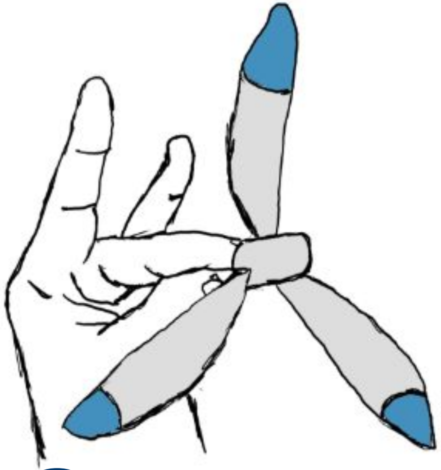


MAE 189 Capstone Design
Midterm Presentation

Group 9: Trust in the Gust

Jacob Brooks, Dennis Chua, Jason Fetherman, Anthony Machuca IV

Project Definition

UCI Samueli School of Engineering

Inspired by the *U.S. Department of Energy's Collegiate Wind Competition*, this team must design and manufacture a Small-Scale Wind Turbine with the following system requirements:

1) Must be able to withstand wind speeds of **18 m/s**

2) Must produce at least **10 W** of power at a wind speed between **5 - 11 m/s**

3) Must generate this power irrespective of wind direction

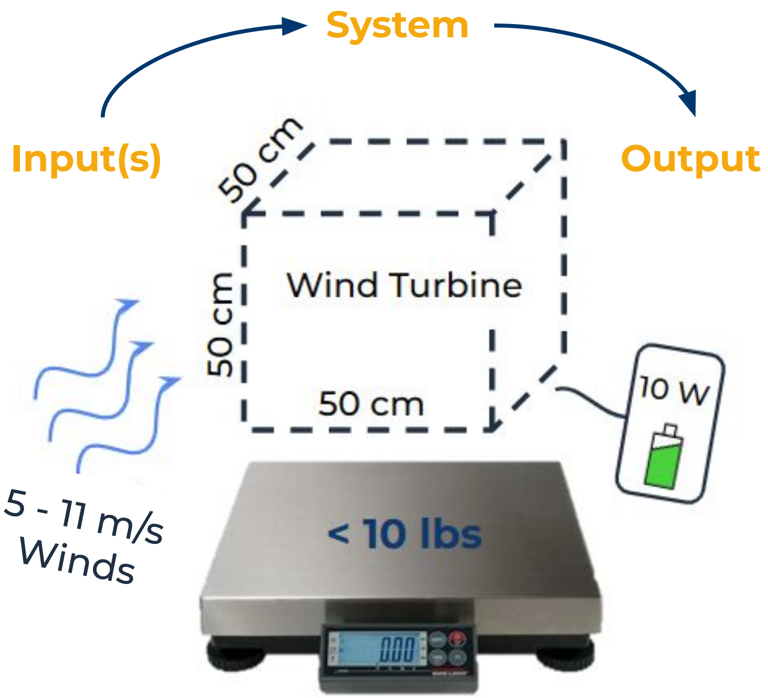
4) Must fit within cube of side length **50 cm** (without mounting assembly)

5) Can be assembled/disassembled easily

6) Must not weigh more than **10 pounds**

7) Budget cost must not exceed **$750**

8)Must be compatible with typical off-the-shelf power bank storage device



Jacob Brooks

Design Attributes

With S.M.A.R.T Requirements

UCI Samueli School of Engineering

Design Attributes Table

Design Attribute	O	C	F	M	Design Attribute	O	C	F	M
Must convert mechanical energy from wind to electricity			✓		Should be portable and lightweight	✓			
Must withstand winds up to 18 m/s		✓			Must be safe to users and wildlife	✓	✓		
Must produce minimum 10 W between wind speeds of 5 - 11 m/s		✓			Should have minimal noise generation from motor	✓			
Must generate 10 W irrespective of wind direction	✓	✓			Should be capable of charging more than one accessory at a time	✓			
Must fit inside cube with 50 cm side length without mounting assembly		✓			Should fully charge power bank in less than 8 hrs under steady wind conditions	✓			
Can be assembled and disassembled easily	✓				Should be operable in rain and other weather conditions without worry	✓			
Must weigh less than 10 lbs		✓			Can be Horizontal-Axis Wind Turbine (HAWT)				✓
Must not exceed a cost of $750		✓			Can be Vertical-Axis Wind Turbine (VAWT)				✓
Must be compatible with a typical off-the-shelf power bank storage device	✓	✓			Motor can be attached directly to propeller or connected via gear train				✓

Design Objectives

- Safety -

user safety, environmentally friendly

- Efficiency -

power generation (10 W), aerodynamics, compatibility, 1 person assembly in < 5 mins

- Portability -

lightweight (<10lbs), deconstructable into at least 2 parts, small size (50cm cube) -

- Durability -

strong (18m/s winds), product longevity (at least 1 year w/ small size)

Design Means

- HAWT or VAWT -

- Power Transmission -

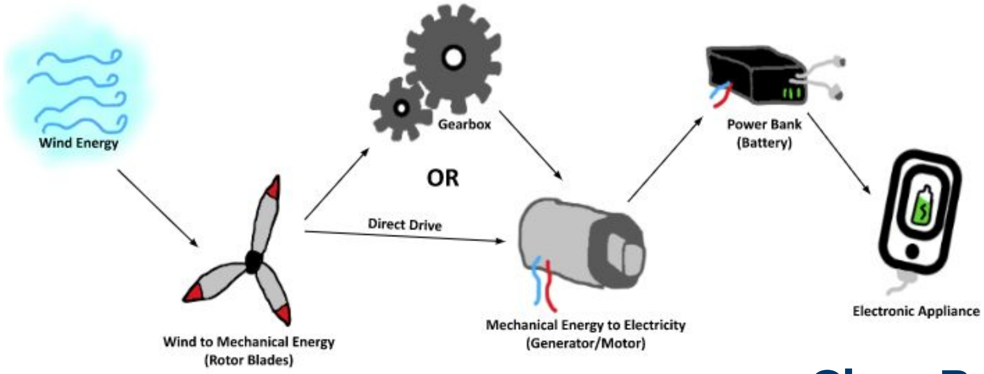
Gearbox, direct-drive, DC/AC Motor

Jacob Brooks

Preliminary Research

UCI Samueli
School of Engineering

- Energy Flow Diagram -



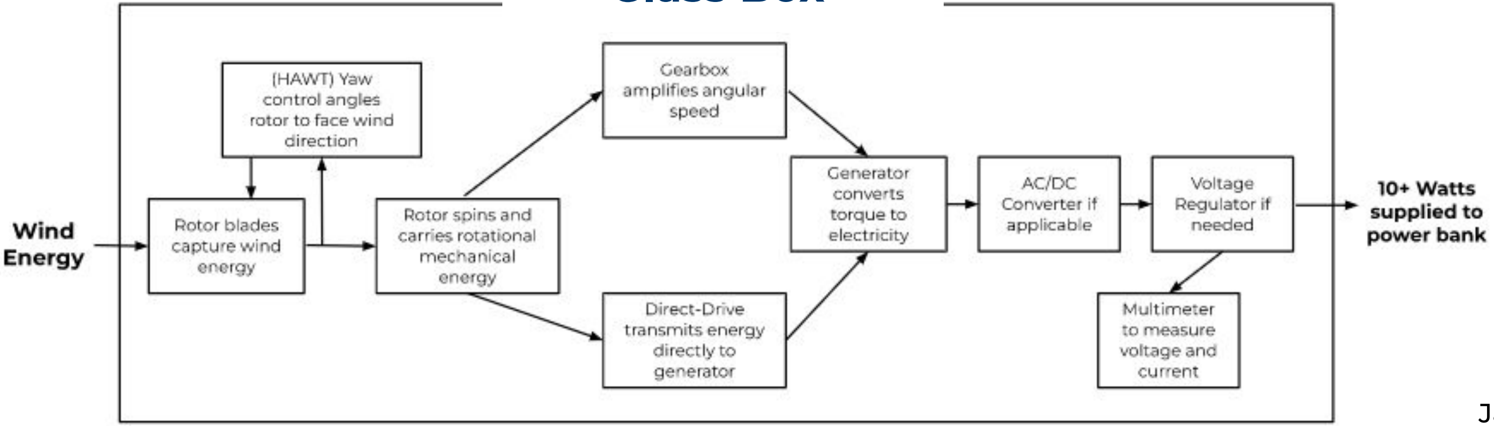
- Types of Wind Turbines -

- VAWT -

Savonius, Darrieus

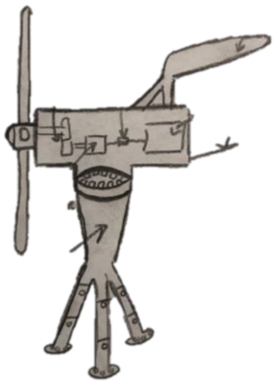
- HAWT -

-Glass Box -



Jacob Brooks

Preliminary Design Sketches



Concept 1

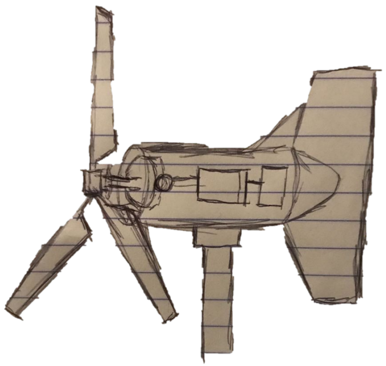
HAWT

3 Blade Rotor

Small Top Rear Fin

2 Gear Trains (one for transmission one for rotation)

3 legged collapsible stands



Concept 2

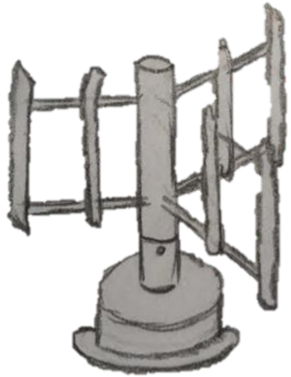
HAWT

3 Blade Rotor

Large Central Rear Fin

Roller Bearing

Cylinder Support



Concept 3

VAWT (H-Darrieus)

6 Blade Rotor

Detachable base with Locking Button

Roller Bearing

Jacob Brooks

Concept Selection (HAWT Design)

UCI Samueli School of Engineering

- Yaw Trade Study -

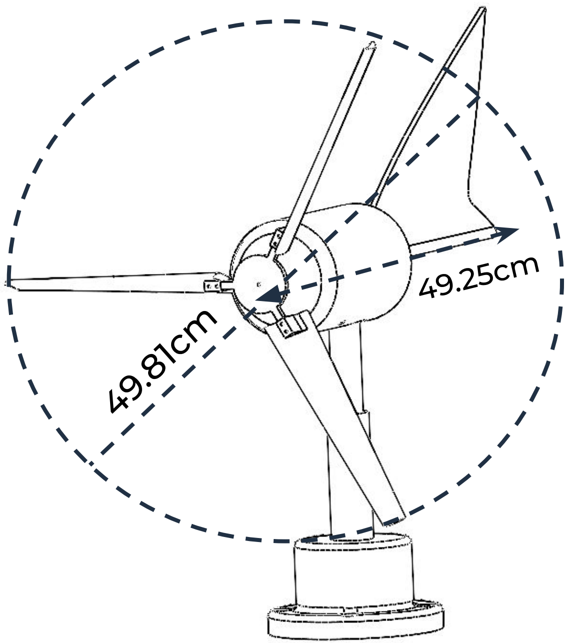
Yaw for HAWT 1(Bad) -> 5(Good)					
Design Choice	Weight	Control Accuracy	Interference with Turbine	Ease of Manufacturing	Score Total
Importance Factor	0.9	1	0.5	0.7	
Small Top Rear Fin	4	2	4	4	10.4
Large Central Rear Fin	3	4	3	4	11.0
Shaft/Mount Fin	2	3	4	3	8.9
Active Yaw with Sensor and Motor Control	2	5	5	1	10.0

Jason Fetherman

Concept Selection (HAWT Design)

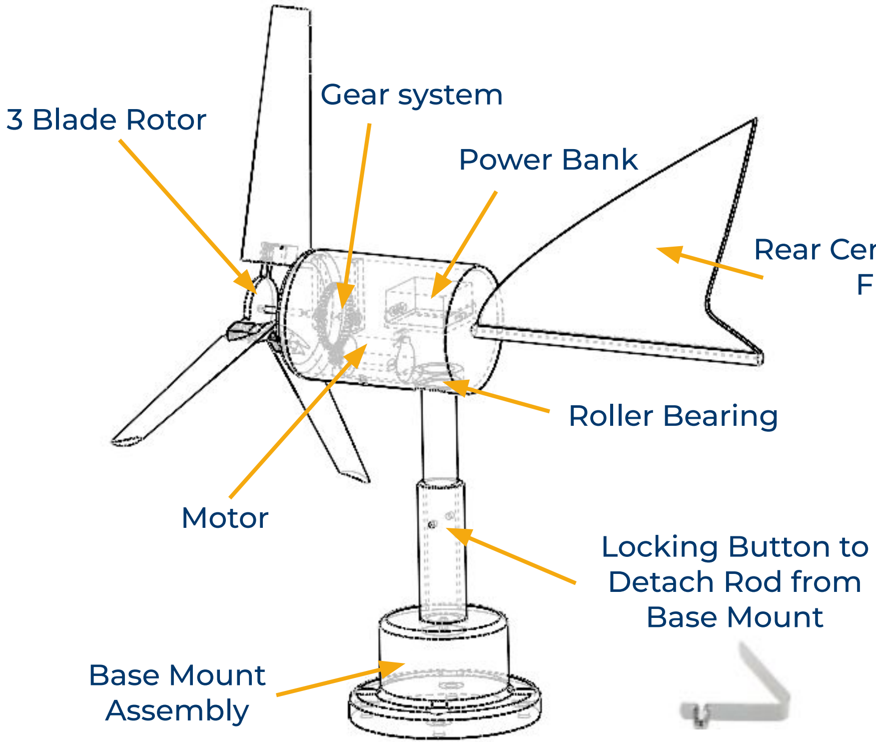
UCI Samueli
School of Engineering

- Engineering Drawings -



Size requirement ✓

Weight: ~ **3.16 lbs**

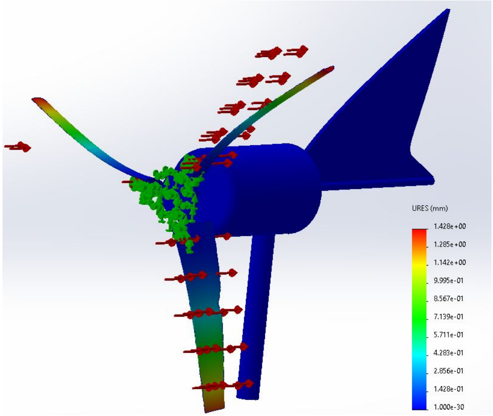


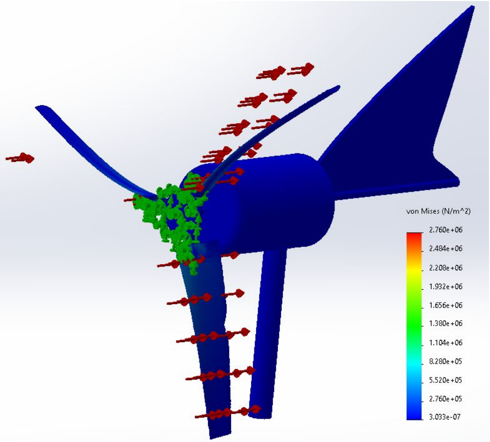
Dennis Chua

Concept Selection (HAWT Design)

UCI Samueli School of Engineering

- Static Test Simulation Results -





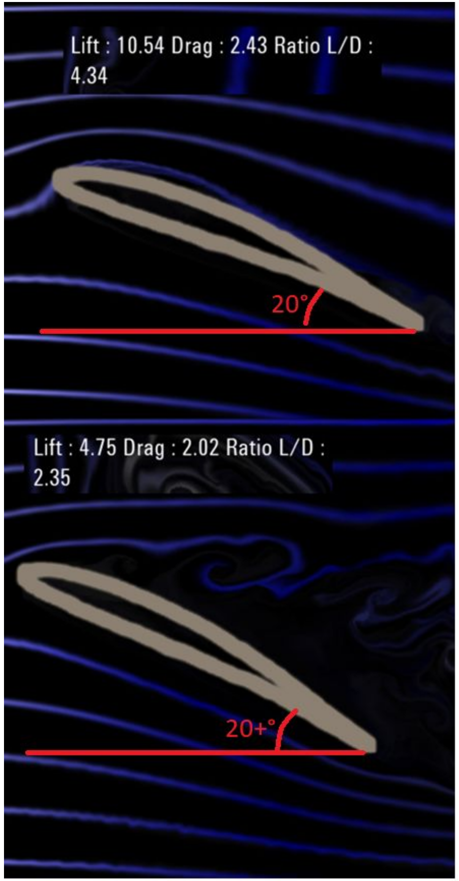
Wind Speed	Wind Pressure	Max Stress	Max Displacement
5 m/s	15.325 Pa	0.213 MPa	.1102 mm
11 m/s	74.173 Pa	1.031 MPa	.5332 mm
18 m/s	198.612 Pa	2.76 MPa	1.428 mm

Yield Strength for Nylon is 40-100 MPa

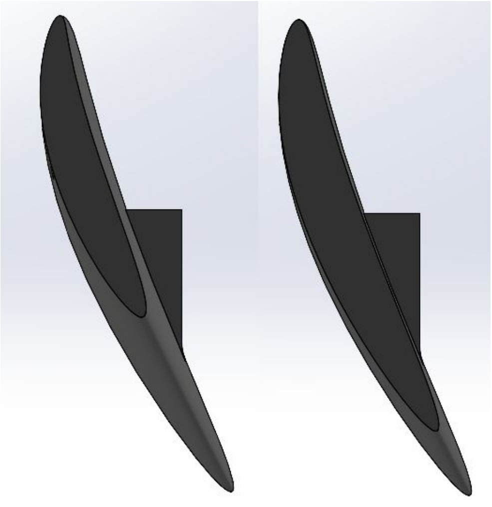
- Animated Assembly -

Dennis Chua

Concept Selection (HAWT Design)



one important design consideration for the HAWT is the wing angle of attack



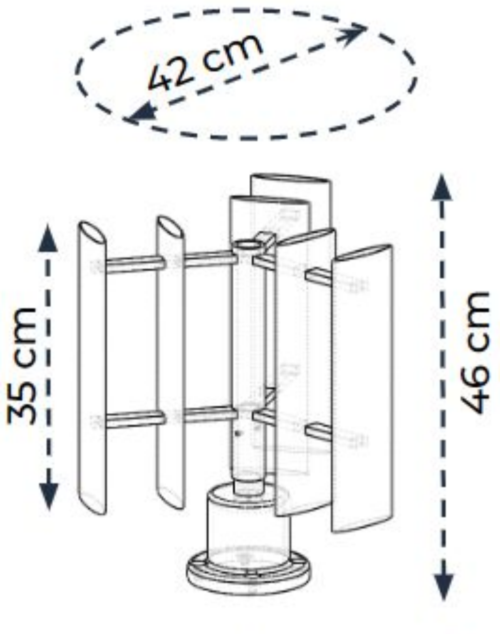
Angle of attack should maximize lift for the wing blade to spin

Dennis Chua

Concept Selection (VAWT Design)

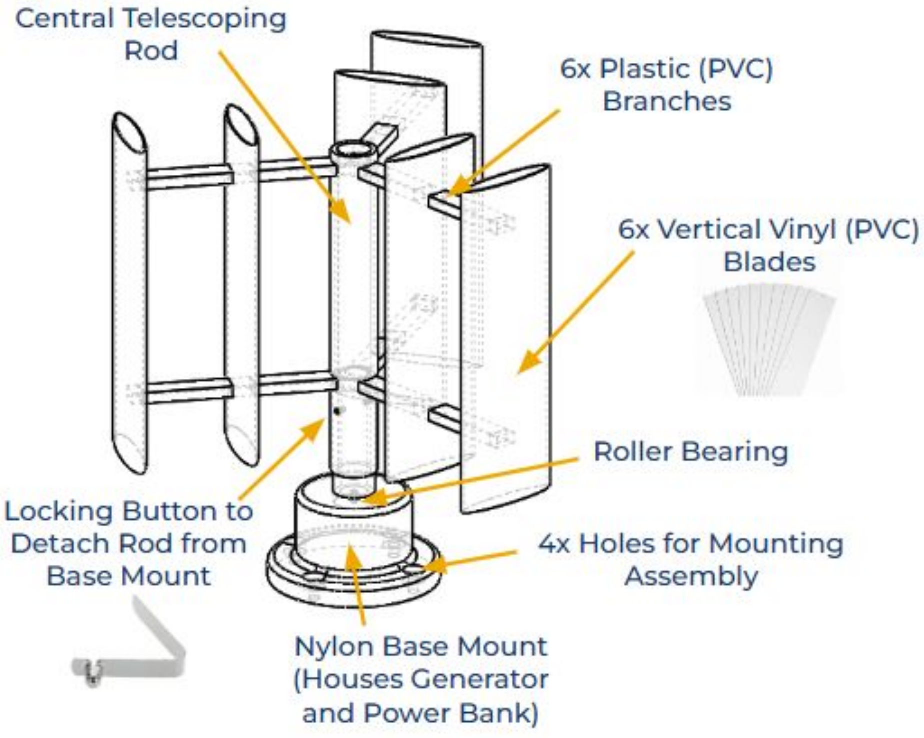
UCI Samueli School of Engineering

- Engineering Drawings -



Size requirement ✓

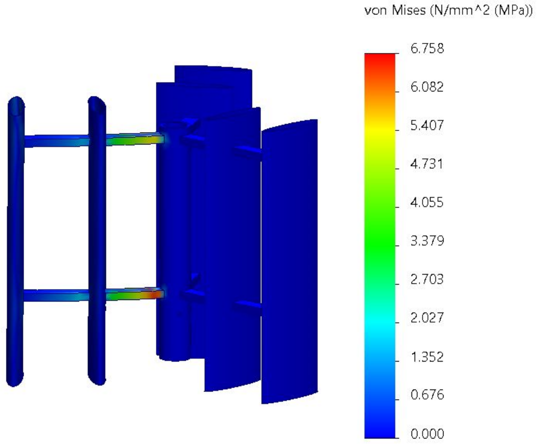
Weight: ~ **3.6 lbs**

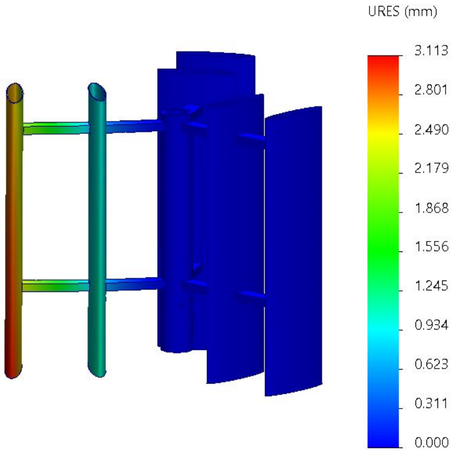


Jacob Brooks

Concept Selection (VAWT Design)

- Static Test Simulation Results -

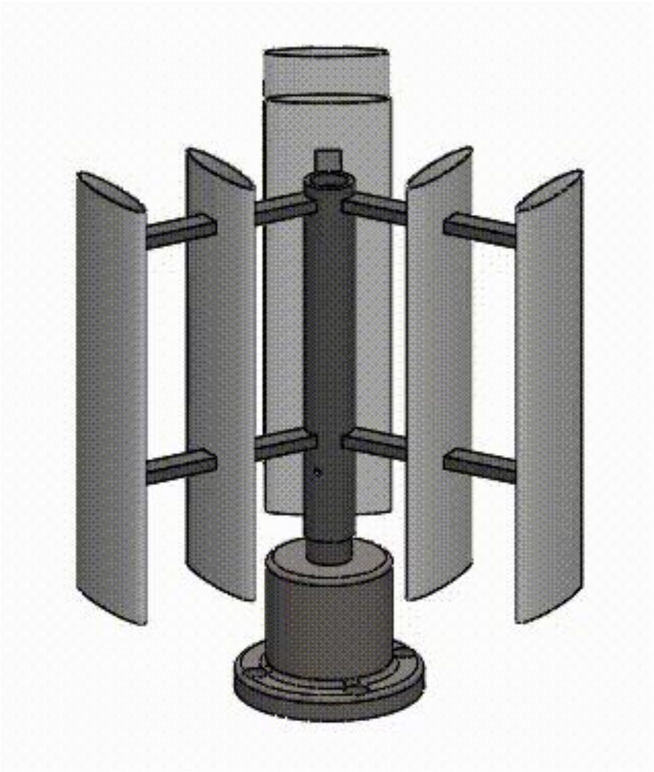




Wind Speed	Wind Load	Max Stress	Max Displacement
5 m/s	1.173 N	0.521 MPa	0.240 mm
11 m/s	5.679 N	2.524 MPa	1.163 mm
18 m/s	15.207 N	6.758 MPa	3.133 mm

Yield Strength for PVC Vinyl is usually around 55 MPa

- Animated Assembly -

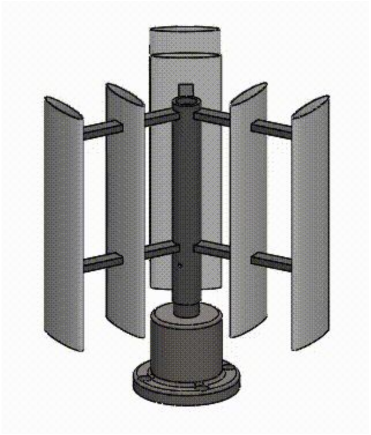


Jacob Brooks

Concept Selection (HAWT vs VAWT)

UCI Samueli School of Engineering

- VS -



Design Choice Trade Study 1(Bad) -> 5(Good)			
Design Choice	Importance Factor	HAWT	VAWT
Weight/Costs	0.7	5	5
Efficiency	1	5	3
Ease of Manufacturing	0.6	3	4
Control	0.8	3	5
Material Strength	0.8	5	4
Total Score		16.7	16.1

HAWT

Better **Efficiency** at Power Generation

Stronger, and More Durable Design

>

VAWT

Easier to Build

No Yaw Control Needed, Works in All Wind Directions

Jacob Brooks

Concept Selection (Motor & Power Bank)

UCI Samueli School of Engineering

AC Motor

- More Efficient
- Larger Relative Size for Same Power Output
- Lack of Appropriate Sizes for Application
- Higher Detent Torque

DC Motor

- Variety of Market Options(size, price, power)
- Lower Detent Torque
- Less Efficient

DC Brushed Motor

- Lower Cost
- Less Efficient
- More Susceptible to Wear

DC Brushless Motor

- More Efficient(Less frictional losses)
- Longer Life
- Higher Cost

Jason Fetherman

Concept Selection (Motor & Power Bank)

UCI Samueli School of Engineering

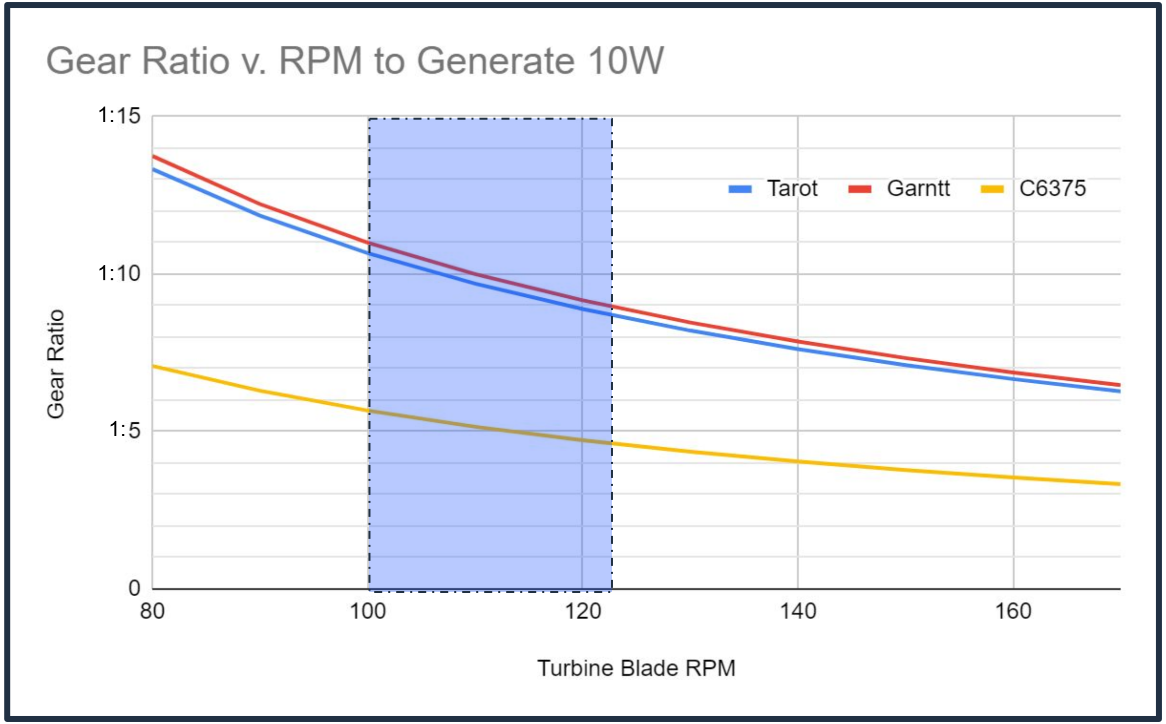
Motor					
Link	KV	Weight	Voltage Capacity	Amperage Capacity	Price
Tarot	320	145g	24V	22.9A	$67.99
GARTT	330	170g	30V	25A	$43.99
C6374	170	861.8g	42V	69A	$52.99

Power Bank				
Link	Voltage	Amps	Weight	Price
Battery Guy	6V	2A	243.8g	$15.95
Tenergy	12V	2A	225g	$21.99
TalentCell	12.6V	3A	190g	$28.79

Jason Fetherman

Gear Ratio

UCI Samueli School of Engineering



Requirement:

Must produce at least **10W** of power at a wind speed between **5 - 11 m/s**

For wind speeds of 5-11 m/s
Rotor Speed ≅ 80-160RPM

Equations Used For Gear Ratio Calculation:

P = IV

KV = RPM/V = ω_{Motor}/V

Gear Ratio = $\omega_{Rotor}/\omega_{Motor}$

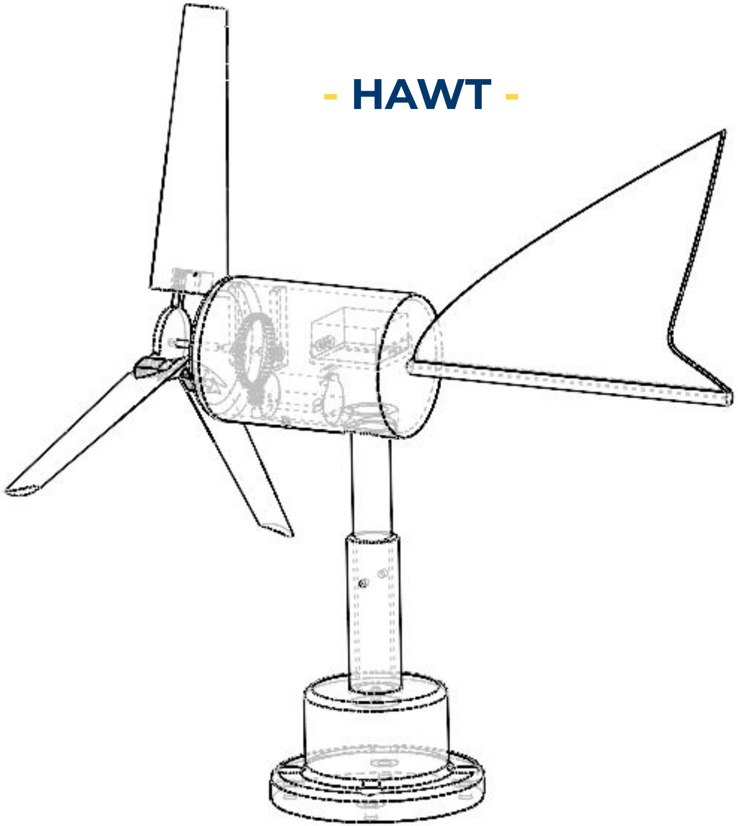
Design to generate 10W around 105-125RPM using a gear ratio **1:8.5 - 1:11**

Jason Fetherman

Proposed Detailed Design

UCI Samueli School of Engineering

- **HAWT** -



- **Major Components** -

3 Blades - MTS (3D-Printed)

Rotor Hub - MTS (3D-Printed)

Nacelle - MTS/OTS

Central Rear Yaw Fin - MTS

Motor - OTS

Gearbox - MTS

Roller Bearing - OTS

Tower - OTS (PVC Piping)

Locking Button - OTS

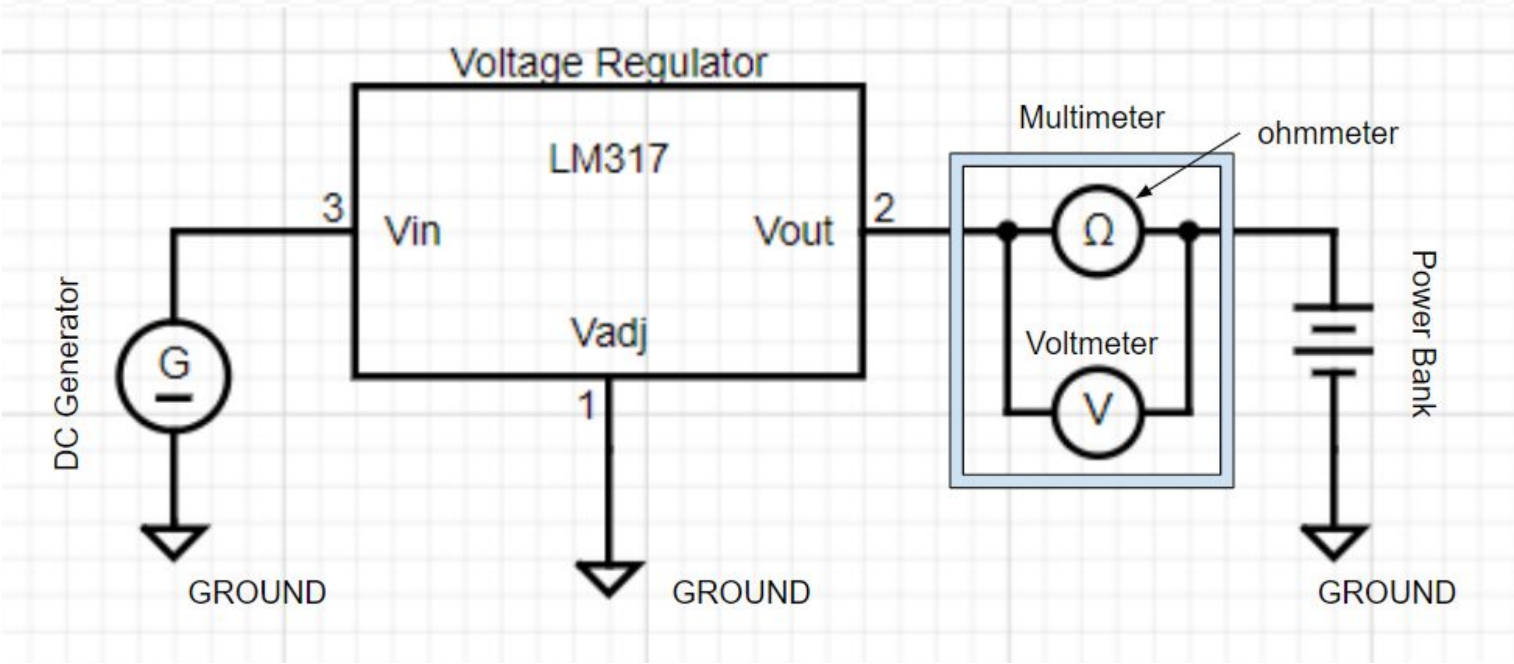
Base - MTS/OTS

*OTS = Off-The-Shelf   MTS = Made to Spec

Anthony Machuca

Proposed Detailed Design

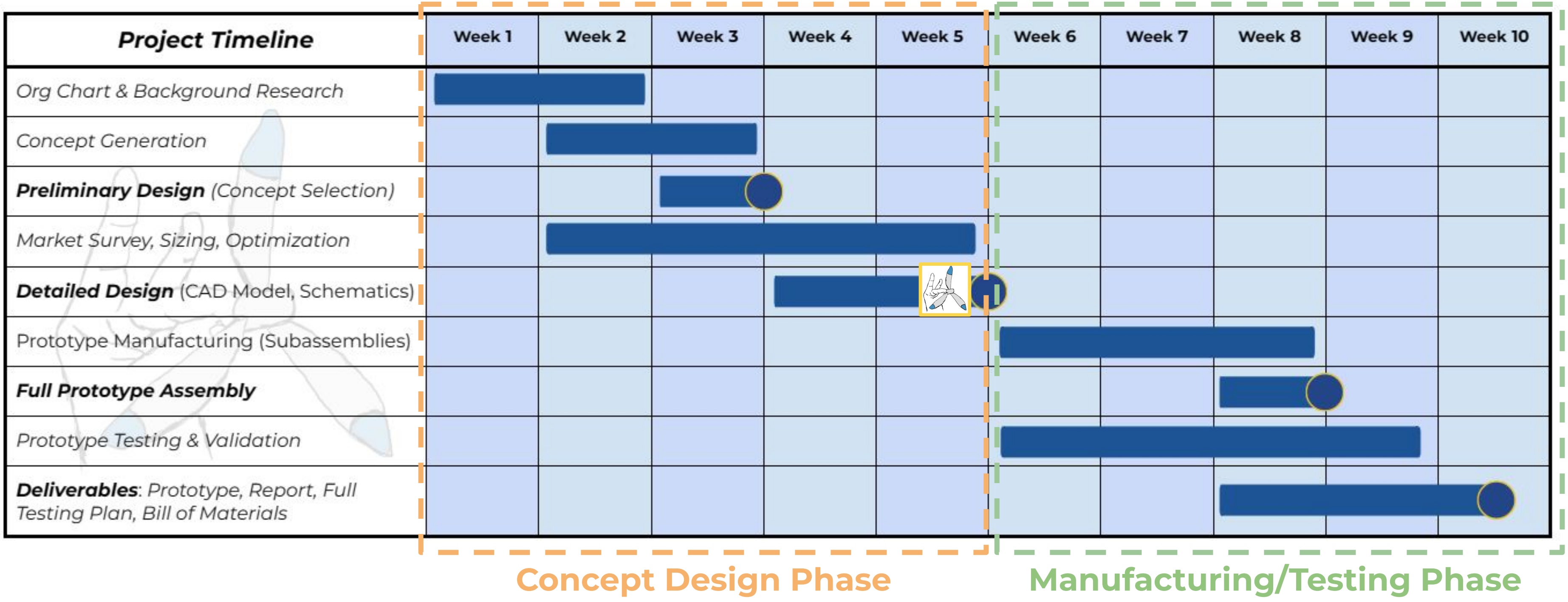
- Circuit Schematic -



Anthony Machuca

Remaining Schedule

UCI Samueli
School of Engineering



We are at the transition from concept design to manufacturing and testing. Beginning Week 6 we start procuring parts and building the prototype. Iterative testing will need to be done with sub-assemblies to verify power generation and optimize components like the yaw and blades.

Anthony Machuca

Team Questions/Concerns

UCI Samueli School of Engineering

Questions

- What resources are available at UCI for wind tunnel testing, or anything similar to that where we can test the prototype with controlled air flow? (Testing plan is one of the project deliverables but being able to do as much testing as possible while building would benefit the design)

Concerns/Expected Challenges

- Will passive yaw alone be enough to spin nacelle of turbine?
    - Selecting optimal geometry of rear fin (iterative design)
    - Minimizing effects of friction for easier rotation

Anthony Machuca

Thank you!