CWC Turbine Hardware Review 2

Barry Benson

Tore Cadmen

Bryce Conner

Joseph Conroy

Stan Kennedy

Aaron Zeek

Overview

Hardware Review I Submission

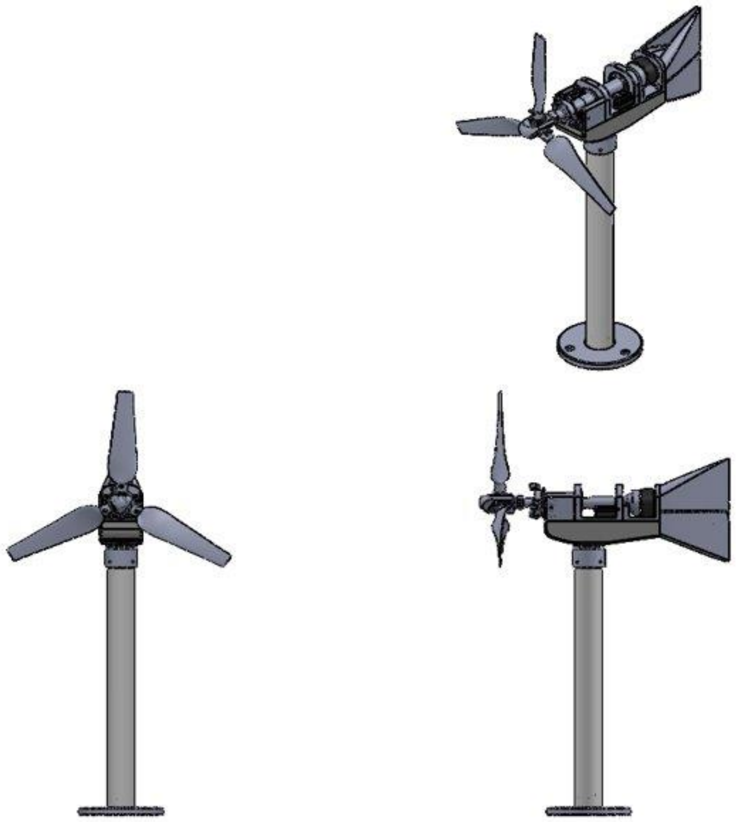

Figure 1:
HWR1 Digital Submission

Figure 2:
HWR1 Physical Submission

Overview

Updated Assembly

Processing Reworks

-Electrical Housing

-Tower

-Baseplate

-Fin

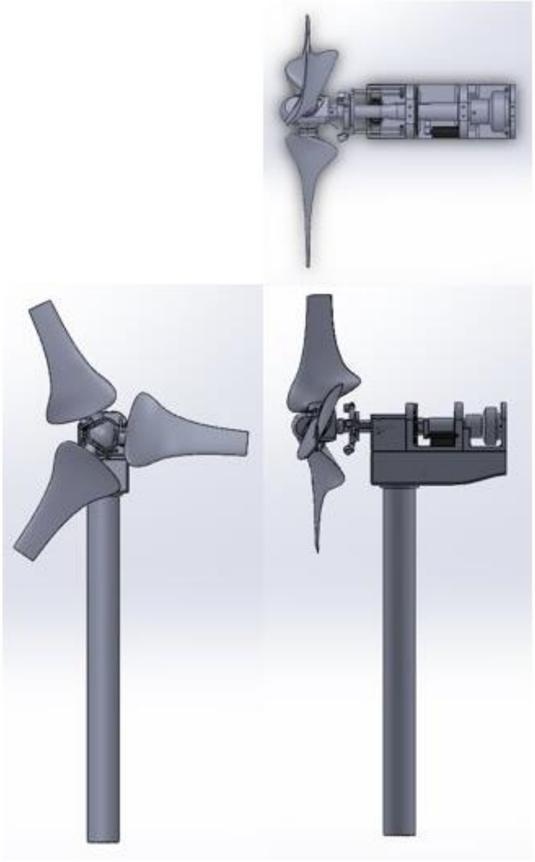

Figure 3:
HWR2 Digital Assembly

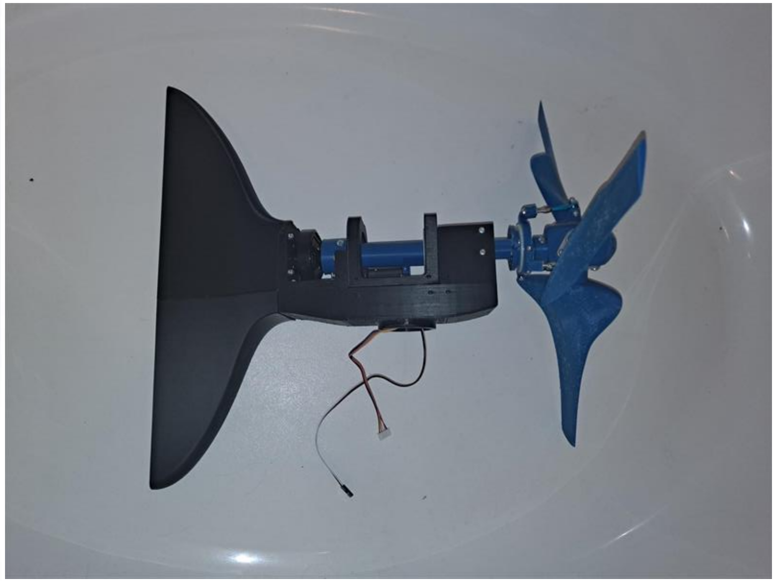

Figure 4:
HWR2 Physical Assembly

PCC Box (Barry Benson)

Completed

- Arduino (Controls)
  - Stepper Motor (Pitching Mechanism)
  - Linear Actuator (Braking Control)
- Arduino (Environmental Data)
  - Multiple Pressure Transducers
  - Temperature Sensors
- PCC Box
  - Anemometer
  - Voltage Readout
  - Ampere Readout
  - Digital LabView Readout and Data Recorder

Next to Complete

- Complete Machining
  - 80% Shaft done needs fine details worked out
  - Tower to hold bearings/ nacelle/ mounting to the base plate
- Arduino (Controls)
  - Emergency Stop
  - Loss of power scenario

PCC Box (Barry Benson)

- NI 6001
  - DAQ system records turbine voltage and current as well as the wind speed
- Voltage drop
  - Using a block for common ground and signal out and voltage in for DAQ recording
  - Uses 570 kOhm and 100kOhm Resistor

Figure 5: Hard-wired Voltage readout

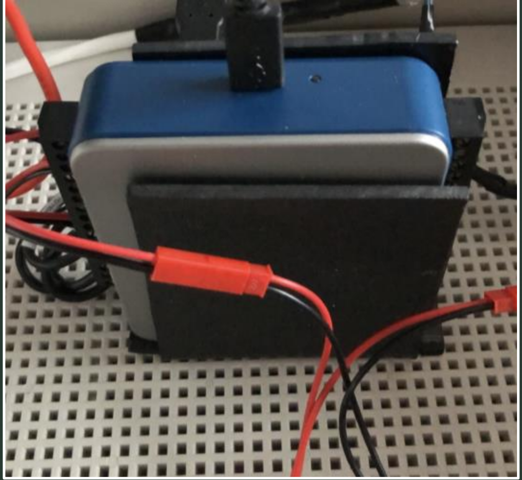
Figure 6: NI DAQ System

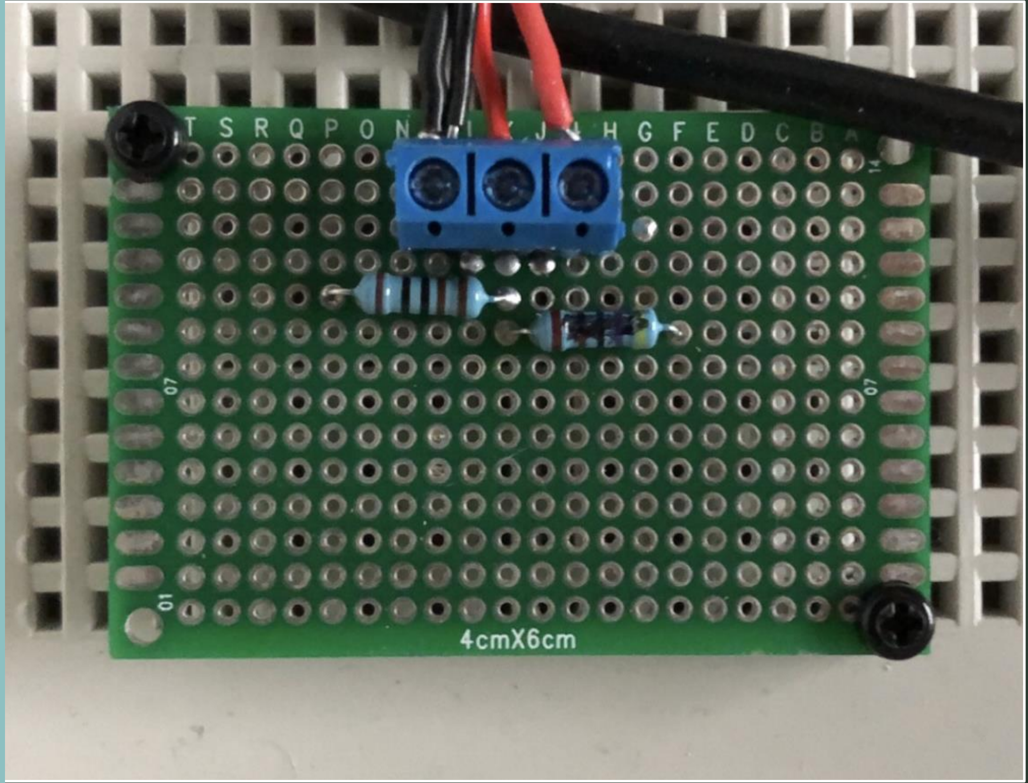

Figure 7: Voltage Drop

Arduino (Environmental)

- LSP25 (Pressure)
- MLP3115A2 (Pressure)
- MAX 31885 (Temperature)

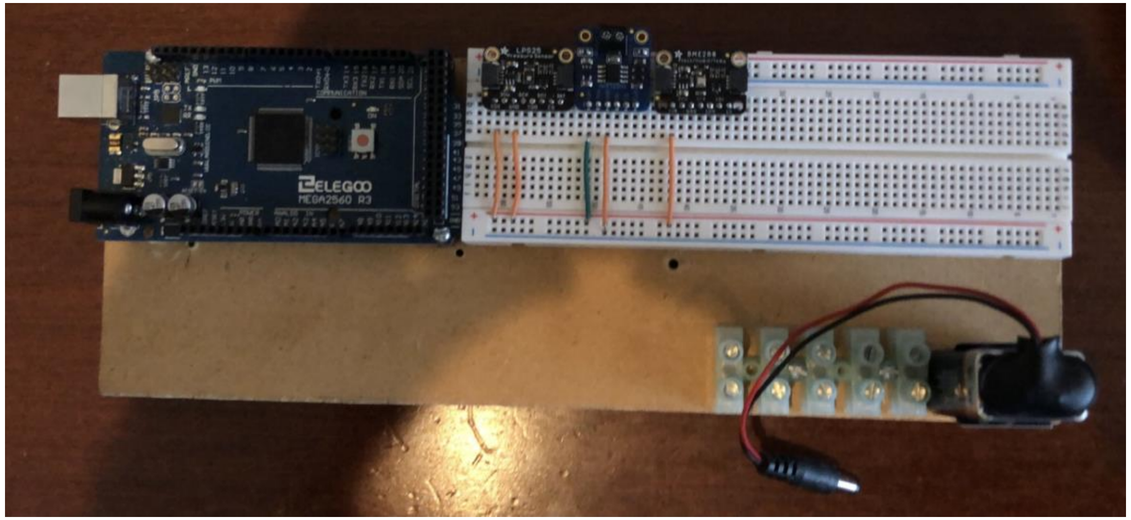

Figure 8: Arduino Testing Facility

Figure 9: LPS25 Pressure Sensor

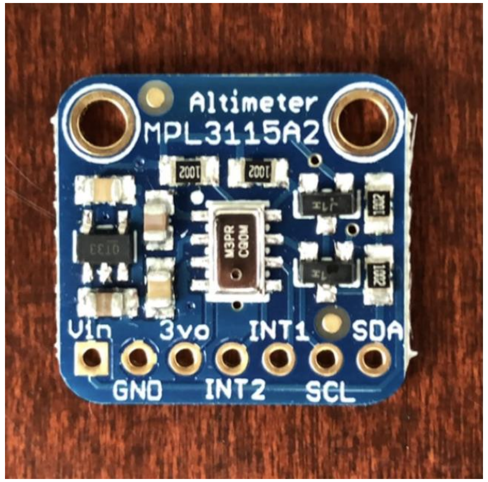

Figure 10: MPL3115A2 Sensor

Figure 11: Liner Actuator

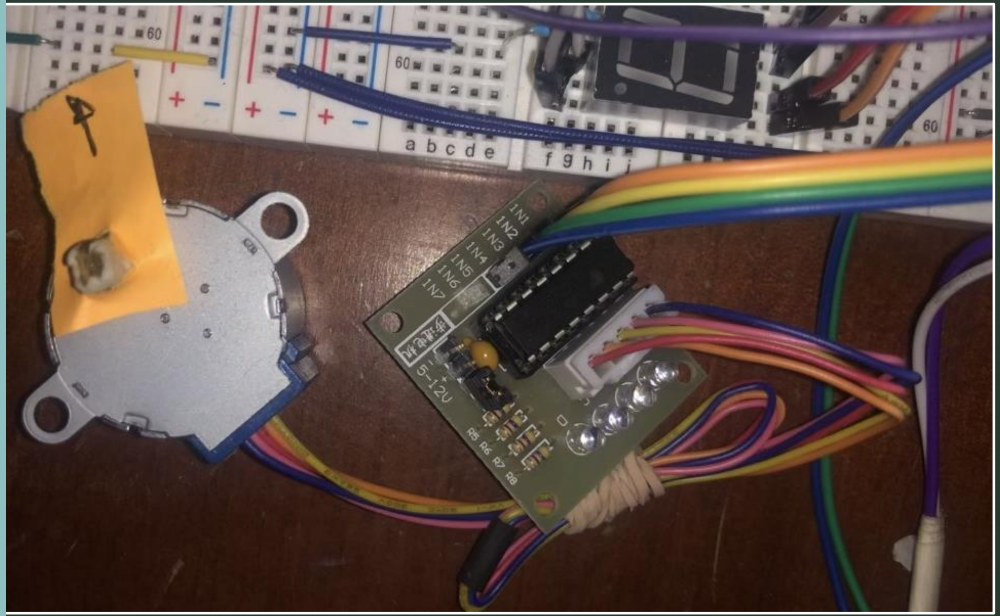

Figure 12: Stepper Motor and Driver

Arduino (Controls)

- Linear Actuator
  - Code has been created for use
- Stepper motor
  - Also created for when team is ready

Shaft Machining (Barry Benson)

- 80% Complete
  - Need to go to machine shop to complete
- More detail later with Bryce
  - Has full CAD file

Figure 13: Partially Machined Shaft and Disk

Tore Cadman

Completed

- Nacelle Cover → *Design/update design*
- Electrical Housing → *Update design for new connection*
- Bracket → *Update design for cover*
- Base Plate → *Remake*
- Tower → *Redesigned + retaining ring*

Next up...

- FEA analysis → *Force analysis*
- System Testing → *Individual/all system testing*

Nacelle-Cover

- Reworked to be one piece instead of three
- Front connection methodology widened
- Front cover piece slope adjustment

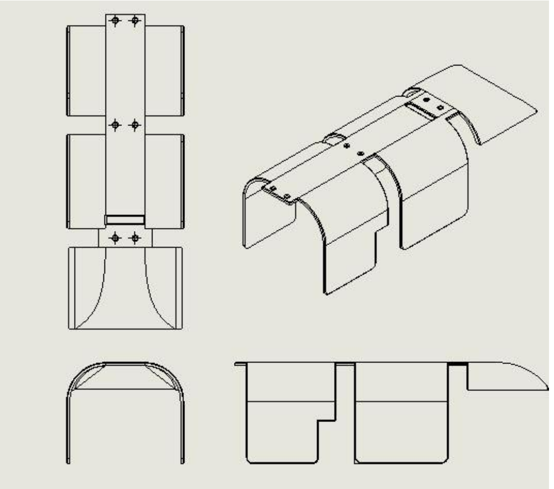

Figure 14: Nacelle-cover drawing

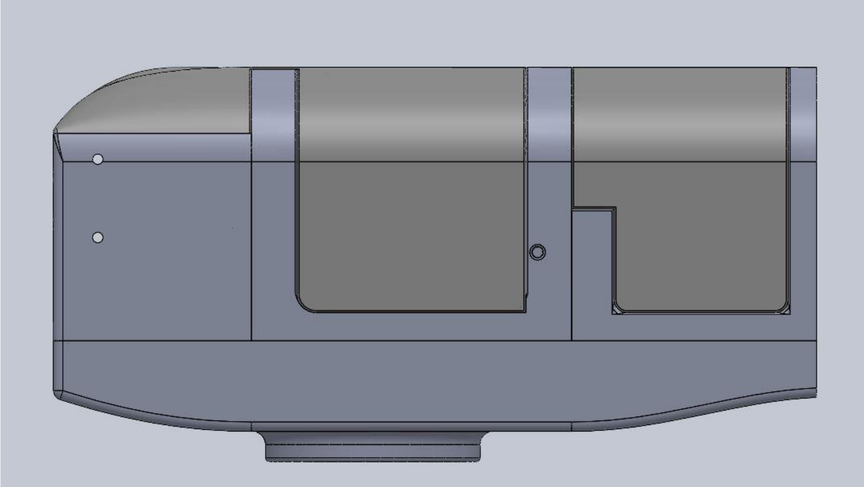

Figure 15: Nacelle-cover on bracket-nacelle

Base Plate

- Not much has changed other than a wider bottom diameter and a thinner plate.
- 6061 Aluminum 9 x 0.5 inches
- Thinner than competition constraints so it fits our model.

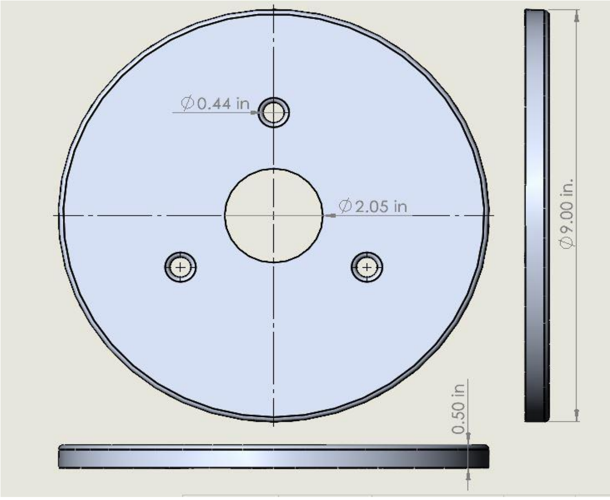

Figure 16: New Base Plate

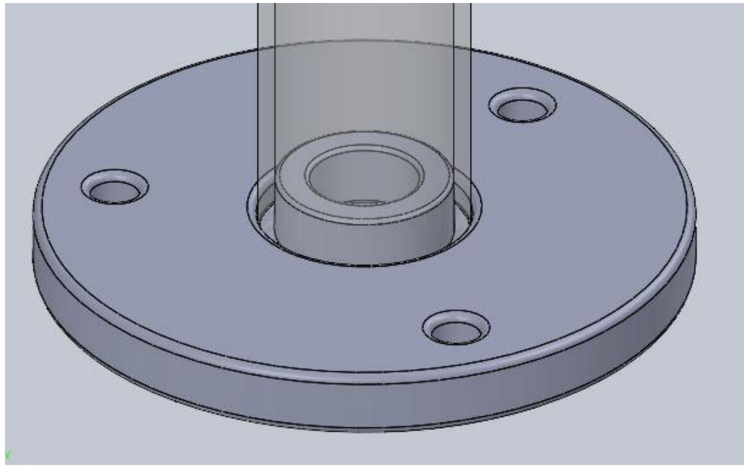
Figure 17: Old Base Plate

Tower/Connection Methodology

- Switched from a PVC pipe tower to a two foot long 6061 Aluminum tower.
- 2.053 outer diameter and 1.220 inner diameter
- Tower connection redesigned for a retaining ring and spacer ring rather than just a press/welded fit.

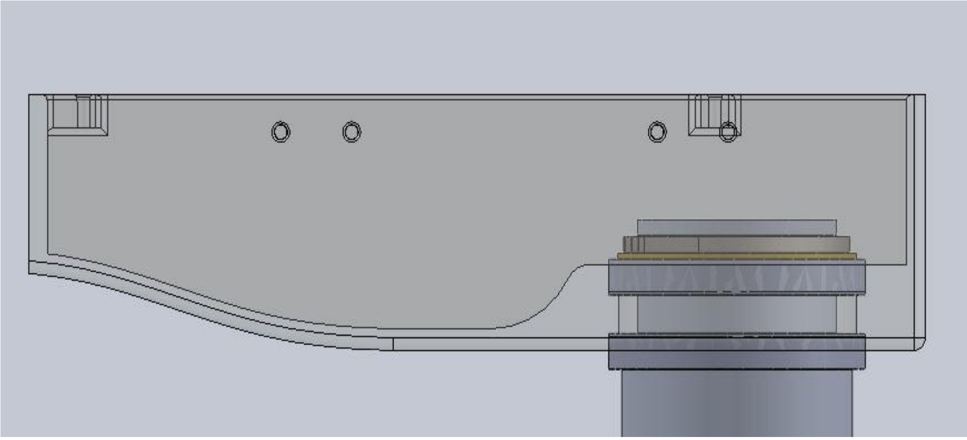

Figure 18: Updated Tower to EE-housing

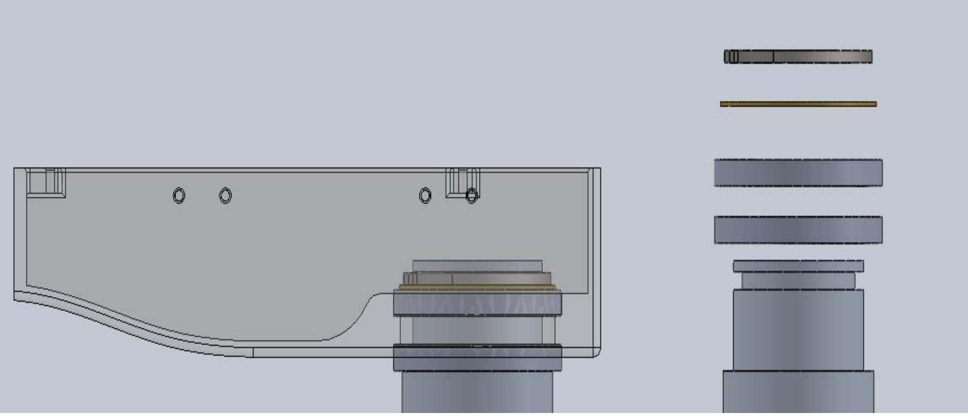

Figure 19: Tower to nacelle connection with exploded view

Bryce Conner

Electrical Housing	Print
Bracket	Reprint
Fin	Redesign and Print
Blade 8	Print
Shaft	Redesign and Print
Static Experiments	Design
Hub	Redesign and Print
Swash Plate	Redesign and Print

Electrical Housing 2 (Tore Cadman - Design)

Print

22 Hours
Warping of Bearing Housing
Extensive Treatment Required

Figure 20:
Printed Electrical Housing

Bracket(s)

Reprint

12-17 Hours
100% infill
PLA Plus
Warping Issues

Figure 21:
Reprinted Brackets using PLA Plus

Fin 3

Design and Print

Larger Surface Area
Midplane Connection
13-15 hours
Brim

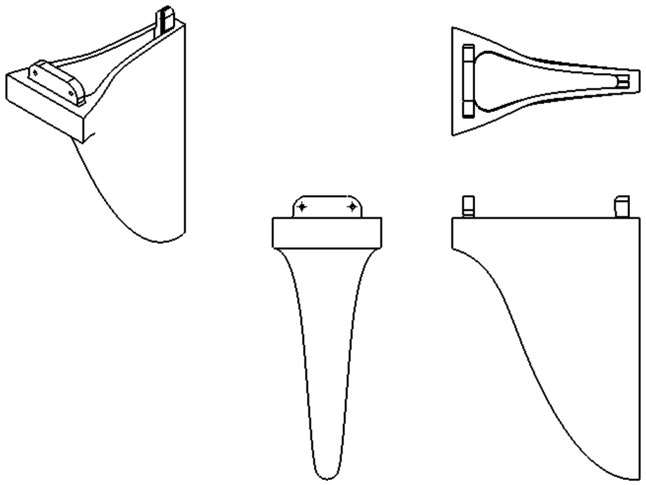

Figure 22:
Lower Segment of Tailfin

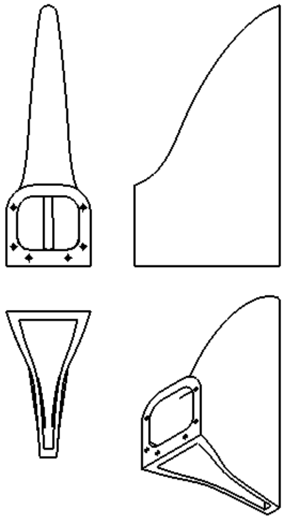

Figure 23:
Upper Segment of Tailfin

Figure 24:
Printed Tailfin Assembly

Blade 8 (Aaron Zeek - Design)

Print

18 Hours
Minimal Treatment
Connection to Heim Joints

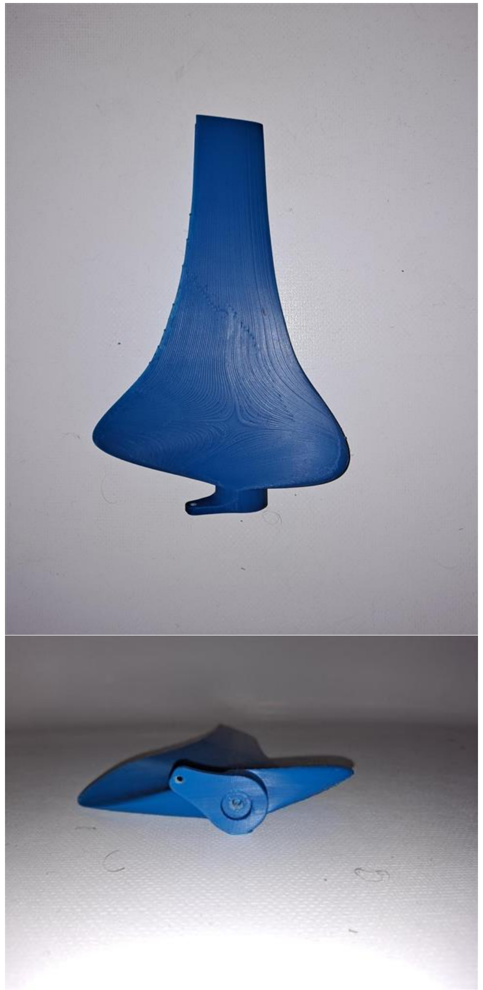

Figure 25:
Printed Blade 8

Shaft 2 (Barry Benson, Joe Conroy – Concept)

Design and Print

One Part
Coupler Clearence
10 Hours

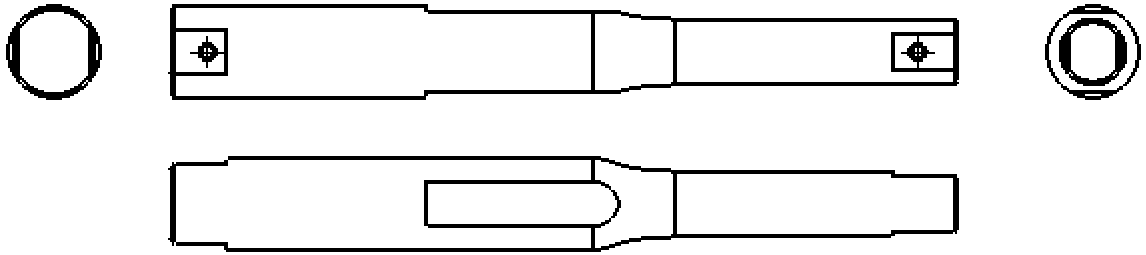

Figure 26:
Single Shaft Redesign

Figure 27:
Singe Shaft Print

Static Experimentation

Design

Weight mouting systems : Start up, Braking, Pitching

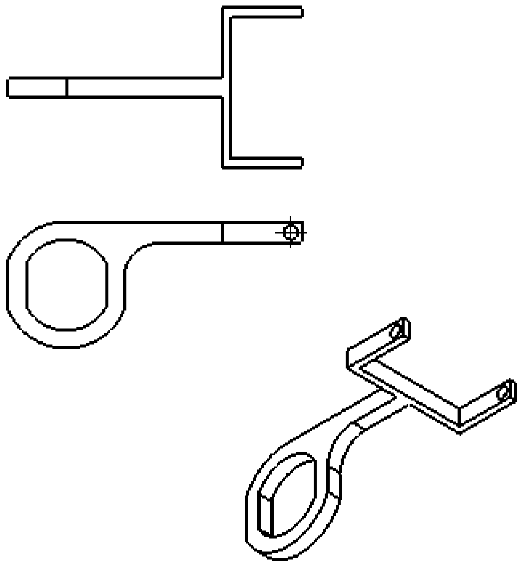

Figure 28:
Start Up Lever Arm

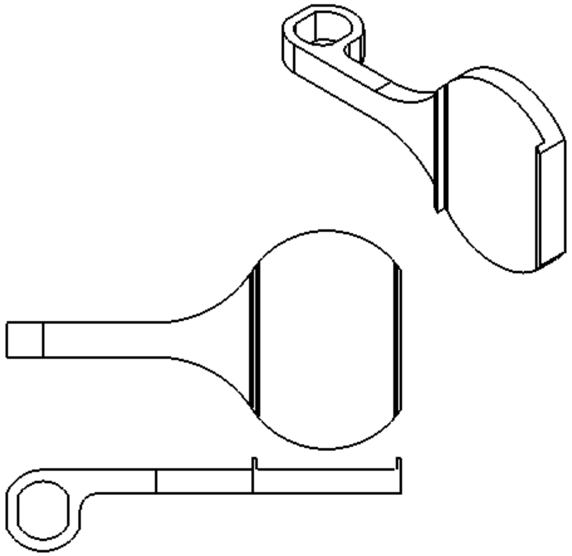

Figure 29:
Holding Torque Lever Arm

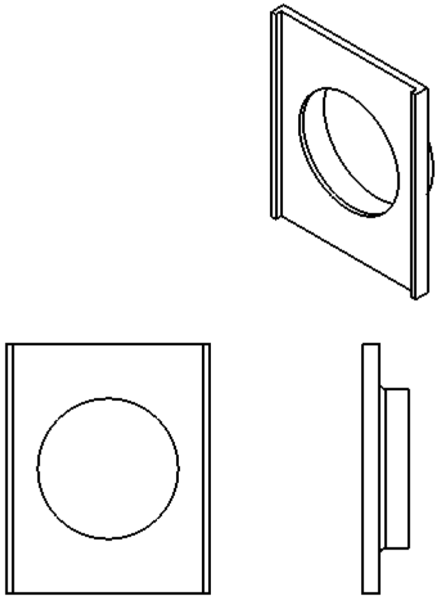

Figure 30:
Rotational Member (Pitch Loading)

Hub

Redesign and Print

M4 Step Up
Sleeves
Extended Surface Area
Deeper Shaft Connection
11 Hours
Minimal Treatment

Figure 31:
Redesigned Printed Hub

Swash Plate

Redesign and Print

Thinner Bearing
Deeper Joint Connections
Larger Pitch Range
Through Holes (Lock Nuts)
PLA Plus
1-2 Hours

Figure 32:
Redesigned Printed Swash Plate

Joseph Conroy

Completed

- Pcc set up
  - Shunt resistor
  - Voltage drop
  - Wiring of PCC box
- Setting up DAQ system
  - Block and dial readout

What's next

- Finishing machining of baseplate
- Setting up final wiring for the turbine
- Conducting initial tests
- Conducting car testing

Turbine set up

Setup
Removing top section of jeep
Place plywood on top of jeep
Place bolts through center holes and strap remaining sections of plywood down

Figure 33: Set up of Jeep without roof

Joseph Conroy

Turbine wiring

- Design and construct
  - Run 12-gauge wiring from PCC to turbine
  - Connect all remaining parts of turbine
  - Ground out all excess wiring

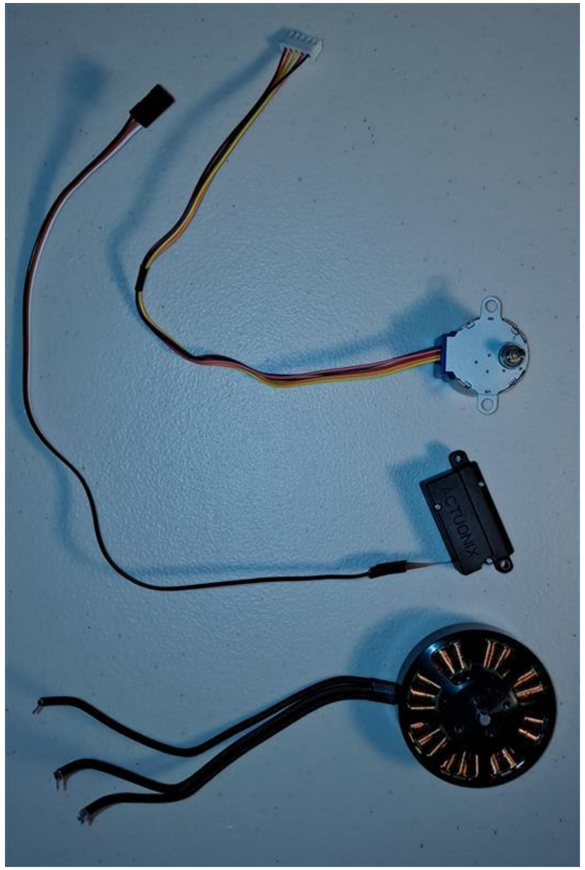

Figure 34: wiring components in the turbine

Joseph Conroy

DAQ system

Redesign
Finalize multipliers to get accurate readouts
Finalize the refresh rate for the dial readouts as well as frequency

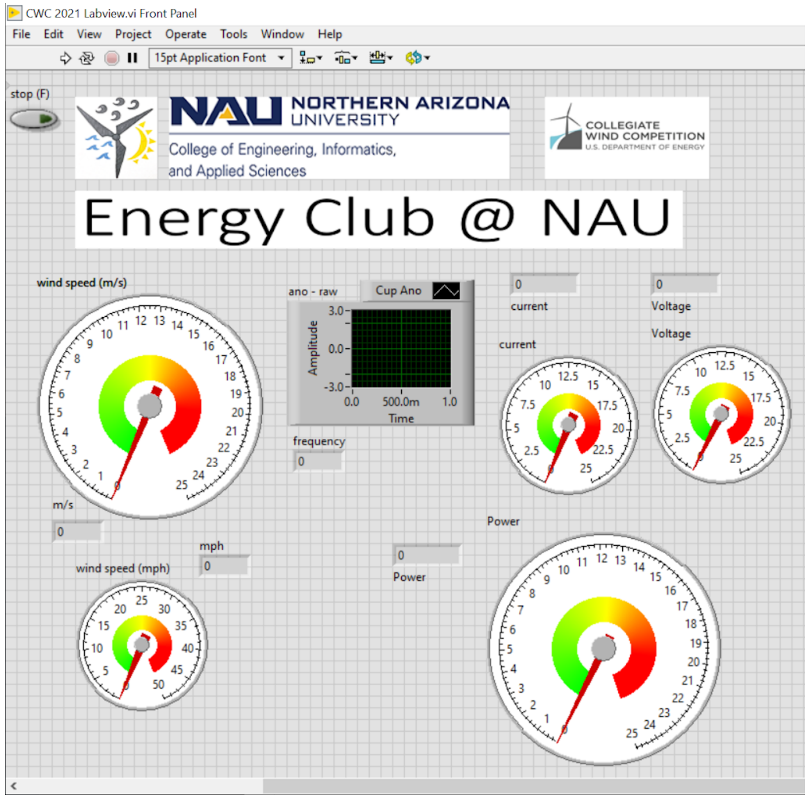

Figure 36: Digital readouts for turbine

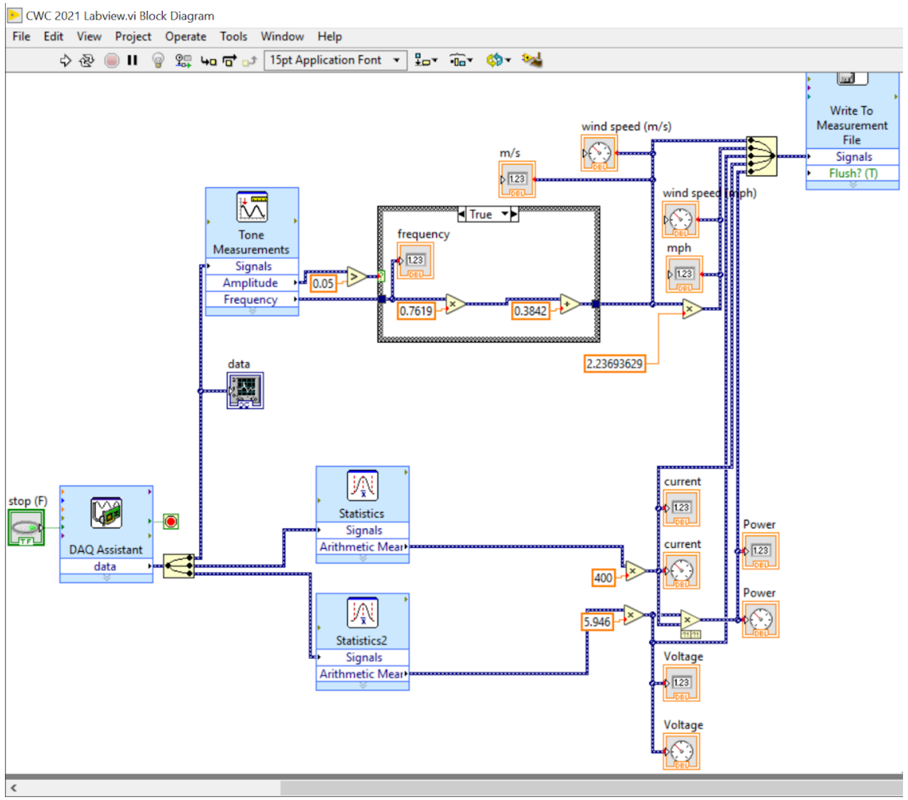

Figure 35: Block Diagram

Joseph Conroy

Stan Kennedy

<u>Completed</u>

- Stepper Motor Reselection
- Brake Pad Boot

<u>Completing</u>

- ANSYS Flow Modeling
- Testing

Stepper Motor Reselection

<u>Initial Product</u>

- Low Holding Torque

<u>Prospective Solutions</u>

- NEMA 17

<u>Prospective Solutions</u>

- Automotive Gauge

Figure 37: Stepper driver

Figure 38: NEMA17 stepper

Figure 39: Stepper motor

Brake Pad Boot

Product Parameters

- High Torque
- Physical Dimensions
- Durable

Designs

- Radial Match
- 2nd Class Lever
- L shaped Boot

Final Design

- L Shaped Boot

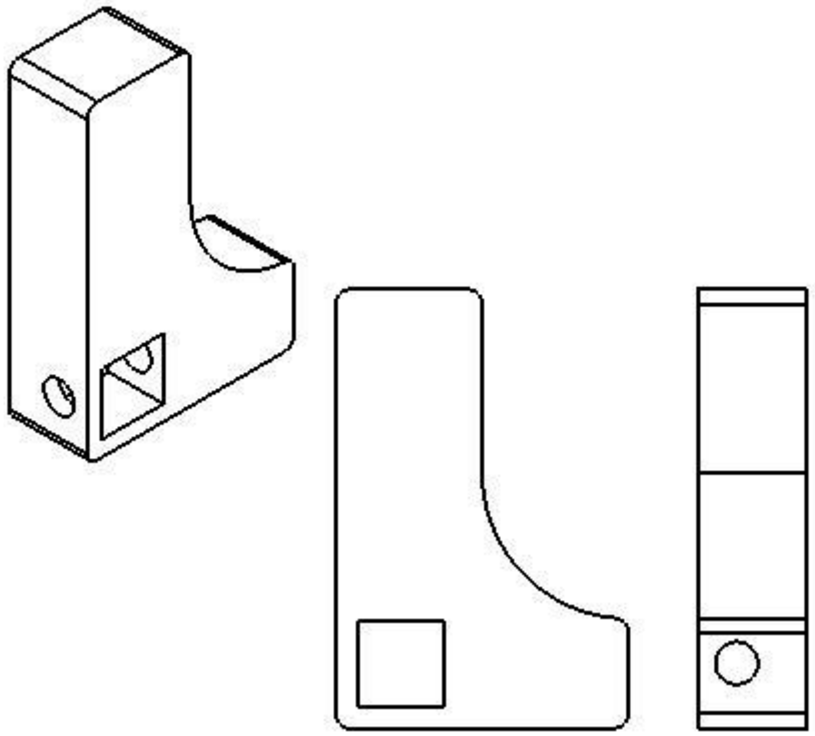

Figure 40:Brake Pad Boot

Aaron Zeek

Blade Redesign: Purpose and Geometry

- Purpose: Meet new engineering requirement of 0.02Nm Torque at start up conditions

- Methodology: Increase rotor solidarity by increasing the chord length near the root

- Airfoils: NACA 2412 & NACA 1412

Table 1 : Blade Geometry

Radial Position [m]	Chord Length [m]	Twist [deg]	in [% chord]	Airfoil Name	360 Polar Name
0.03	0.02	0.00	0.25	Circular Foil	CD = 1.2 360 Polar
0.04	0.02	0.00	0.25	Circular Foil	CD = 1.2 360 Polar
0.06	0.14	31.61	0.25	NACA 2412	T1_Re0.125_M0.00_N9.0 360 M
0.08	0.11	22.50	0.25	NACA 25412	T1_Re0.122_M0.00_N9.0 360 M
0.10	0.08	16.19	0.25	NACA 2412	T1_Re0.083_M0.00_N9.0 360 M
0.12	0.06	13.37	0.25	NACA 1412	T1_Re0.095_M0.00_N9.0 360 M
0.14	0.05	10.30	0.25	NACA 1412	T1_Re0.095_M0.00_N9.0 360 M
0.16	0.04	8.03	0.25	NACA 1412	T1_Re0.092_M0.00_N9.0 360 M
0.18	0.04	6.29	0.25	NACA 1412	T1_Re0.095_M0.00_N9.0 360 M
0.20	0.04	4.93	0.25	NACA 1412	T1_Re0.100_M0.00_N9.0 360 M
0.22	0.04	3.83	0.25	NACA 1412	T1_Re0.100_M0.00_N9.0 360 M

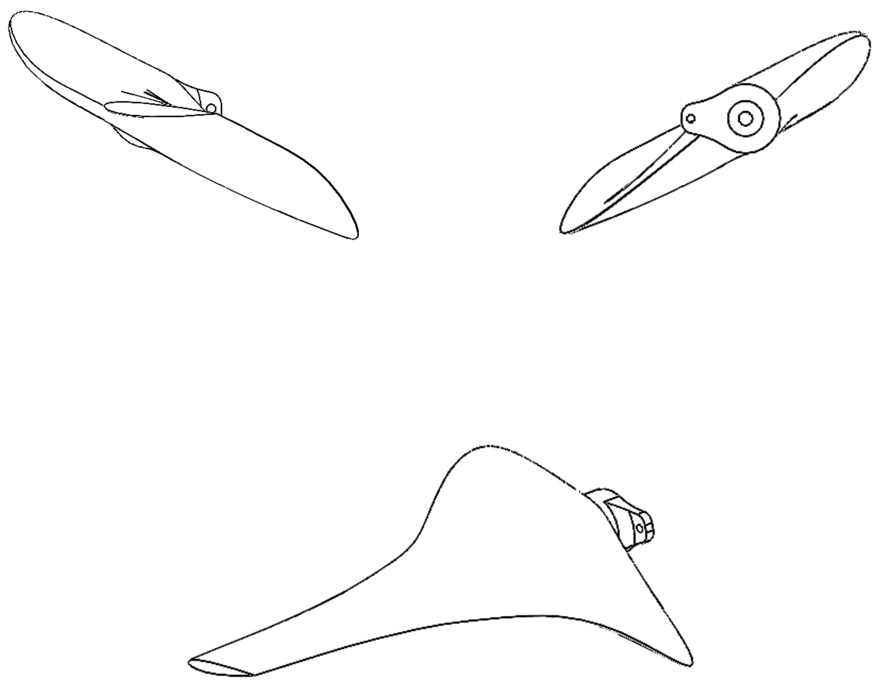

Figure 41:
Blade 8 Design

Aaron Zeek

Blade Redesign: Performance

- Cp = 0.45 at operating conditions
- 0.022Nm at 3 m/s wind speeds and angle of attack of -44 degrees

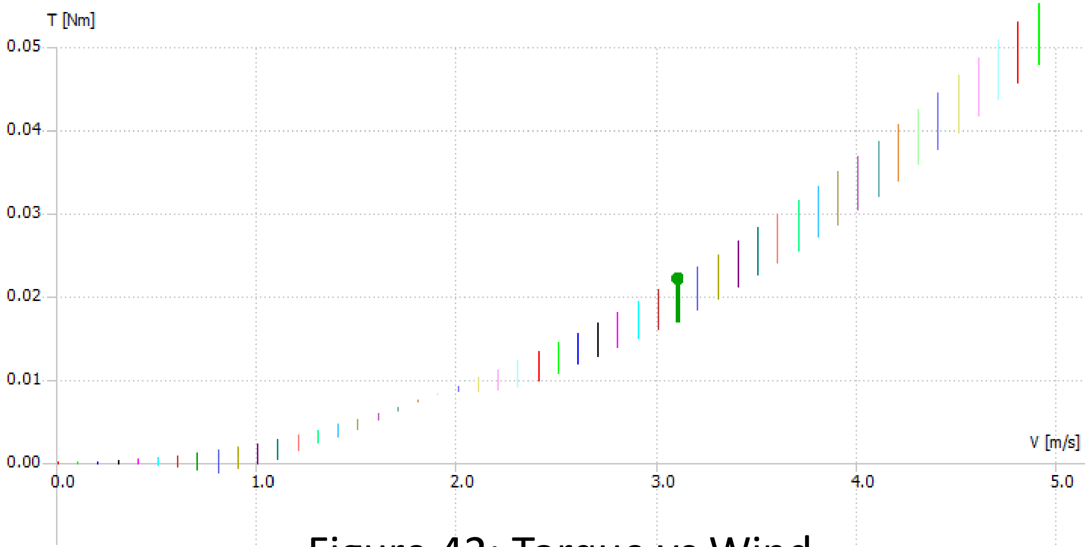

Figure 42: Torque vs Wind speed

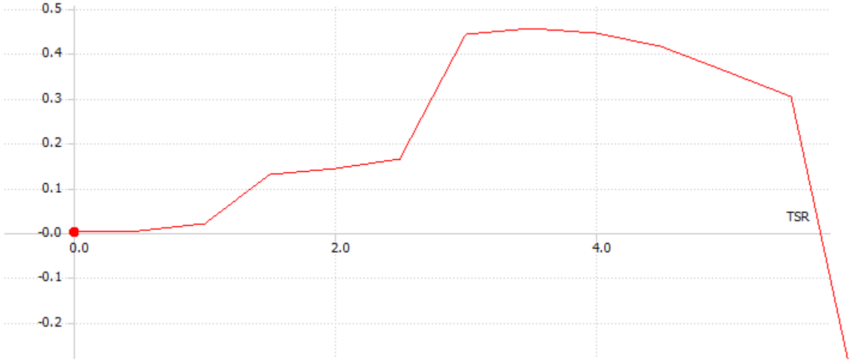

Figure 43: Cp vs Tip Speed Ratio

Future Steps

Redesign

Fin	Bryce
Baseplate	Tore
Slip Ring	Aaron

Printing (Bryce)

Testing Equipment
Electrical Housing 3
Blade 8 (Connection Methodology)
Brackets

Analysis

FEA of Tower	Tore
FEA of Rotor	Bryce

Machining

Shaft	Barry
Tower	Barry
Baseplate	Joe
PCC	Joe

Testing (Team)

Pitching
Start Up
Stall
Rotor Strength
Brake
Yaw
Electrical Load

Submissions (Team)

Hardware Review 2 Memo
Final Presentation
UGRADs Poster
Subassembly and Testing (DoE)
Final Report
Operation Manual
Final CAD Package
Finalized Website
Project and Turbine Report (DoE)

Questions