 V ~ 5.5 V	1.19	Smol	Medium	PWM	https://www.digikey
		TMP35GRTZ-REEL7	Digikey		±3°C (±4°C)	10mV/°C	10°C ~ 125°C	50 µA	0.5 uA	2.7 V ~ 5.5 V	1.53	Smol	Easy	Analog	https://www.digik
		G-NICO-018	Digikey	1	±0.1°C (±0.5°C)	24 b	-40°C ~ 125°C	<12.5 µA	0.14 uA	2.2 V ~ 3.6 V	6.8	Smol	Easiest	I²C, SPI	
	Thermocouple	240-080	Digikey		DEPENDS ON ADC	DEPENDS ON ADC	-73°C ~ 482°C	LOW. Requires externalADC		DEPENDS ON ADC	9.99	Smol	Hard	Analog	
	Thermistor	KS102J2*	US Sensors			0.1 deg C	-55 to 135 C	Depends	Depends	Depends			Medium	Analog	http://www.ussen
			US Sensors			0.05 deg C	-55 to 135 C	Depends	Depends	Depends			Medium	Analog	http://www.ussen

Time Sensors*		Name	Source	Overall Rating	Drift Rate	Drift Typical 1 yr	Current Draw	Sleep Current	Supply Voltage	Cost	Interface	Features	Link
	IC's	AB0815-T3	Digikey	1	p/m 2 ppm	3 ppm	0.17µA ~ 0.22µA		1.5 V ~ 3.6 V	1.81	SPI	Alarm, Leap Year, SRAM, Trickle-Charger, Watchdog Timer	https://www.digikey.com/product-detail/en/abracon-ll
		AB-RTCMC-32.768 KHZ-IBO5-S3-T	Digikey		p/m 2 ppm	3 ppm	0.29µA ~ 0.33µA		1.4 V ~ 3.6 V	4.84	I²C, 2-Wire Serial	Alarm, Square Wave Output, SRAM, Trickle Charge, Watchdog Timer	https://www.digikey.com/product-detail/en/abracon-ll
		DS2417P+T&R	Digikey		-	47 ppm	0.45µA		2.5 V ~ 5.5 V	2.35	1-Wire® Serial	Unique ID	https://www.digikey.com/product-detail/en/maxim-int

* Note: many of the microcontrollers in question contain an onboard RTC

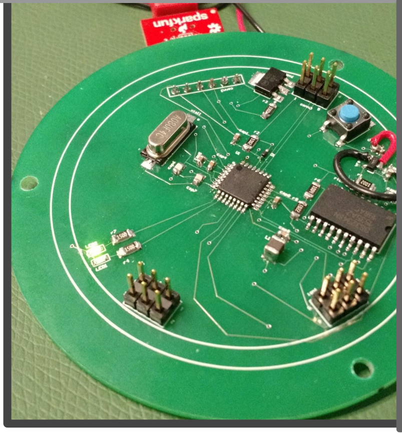
Wind sensors		Name	Source	Overall Rating	Magnitude?	Velocity?	Susceptibility to Env.	Speed Accuracy	Direction Accuracy	Speed Resolution	Direction Resolution	Power Consumption	Supply Voltage	Interface	Cost
	Pitot-static*	General	widely available		yes	only with more measurement directions and math	medium, ports may ice over becoming blocked	decent, requires temperature to correct for density	?	?	?	Low (IC based mems pressure tansducer)		Severl option available	?
		HSCMRRN060MDSA3	Digikey	2	Yes	""	""	Calculate based on pressure accuracy ±0. 25%	?	12 b	?	2.1 mA @ 3.3V	3 V ~ 3.6 V	SPI	35.48
		HSCMRRN001PD2A3	Digikey		Yes	""	""	Calculate based on pressure accuracy ±0. 25%	?	12 b	?	2.1 mA @ 3.3V	3 V ~ 3.6 V	I2C	35.48
	Ultrasonic Anemometers														
		Homebrew	We build	1	Yes	Yes	Low	Medium/High	Medium/High			Medium		Custom	TBD, less than $200
		VENTUS-UMB Ultrasonic Wind Sensor	lufft			Yes		±0.2 m/s or ±2 % RMS of reading (whichever is greater) for 0...65 m/s - otherwise ±5 %	±2° RMSE >1.0 m/s	0.1 m/s	0.1 °			RS485	2500+
	Hot Wire Anemometers														
		General	custom (few if any sensor systems available)		Yes	Only with more custom measurement directions and math	low, but not negligible	?	?	?	?	High (relatively speaking because you have to heat a wire)			?
	Vane Anemometers														
		General	Can be built using encoders, few off-the-shelf options available		yes	yes, if weathervane included	medium, moving parts could ice over	?	?	?	?	Low.		Custom	?
	* Note: for pitot static sensors we must establish the maximum expected differential pressure (AKA dynamic pressure).	q = (1/2) rho * V^2	maximum wind speeds measured at 95 mph = 44 m/s	Using R = 287 J/kg/K, T=-15 C = 258 K, P = 99000 Pa	rho = P/(RT)	rho = 99000/ (287*258)	rho = 1.337006726	At a Vavg = 10 m/s then q = 50*1.34 = 67 pa	At Vmax = 45 m/s then q = 1.36 kPa	A reasonable maximum windspeed to see might be 30 m/s where q = 650 Pa	Add a factor of safety and say the pressure sensor must withstan 1 kpa	Turns out nearly any sensor can withstand that, so we are goood			

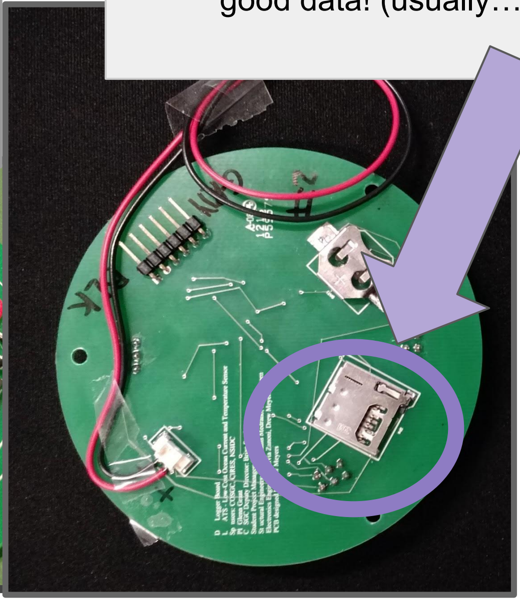
Humidity Sensors		Name	Source	Overall Rating	Accuracy	Resolution	Range	Supply Voltage	Current Draw	Current Draw Sleep	Response time	Interface	Cost	Link
	ICs	HDC1000YPAT	Digikey		±3% RH	11b	0 ~ 100% RH	2.7 V ~ 5.5 V	1.2 uA max	0.2 uA	15s	I²C	8.5	https://www.digikey.com/product-d

Data Storage

SD Flash!

- Data is preserved without power
- Data is stable. SD cards recovered from sounding rocket and from being lost in the ocean still return good data! (usually…)

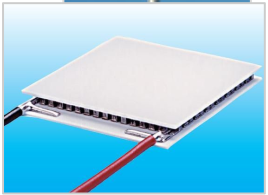




Power

Extended data logging missions pose a significant challenge to the power subsystem.

1. Increasing efficiency of sensors and actuators (the system)
2. Cutting off inefficient sensors from power
3. Using available methods to gain energy from environment.



Efficiency of the system

- Power saving modes are weighted heavily in sensor selection
- A μC that exceeds computational needs should be avoided

Cutting off sensors

- Buffers and relays can be used to physically disconnect devices
- This could be applicable to idling actuators

Draw energy from environment

- Solar
- Thermal
- Kinetic
- MPE

Power Budget

Combination	Pros	Cons
LiFe Battery	● More resistant to charge levels ● More Coulombs per charge	● Heavy ● Not commonly used or documented
Lipo Battery	● Commonly used and documented ● Multiple sizes and voltages ● Small and light	● Susceptible to overcharging and undercharging ● Less Charge cycles
Solar Panel	● Easily integrated and used ● Can charge batteries ● Cheap	● Weight ● Not enough charge provided
Pump/Fan (with any source above)	● More intake when on ● Could be used for some power generation when intake is 'passive'	● Heavy ● Prone to freezing and failure ● Takes a **considerable** amount of power ● Would require roughly a large battery to power for the lowest duration and capabilities ● Creates noise in the system that could affect sensors

Electrical Risks/Worries

- Biggest Concerns:
  - The power is very dependent on the system and is the most affected by temperature. Charging and discharging is greatly impeded by cold.
  - Wind direction is hard to get an accurate reading of since it is erratic and hard to sense.

- Solutions:
  - Multiple power sources (Battery and solar cell) should provide enough power to meet the mission requirements
  - Using a ultra low power microprocessor and having the ability to cut power completely to sensors will extend the life
  - Since the unit will be self orienting to the wind, simply measure the angle relative to the pole will tell wind direction.
  - Wind speed can easily be recorded with a pitot tube.

Electrical Next Steps

- First iteration schematic - ensure no conflicts in resource usage
- Ensure all required peripherals are accounted for (regulators, switches etc...)
- Ensure interface with actuators
- Develop algorithm and code structure
- Develop data format

Management

Schedule

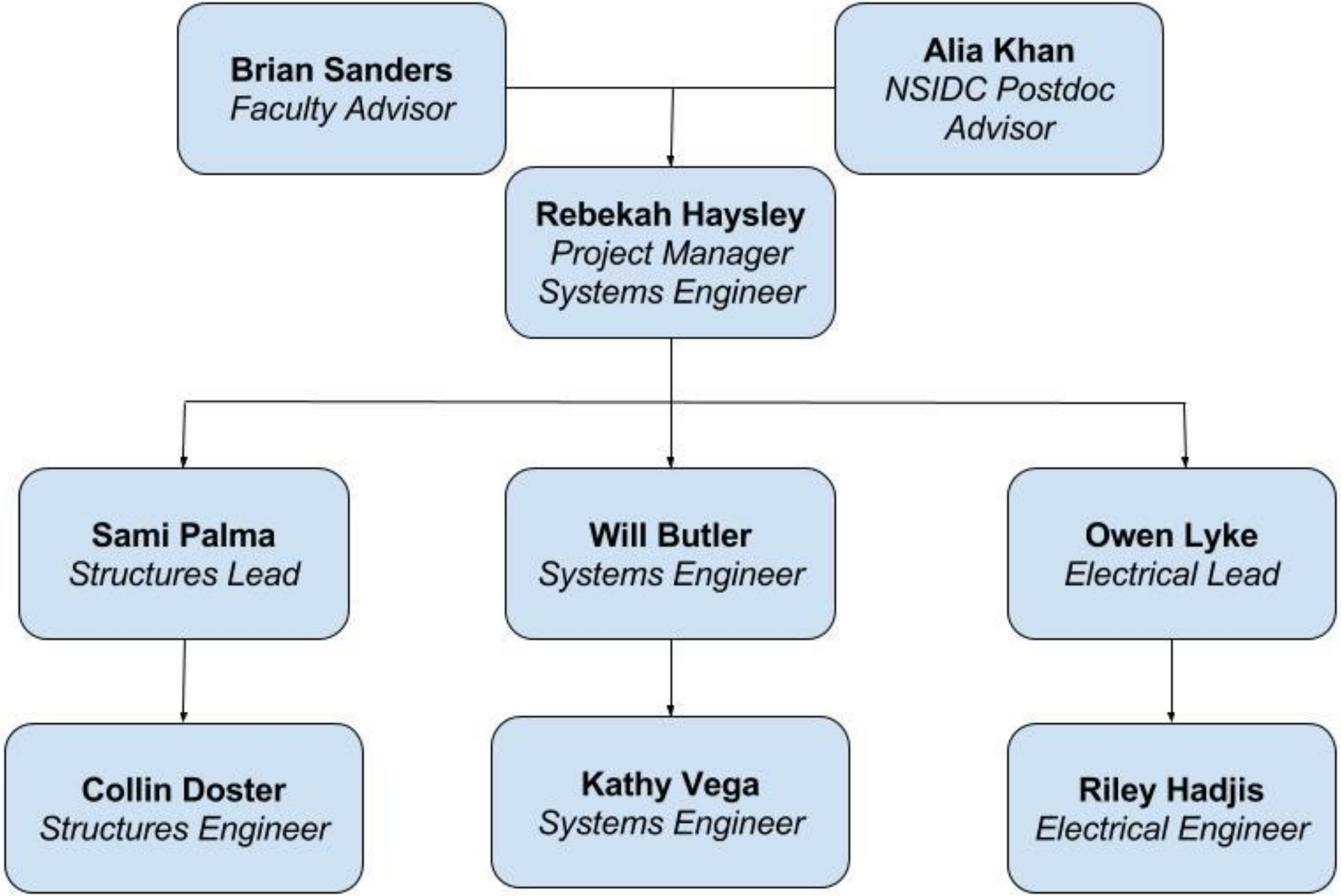
DATE	GOAL
8/29	Team Organization
9/12	Team forming and literature study
10/13	Conceptual Design Review
10/24	Preliminary Design Review
11/14	Critical Design Review
12/19	Prototype1
1/16	Winter Break
2/13	Prototype2
2/27	Final Build
3/27	End of Semester Report
4/10	Field Deployment

Budget Overview

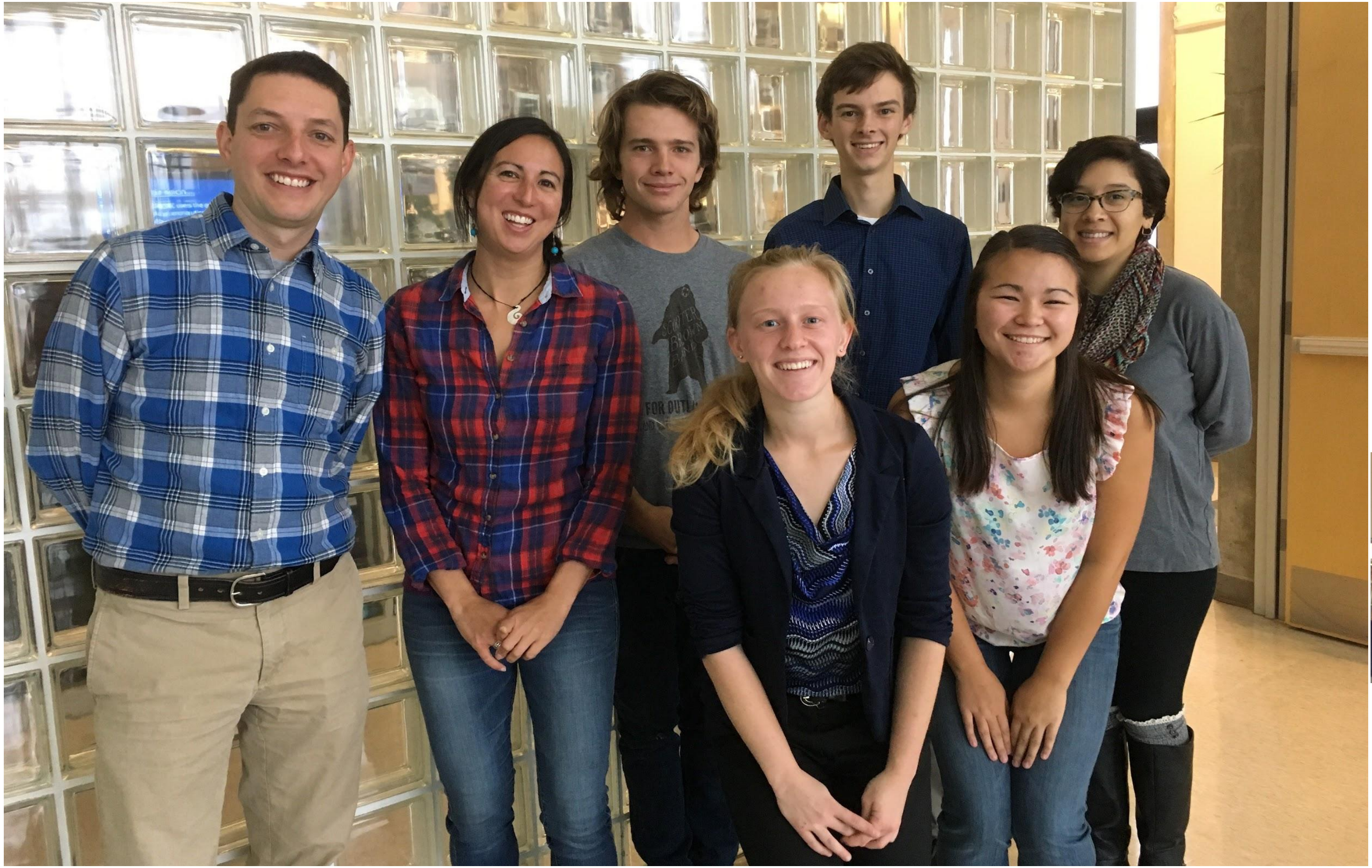
Component	Cost ($)
Structural Metal	600
Motors	200
Sensors & Microprocessor	300
Power (Battery)	200
Wiring and Hermetic Seals	200
Glass Fiber Filters	300
Pump	200
Margin	1000
Prototyping	1400
Total (w/o margin/proto)	2000
Total	4400

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

Team Structure



Team Picture!



Thank you!

Questions?

Sources

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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https://www.eea.europa.eu/highlights/black-carbon-better-monitoring-needed