Aero Micro Midpoint Presentation

NAU Capstone 2019-2020: The Prop Dogs
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3/4/20

Zach

Agenda

1. **Project Review and Description**
2. **Design Description and CAD model**
3. **Current State of System**
    a. Manufacturing and Assembly
    b. Engineering Requirements
    c. Bill of Materials and Budget
4. **Implementation Plan**
5. **Testing Plan**

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Project Review & Description

SAE Aero Micro Class Design
Sponsor: W.L. Gore and Associates
Faculty Advisor: Dr. John Tester

Design process to date:

- Literature Review
- State of the Art Design
- CRs, ERs, and QFD
- Initial Budget and Schedule
- Functional Decomposition: Black Box and Functional Model
- Concept Generation: Methodology and Subsystem Variants
- Concept Evaluation: Pugh Chart & Decision Matrix
- Concept Selection
- Final Design Selection
- Purchasing Parts

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Design Description: Current State Model

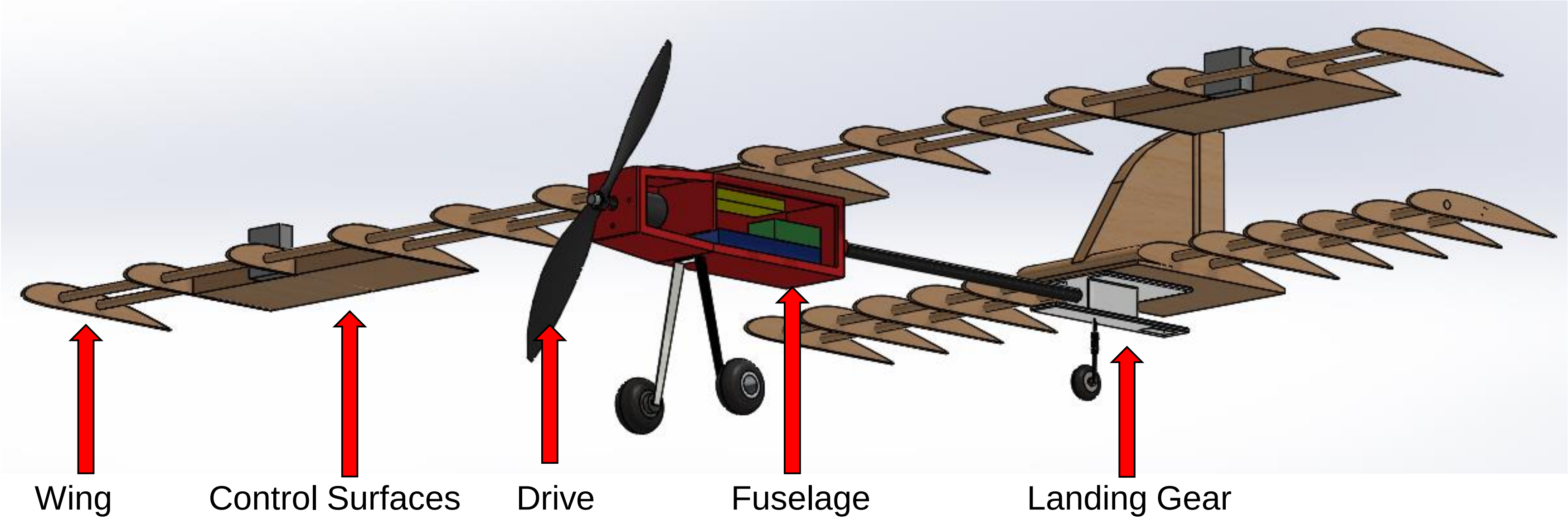

Figure 1: Current State CAD (Iso View)

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Design Description: Current State Model

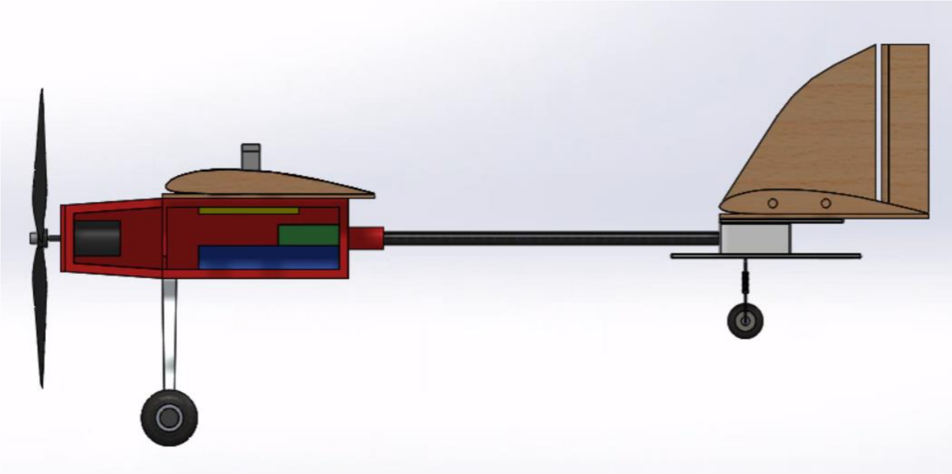

Figure 2: Current State CAD (Side View)

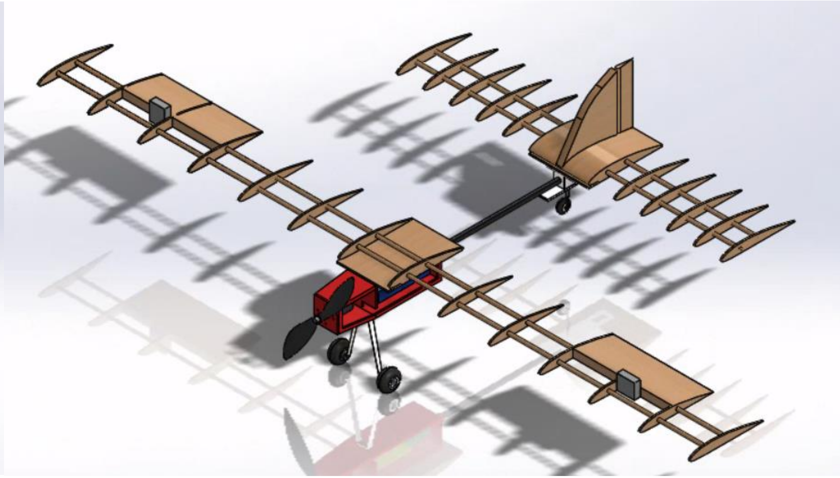

Figure 3: Current State CAD (Iso View)

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Design Description: Current State Model

Table 1: Current State Model

Subdesign	**Design Details**
Drive	Propeller, motor, ESC, battery, wiring, and wire connectors
Fuselage	Frame geometry and material, drive housing, connections with carbon fiber rod, landing gear, and wing
Wing	Airfoil, chord length, wingspan, frame and cover material, wingspan connectors
Landing Gear	Geometry, material, steering mechanism
In-Flight Control	Linkages, motors, receiver, controller, control surface geometry

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Design Implementation Tasks

Table 2: Implementation Tasks

Task	Description	Team Member Assigned
Purchases	Purchasing all materials and keep all invoices for later reimbursement	All team members
Wing ribs	Laser cut balsa wood into Clark Y airfoil profile	Zach: G code Corbin/Eli: Laser cutting
Wing frame segments	Connect ribs using ¼ inch wooden dowels	Eli/Corbin
Ailerons/Elevator	Trim ends of wing sections and pin ailerons/elevator and glue servo and control horns in place connected with push pull rods	Ailerons: All team members Elevator: Corbin

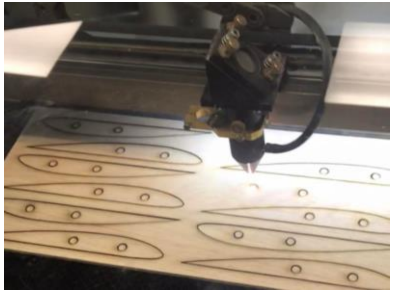

Figure 4: Wing rib laser cutting

Figure 5: Wing segments

Corbin

Design Implementation Tasks

Table 3: Implementation tasks

Task	Description	Team Member Assigned
Fuselage	Using solidworks 3D model fuselage to be able to fit drive components; motor, ESC, Battery, and receiver which are all held in place using velcro and motor mount	Solidworks: Zach
Mount wings to fuselage/empennage	Using nuts and bolts connect base plate of center members of	All team members
Mount fuselage/empennage to carbon fiber rod	Drill holes through shaft collar at rear of fuselage and front of empennage with carbon fiber rod in place and pin using nuts and bolts	Eli/Zach
Landing gear	Bolt front landing gear with two bolts to bottom of fuselage and bolt rear steerable landing gear to empennage connector with servo embedded in empennage connector	All team members
Rudder	Cut vertical stabilizer & rudder profile; attach both using a hinge, glue servo and control horn in place	Eli/Corbin
Controller Setup	Solder ESC and motor and connect ESC to both battery and receiver. Set up controller to actuate servo motors	Corbin/Zach
Monokote	Wrap the wing sections with monokote using sealing iron and heat gun to remove wrinkles	All team members

Corbin

Design Implementation: Design Changes

Wing Design

Wing Calculations

- Wingspan = 52 inches
- Chord Length = 5.9 inches
- Planform Area = 306.8 squared inches
- Aspect Ratio = 8.814

Balsa:

- High manufacture time
- Readily available
- Low density→ low weight

Finalized Wing Design

Wing Calculations

- Wingspan = 39 inches
  - 3 wing segments of 13 inches
  - Desired length based on ERs and CRs
- Chord = 5.9 inches
- Planform Area = 230.1 squared inches
- Aspect Ratio = 6.61

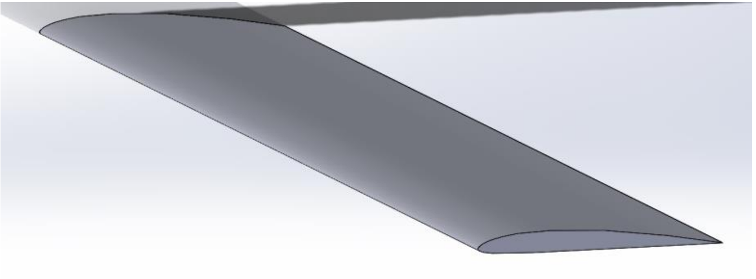

Figure 6: Airfoil Design

Eli

Design Implementation: Design Changes

Figure 7: First Laser cut design

Figure 8: Final Wing Rib Design

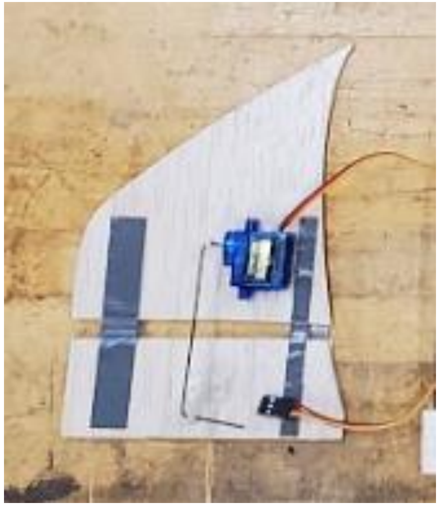

Figure 9: First Rudder Iteration

Figure 10: Final Rudder Design

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Design Implementation: Design Changes

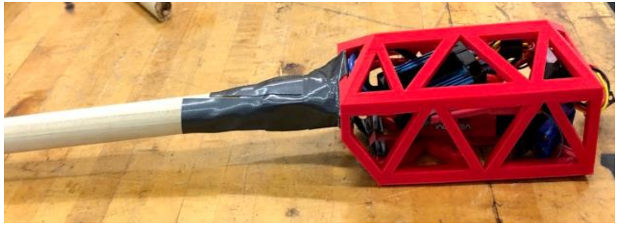

Figure 11: Prototype of the Fuselage

Figure 12: Final Result of Fuselage

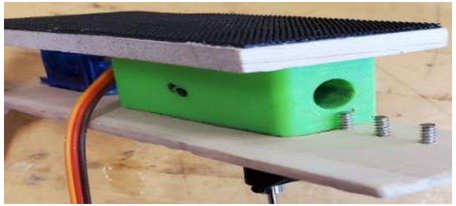

Figure 13: Prototype of Empennage Connection

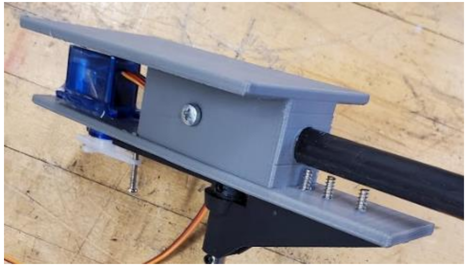

Figure 14: Final Design for Empennage Connection

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Current State of System: Manufacturing

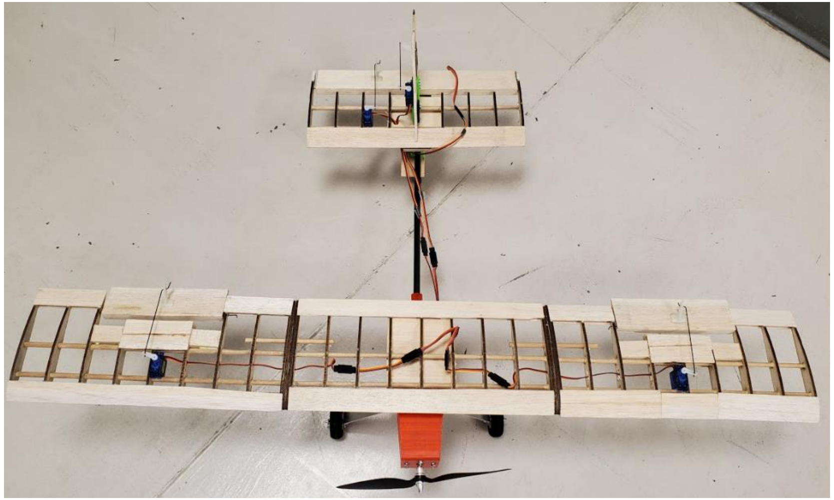

Figure 15: Final Result of Fuselage pre-Monokote

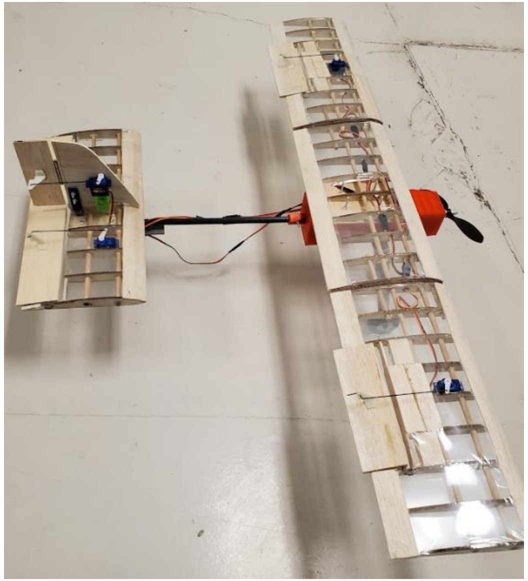

Figure 16: Final Result

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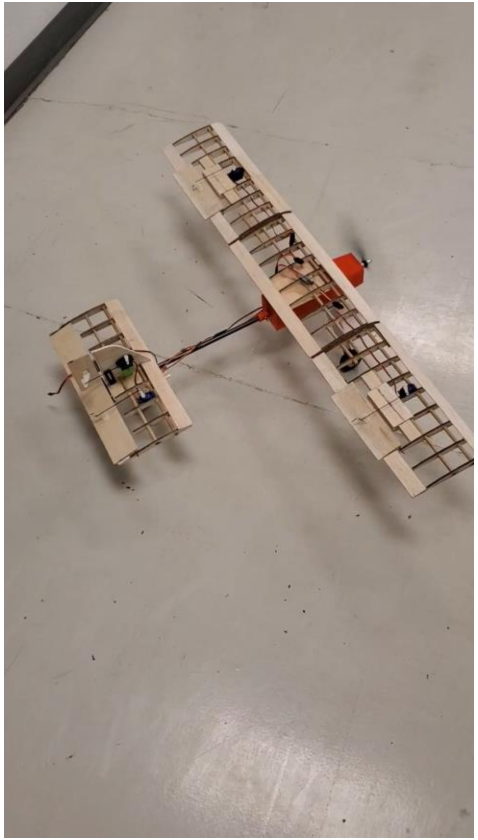
Current State of System: Manufacturing



Eli

Current State of System: ERs

Table 4: Engineering requirements

Engineering Requirements	Target	Tolerance (+-)	Target and Tolerance Rationale
Control Frequency (GHz)	2.4	0.1	Exact competition requirement
Motor Power (Watts)	350	50	Power limited by 2200 mAh battery
Total Weight (lbs)	5	1.5	Benchmarked weights approx. 4-5 pounds [2,3]
Assembly Time (min)	2	0.5	Competition requires assembly under 3 minutes
Battery Capacity (mAh)	1000	250	Optimize weight, max battery capacity 2200 mAh
Storage Volume (in^3)	72.3	20	Calculated for 2-lb payload given PVC density
Storage Length (inch)	16.3	5	Calculated for 2-lb payload given PVC volume
Current (Amperes)	15	5	Benchmarked value for aero micro planes [2,3]
Launch Angle (deg)	5	1.5	Benchmarked value [2,3]
Launch Acceleration (ft/s^2)	1.3	0.3	Benchmarked average overhand acceleration [2,3]
Propeller Velocity (m/sec)	variable	variable	Variable motor rpm
Motor Speed (rpm)	variable	variable	Variable motor rpm
Lift (lb)	2	0.5	Benchmarked value [2,3]
Thrust (lb)	3	0.5	Benchmarked value [2,3]
Cost ($)	550	100	Calculated given budget and prototype materials
Frame Yield Strength (psi)	145	15	Known yield strength of balsa wood

Corbin

Current State of System: BOM and Budget

Table 5: Bill of Materials and Budget

Part #	Part Name	Qty	Description	Functions	Cost ($)
1	Luminier Battery	1	Lumenier 1800mAh Lipo Battery	Stores Power	28.81
2	Ovonic Battery	1	Ovonic 2200mAh Lipo Battery	Stores Power	19.64
3	XT-60 Connectors	4	XT-60 connectors battery to ESC	Connects battery wires to speed controller	7.99
4	XT-60 adapter	10	XT-60 to deans plug adapter	Connects deans battery plug to xt60	10.55
5	Jewelry box hinges	10	Stainless steel butt hinges	Connects rudder to tail wing	11.40
6	Heavy duty velcro	4	Heavy duty j-hook velcro	1st attempt at wing connections	5.36
7	Propeller adapter	4	Mulit-diameter, dome-shaped linkage	Connects 3.5mm motor shaft to propeller	7.63
8	RayCorp 9x4.7 SF propeller	8	Plastic slowfly propeller	generates thrust	11.99
9	APC 8x4.7 SF propelller	1	Plastic slowfly propeller	generates thrust	5.85
10	Enegitech battery charger	1	Charges LiPo batteries	Recharges energy supply to fly and steer plane	30.02
11	Front landing gear	1	Twin-wheeled A-frame landing gear	Translates flight speed into rotational motion	15.99
12	Tail landing gear	1	single-wheeled, springed landing gear	Translates flight speed into rotational motion	10.19
13	Controller and Reciever	1	FlySky 6-channel RC controller and reciever	Programs speed controller and servo motors	45.00
14	Push-pull rods	10	small diameter steel rods	pushes/pulls control surfaces	9.99
15	Control horns	10	triangle-shaped plastic pieces with holes	Mount to control surface and connect to push/pull rods	7.99
16	Servo motors	10	Small electric motors	Convert electrical energy to rotational motion	25.42
17	Carbon Fiber rod	1	3/8"x48" carbon fiber rod	Connect fuselage to rear connector	39.18
18	Motor mount	1	16mmx19mm steel x-mount	mounts fuselaage frame to motor	7.20
19	Scorpion motor	1	HK-2520-1880KV electric motor	Converts electrical energy into rotational energy	121.99
20	Scorpion ESC	1	Commander 15V 45A speed controller	Powers reciever, programs variable speeds to motor	59.99
21	Scorpion Prop adapter	1	Mulit-diameter, dome-shaped linkage	Connects 3.5mm motor shaft to propeller	8.99
22	ECalc Subscription	1	Online flight calculator	Predicts flight charachteristics given drive components	6.99
23	Fuselage prototype	1	Fuselage frame prototype Fall 2019	Provides visual for housing drive components	8.35
24	Hardware	N/A	M3 machine screws,nuts at various lengths	fastens plane components together	20.00
25	Fuselage Frame 1	1	Square-bodied ABS frame	1st attempt at connecting wing, landing gear, and CF rod	12.62
26	Fuselage Frame 2	1	Square-bodied ABS frame	Final attempt at connecting wing, landing gear, and rod	19.45
27	Rudder tabs	4	Rectangular ABS segments	Connect rear wing to rudder	2.34
28	Rear connector	1	I-beam shaped ABS connector	Connects CF rod to tail wing and rear landing gear	5.59
29	Monokote	2	Thin airfoil material	Conforms to wing rib shape, generates lift	30.00
30	Balsa Sheet	1	Thin balsa sheet to cut out wing ribs	Wing ribs have airfoil profile and generate lift	43.29
31	Monokote Iron Sock	1	Cotton cover for monokote iron	Protects monokote from melting	4.00
			Total Cost:		**643.80**
			Overall Budget:		**2000.00**

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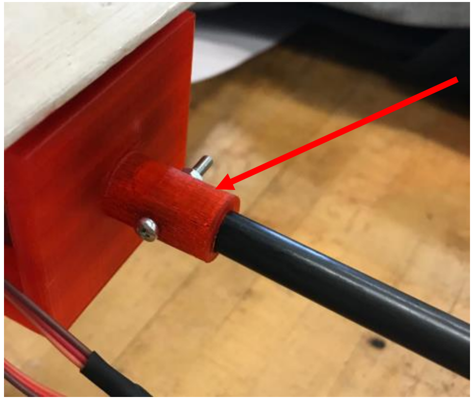
Future Implementation Tasks



Bolt connection through shaft collar

Figure 17: Fuselage/Carbon Fiber Connection

First design of carrying payload

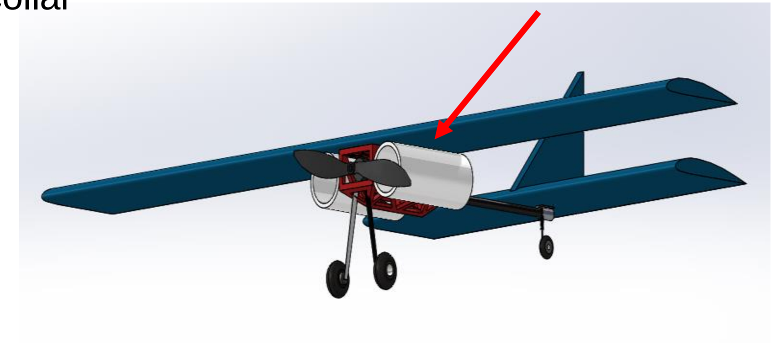


Figure 18: Preliminary Design

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Testing Plan

Testing Procedures:

1. Thrust test ~ March 9th
2. Center of Gravity/Weight test to satisfy ERs ~ March 9th
3. Assembly test to satisfy ERs ~ March 9th
4. Flight Test ~ March 10th

Eli

Questions?

Appendix A: Drive Design

Table A1: Drive Selection

Drive Part	Brand/Model	Size	Weight (oz)	Cost ($)
Prop	APC Electric SF 8x4.7	8" dia x 4.7" pitch	0.25	2.45
Motor	Scorpion HK-2520-1880KV	1" dia, 0.8" length (0.63 in^3)	3.64	80.00
ESC	Scorpion Commander 15V 45A ESC SBEC (V3)	2.83"x1.18"x0.32" (1.06 in^3)	1.55	60.00
Battery	Lumenier 1800mAh 3s 35c Lipo Battery	4.1"x1.34"x0.79" (4.34 in^3)	4.94	20.00
Total		6.03 in^3	10.38	162.45

Figure A1: APC Electric 8x4.7 SF

Figure A2: Scorpion Motor

Figure A3: Scorpion ESC

Figure A4: Lumenier Battery