SAE AERO: Micro Class

Spencer Makar – Project Manager

Ethan Shoemaker – Logistics Manager

Ryan Downey – Test Engineer

Conner Nolan – Manufacturing Engineer

Katrina Kevorkian – Financial Manager

Hector Medrano – CAD Engineer

Project Description

- SAE Micro Aero Competition
  - Build and design full electric airplane to compete in S22
  - Abide by standards and rules outlined in competition handbook
  - Stakeholders: Dr. Willy, CEIAS
- Objectives
  - Prototype and test airplane soon and often
  - Refine and improve areas of weakness

Current CAD Model

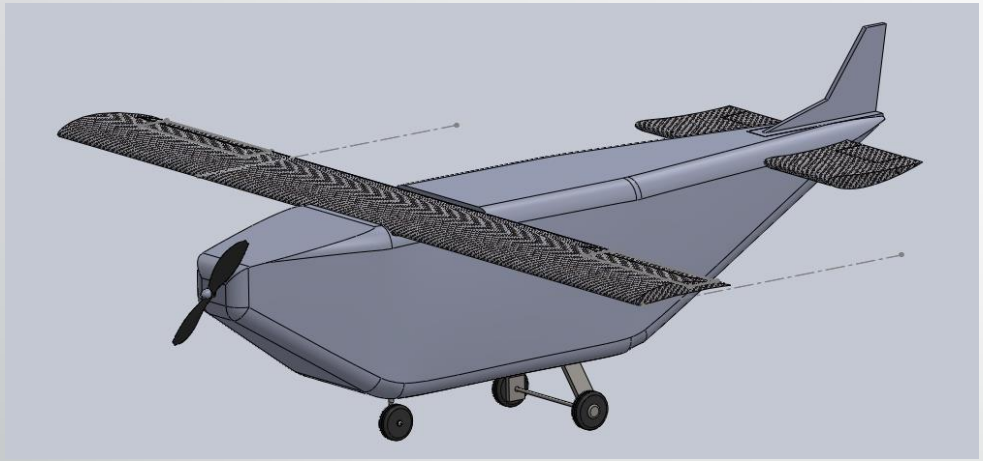

Figure 1: Isometric View - Assembly

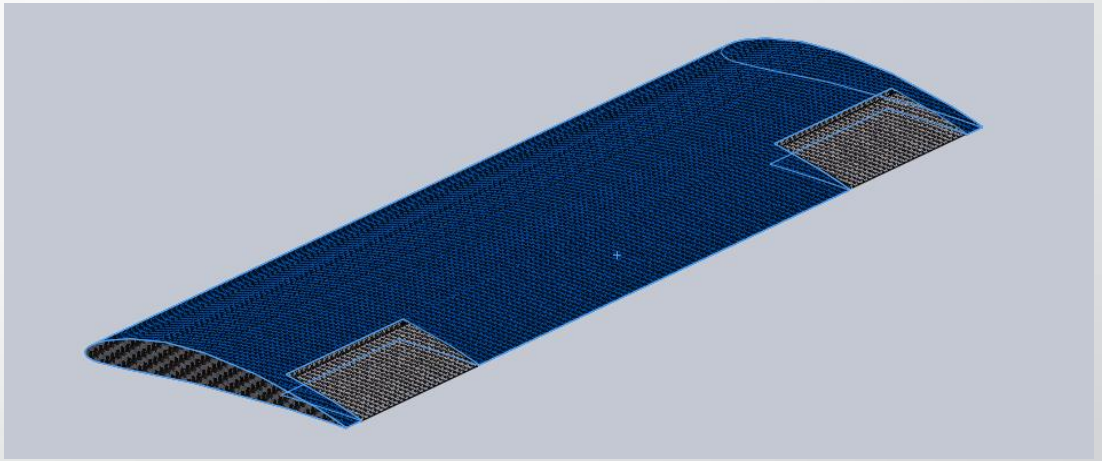

Figure 2: Isometric View - Airfoil

Customer Requirements

- Minimize time of flight in first 300'
- Carry Payload
  - 12" x 12" x 2"
  - 6" x 6" x 4"
  - Metal payload
- 2.4 GHz operating frequency
- Unload payload in less than 1 minute following landing

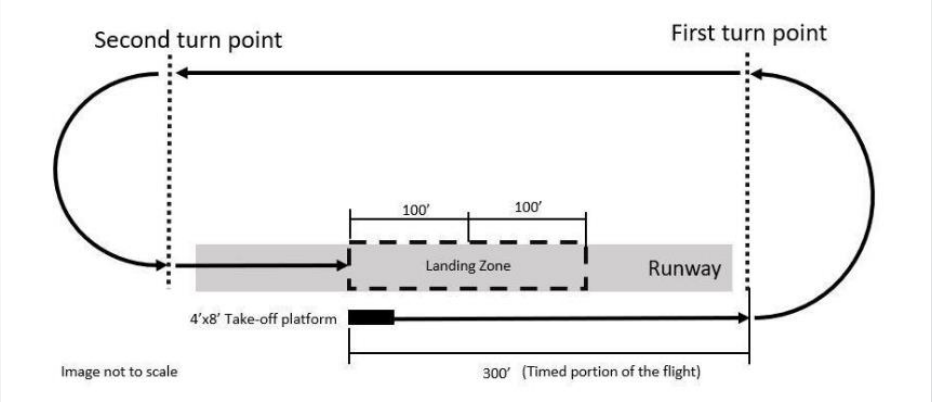

Figure 3: Competition Track

Competition Scoring

$$Flight\ Score = FS = 80 * \frac{\sqrt{W_{Payload} * Bonus}}{T_{Flight}}$$

$$Bonus = 0.5 + (1.0 * N_{Large}) + (0.4 * N_{Small})$$

Figure 4: Individual Flight Scoring

$$Final\ Flight\ Score = FSS = FS_1 + FS_2 + FS_3$$

Figure 5: Flight Score Summation

- Attempt to minimize T_{Flight} and maximize $W_{payload}$
- Will not carry a large box in order to retain a traditional aircraft geometry and carry more weight in the form of metal payload

Design Analysis

- Lift/Drag Analysis
  - Estimated to be able to carry up to three times dry weight
- Power Analysis
  - All electronic components can handle supplied current
- Manufacturing Analysis
  - Ease of manufacturing will be accomplished through partnership with Novakinetics

Lift/Drag Analysis

- Estimated dry weight of aircraft (no payload) ~2.85 lbs
- Estimated maximum lift force ~9lb

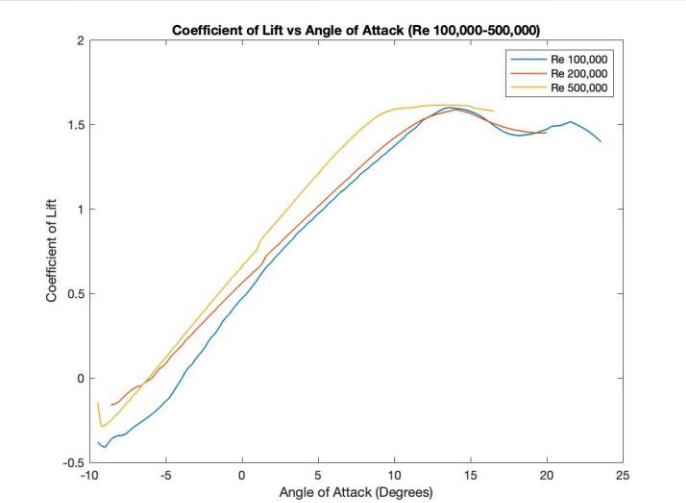

Figure 6: Coefficient of Lift vs AoA

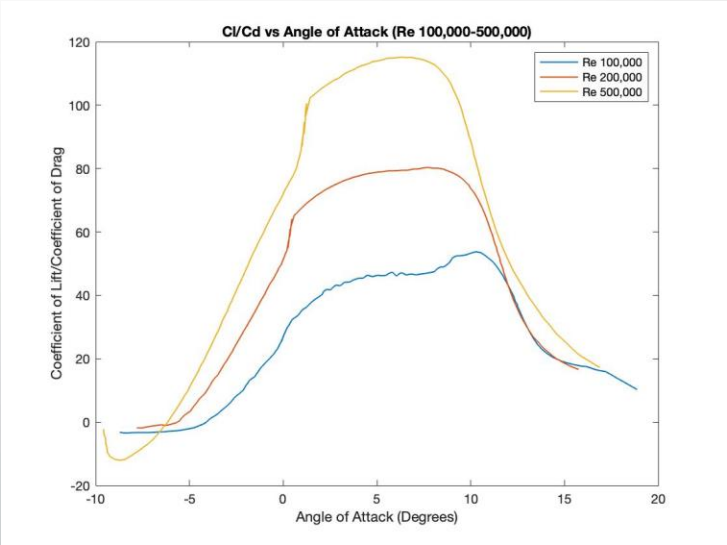

Figure 7: Cl/Cd vs AoA

Power Analysis

- Motor will draw ~30.5 A; all chosen components are capable of handling this current
- 1000 mAh battery will support this system for almost 2 minutes

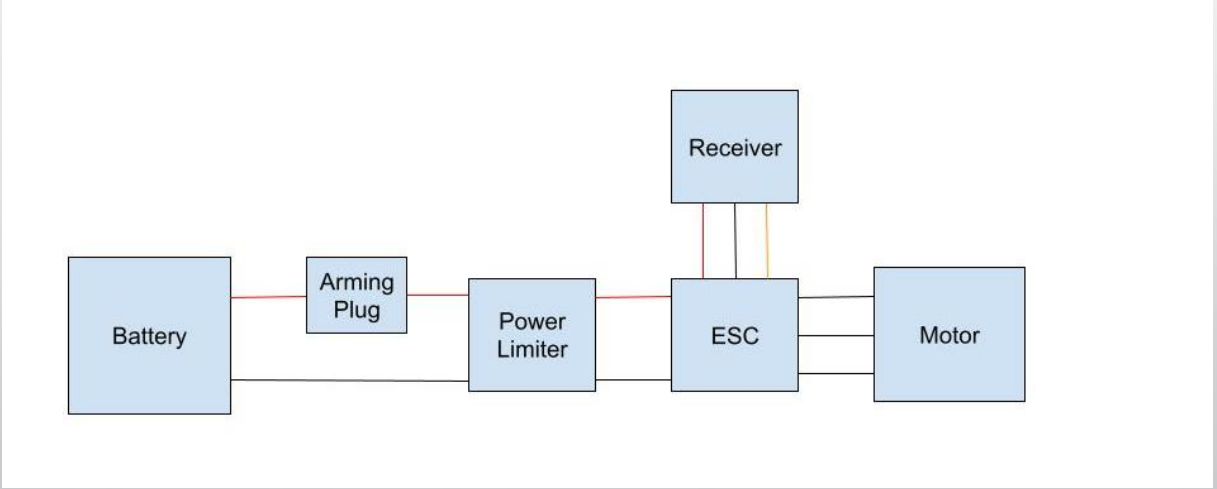

Figure 8: Electronic Schematic

Manufacturing Analysis

- Will begin by constructing a prototype made of foam
- Carbon fiber manufacturing techniques
  - Wet lay-up
  - Pre-preg

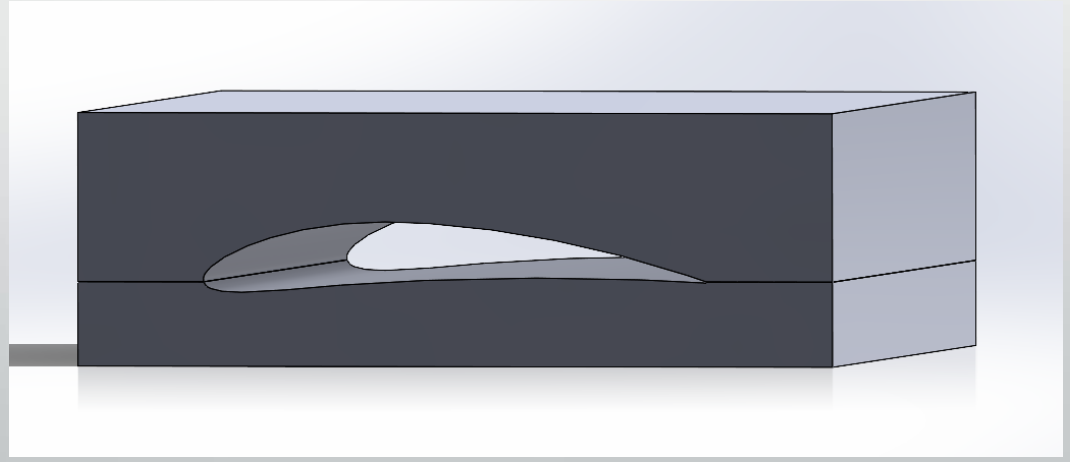

Figure 9: Female Mold

FMEA

Table 1: FMEA Analysis

Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Causes and Mechanisms of Failure	Occurance (O)	Current Design Controls Test	Detection (D)	RPN	Recommended Action
1.Transmitter	Signal Interference	Loss of control/crash	8	out of range	4	Test moving components	1	32	none
2. Servos	High-cycle fatigue	limited control of rolling aircraft	7	overstressing	2	move ailerons	1	14	pair proper servo with function
3. Power Limiter	Corrosion Fatigue	incorrect power supplied	4	over voltage/current input	2	test controls	2	16	redesign internal electronics
4. Receivers	Connection Error	no connection between remote and plane	9	no power	2	ensure connection	3	54	redesign for a longer range
5. Motor	High-cycle fatigue	bearnings in motor fail	8	over use /incorrect power supplied	3	ensure motor runs properly	1	24	consider replacing motor sooner
6. Propeller	deformation wear	no thrust achieved	7	impact, plastic strain	2	run motor and spin propeller	1	14	replace with more suitable propeller
7. Speed Controller	elecrical overstress	no control of speed	5	incorrect power supplied	3	run motor at varying speed	3	45	replace connections or device
8. Battery	thermal fatigue	decreased capacity	4	incorrect charging	5	test flight time	7	140	replace battery
9. Airfoil	fretting wear	deform airfoil shape, altering lift	3	assembly error	4	analyze structural integrity	2	24	use material with lower plastic deformation
10. Kill Switch	Galvanic Corrosion	inoperable kill switch	7	kill switch does not work in emerge	1	ensure connection between kill switch and wires is correct	4	28	use less corrosive conductive material
11. Landing Gear	Buckling	loss of landing functionality	5	impact with ground	6	put plane on ground	3	90	redesign with a more ductile material
12. Wires	Thermal fatigue	failure of other components	7	constant prolonged use	3	test electrical components	4	84	use wires with higher thermal capacity
13. Fuselage	Impact Fatigue	fuselage will fall apart, rendering unusable	9	impact with ground	3	test flights	1	27	redesign with stronger material

- Critical Potential Failures
  - Battery –Thermal Fatigue (140)
  - Landing Gear – Buckling (90)
  - Wires – Thermal Fatigue (84)

Mitigation of Failure

- Battery- Thermal Fatigue
  - Ensure that proper charging techniques are followed and that the battery is properly selected for its purpose and intended performance
- Landing Gear- Buckling
  - Design landing gear with a factor of safety that will be able to withstand the force exerted when the plane is landing, so no buckling occurs
- Wires- Thermal Fatigue
  - Chose wires that are rated for the current that is going through them, so they do not overheat and fail in testing and or competition. This was proven to not currently be an issue through the power analysis performed.

Testing Process Success Criteria

- Successfully flight testing with a load will validate that the design is suitable for competition and meets the engineering requirements in the following ways:
- Successful take off shows that the aircraft can be controlled on the ground and that lift, drag and thrust requirements are met, and the plane is usable
- Completing a competition trial in testing proves that the battery is suitable, along with the range of the RC being adequate to compete, and the aircraft having proper flight control
- Testing durability of the aircraft will happen if the plane crashes, if it is usable afterwards, the durability requirement will be met

Testing

- Locations
  - Open areas such as parking lot, field, park for takeoff testing and competition simulation
- Equipment
  - Flat hard space for the plane to take off from
  - Stopwatch
  - Weights
  - Plane and pilot
- Resources
  - Computer
  - Time
  - Team availability
  - Spare parts for instance of failure

Schedule

- Based on the weeks section
- Team Goals
  - Foam Prototype completed by week 4
  - Carbon fiber prototype completed by week 8

ME 486C – Mechanical Engineering Design II

Fall 2021 - Tentative Schedule

(subject to change – check Bb Learn for the current schedule)

Week	Week Starts	Agenda	Individual Assignments	Team Assignments
1	23-Aug	Team/Staff Meetings		**Post Mortem Due**
2	30-Aug	Team/Staff Meetings	**Self Learning Due**	
3	6-Sep	Team/Staff Meetings		
4	13-Sep	**Hardware Review**	**Peer Eval 1 due**	
5	20-Sep	Team/Staff Meetings		**ERs and TPs revamp memo**
6	27-Sep	Team/Staff Meetings		**Website Check**
7	4-Oct	Team/Staff Meetings		**Implementation memo**
8	11-Oct	**Midpoint Presentation**	**Peer Eval 2 due**	**Presentation**
9	18-Oct	Team/Staff Meetings	**Individual Analysis II due**	
10	25-Oct	**Hardware Review**		**Hardware Review 2 meeting and memo**
11	1-Nov	Team/Staff Meetings		**Website Check**
12	8-Nov	Team/Staff Meetings		**Draft of Poster**
13	15-Nov	**Final Presentations**	**Peer Eval 3 due**	**Presentation**
14	22-Nov	**Final Product Due**		**Final Product, Operation/Assembly Manual**
15	29-Nov	Team/Staff Meetings		**Final Report, Final Poster**
Finals	6-Dec	**Client Project Handoff**	**Peer Eval 4 due**	**CAD package, Website Check**

Adapted from 486C schedule

Simplified Budget	
3000	Total Budget
-1500	Registration Fee
-423.41	Order 1
-53.83	5% Safety
1022.76	Remaining Budget

Simplified Budget

Budget

SAEaero Capstone Project

NOTE: Difference columns in table will show if actual went over estimated amounts. Red numbers show went over (negative) and black shows under numbers (positive).

			Itemized Cost ($)			Total Cost ($)		
Area	Items	Quantity	Estimated	Actual	Difference	Estimated	Actual	Difference
Propeller	acp 9x4 Propeller	7	($3.00)	($2.84)	$0.16	($21.00)	($19.88)	$1.12
Propeller	acp 9x4 Propeller Z Shipping/Tax	1	($5.00)	($4.50)	($0.50)	($5.00)	($4.50)	$0.50
Electronics	Amazon Adaptors	1	($10.00)	($9.42)	$0.58	($10.00)	($9.42)	$0.58
Electronics	Amazon Wires	1	($10.00)	($9.89)	$0.11	($10.00)	($9.89)	$0.11
Electronics	Amazon Z Shipping/Tax	1	($1.00)	($1.77)	($0.77)	($1.00)	($1.77)	($0.77)
Electronics	Hobby King Battery	3	($18.00)	($17.01)	$0.99	($54.00)	($51.03)	$2.97
Electronics	Hobby King Connectors	1	($4.00)	($3.03)	$0.97	($4.00)	($3.03)	$0.97
Electronics	Hobby King Servos	7	($4.00)	($3.49)	$0.51	($28.00)	($24.43)	$3.57
Electronics	Hobby King Speed Controller	1	($22.00)	($21.99)	$0.01	($22.00)	($21.99)	$0.01
Electronics	Hobby King Z Shipping/Tax	1	($15.00)	($29.36)	($14.36)	($15.00)	($29.36)	($14.36)
Wings	Horizon Hobby Material for Wings	1	($13.00)	($12.99)	$0.01	($13.00)	($12.99)	$0.01
Wings	Horizon Hobby Material for Wings Z Shipping/Tax	1	($5.00)	($5.55)	$0.55	($5.00)	($5.55)	($0.55)
Motor	Motor	1	($100.00)	($146.57)	($46.57)	($100.00)	($146.57)	($46.57)
Registration Fee	Registration Fee	1	($1,500.00)	($1,500.00)	$0.00	($1,500.00)	($1,500.00)	$0.00
Electronics	SAE Competition Power Limiter	1	($75.00)	($83.00)	($8.00)	($75.00)	($83.00)	($8.00)
Total Budget	Total Budget	1	$3,000.00	$3,000.00	$0.00	$3,000.00	$3,000.00	$0.00
Subtotal			$1,215.00	$1,148.59	($66.31)	$1,137.00	$1,076.59	($60.41)
Unexpected Costs (add 5% estimated)			($57.43)			($53.83)		
Total costs			$1,157.57			$1,022.76		