SAE Aero Competition

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Project Description

- SAE Aero Competition
- Improve upon previous designs
  - Stability and controllability
  - Avoid crashing
  - Power issues

Figure (1): SAE Logo [1]

Figure (2):Last years design [2

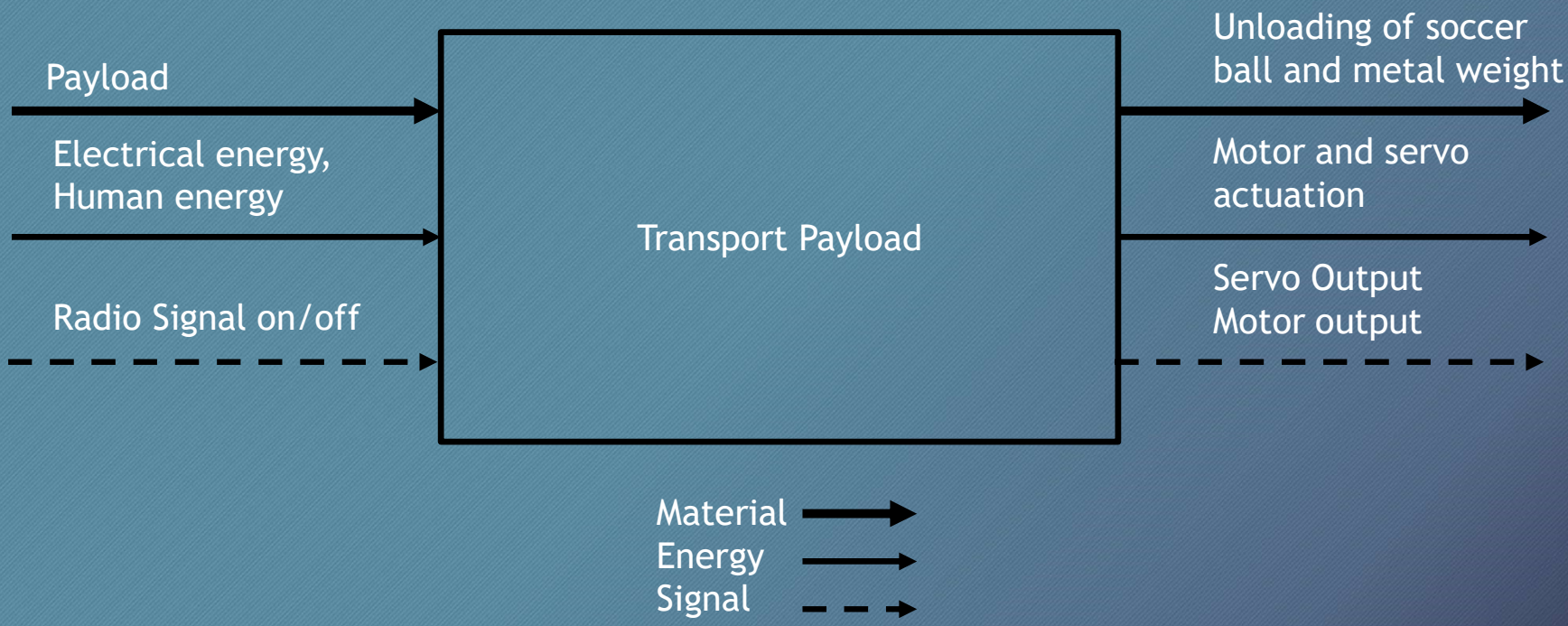
Slide 2

RJS1 THoughts Aiden I changed the colors
Ryan J Stratton, 2/21/2021

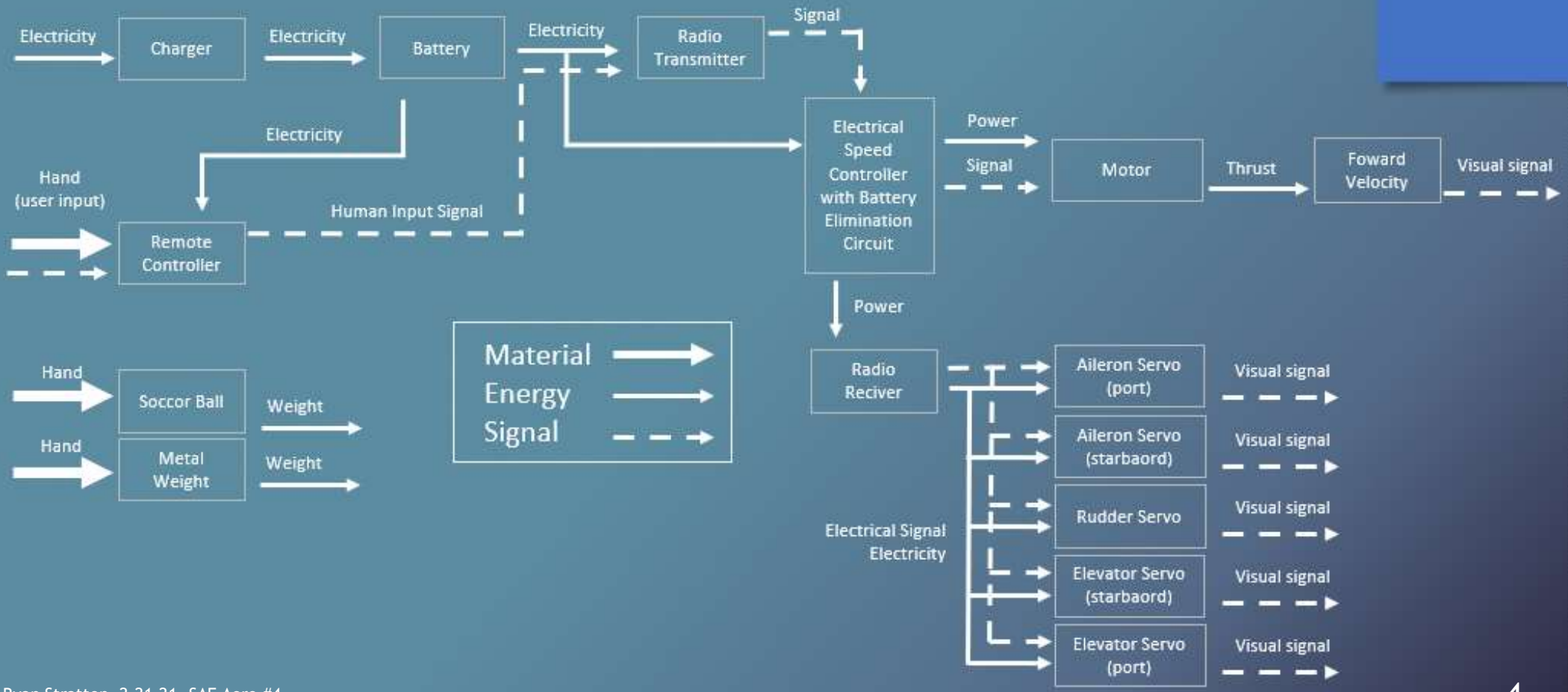
AH1 Looks good
Aiden Hudson, 2/21/2021

RJS2 Glad you dont hate it that off blue was killing me
Ryan J Stratton, 2/21/2021

Black Box


Payload
Electrical energy,
Human energy
Radio Signal on/off
Transport Payload
Unloading of soccer
ball and metal weight
Motor and servo
actuation
Servo Output
Motor output
Material
Energy
Signal

Functional Model



Concept Generation

- To better understand our decisions, lets first go over competition limitations
  - Aircraft must carry a soccer ball
    - Additional weight helps
  - Take off in less than 100 ft of runway
  - Land in less than 400 ft of runway
  - Must complete flight in less than 120s
  - Wingspan needs to be less than or equal to 10 ft
  - 1000 W power limiter

$$Flight\ Score = 120 * \frac{3*S+W_{Payload}}{b+L_{Cargo}}$$

S = Number of Soccer balls

$W_{Payload} = Weighted\ Paylod\ (lbs)$

$L_{cargo} = Length\ of\ Cargo\ Bay\ (inches)$

b = Aircraft Wingspan (inches)

Competition Main Limitation

- When designing the aircraft our biggest limiting factor is power per pound ratio
  - 50-70 watts per pound; Minimum level of power for decent performance, good for lightly loaded slow flyer and park flyer models
  - 70-90 watts per pound; Trainer and slow flying scale models
  - 90-110 watts per pound; Sport aerobatic and fast flying scale models

  - Our design is limited to 55 lbs

Figure (3): Rc airplane weights less than 0.5 lbs and has a 25-watt motor [3]

Fuselage Considerations

- Battery Size and Weight
- Payload Size
  - ~8.6-9.0 in. Diameter
- Scoring
- Parameters
  - Must fully enclose payload

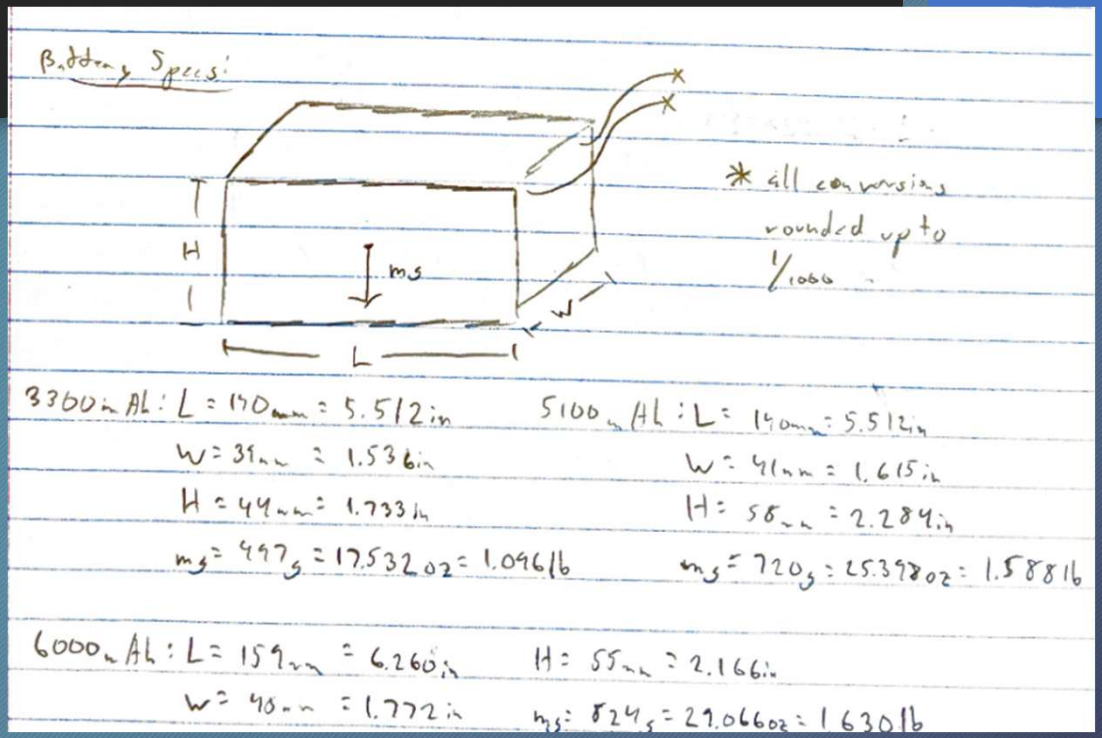


Figure (4): Battery Dimensions

Fuselage Concept Designs

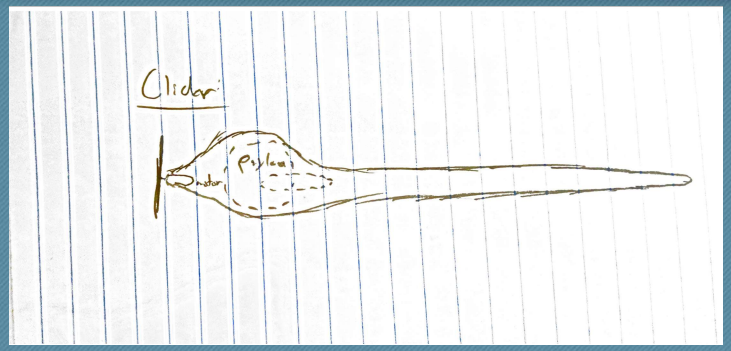


Figure (5): Glider Fuselage

- Glider Design
  - Light, but complex
- Icon Design
  - Light and compact, but made for sport
- Light GA Design
  - Simple, but long fuselage

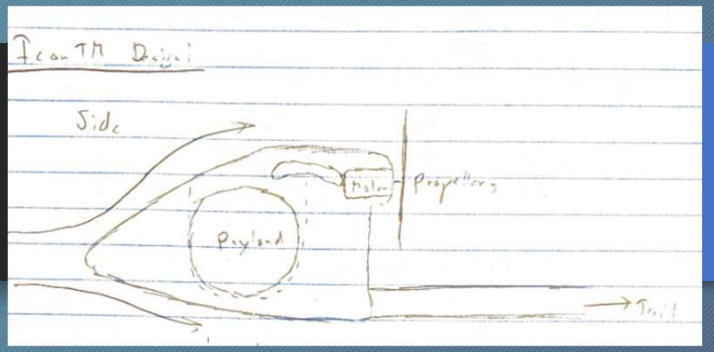


Figure (6): Icon A5 Fuselage

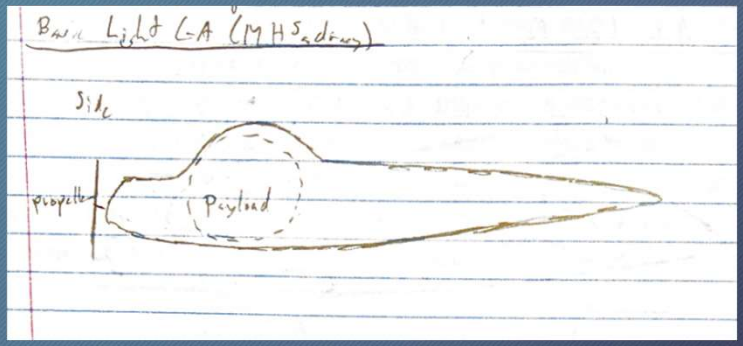
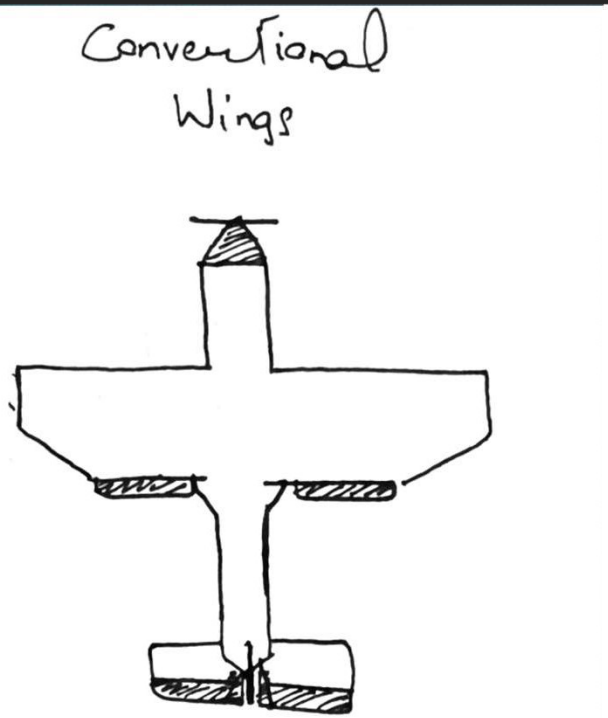


Figure (7): Light GA Fuselage

Wing Concept Design



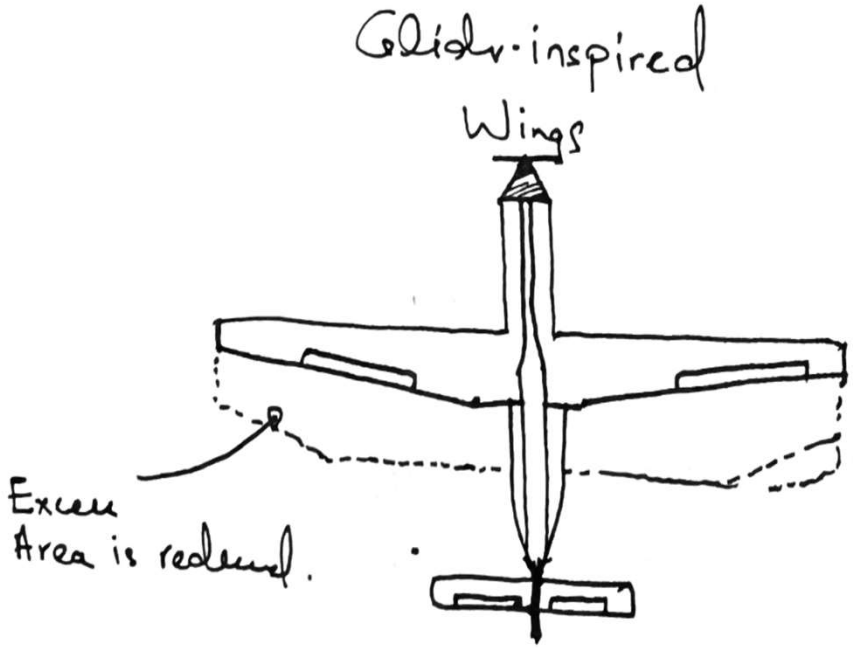


Figure (7): Straight Lead Tapered Wings

Figure (8): Glider-Inspired Wings

Wing Concept Design

- Wider and Slimmer wings than conventional aircraft designs.
- High aspect ratio
- Maximizes induced drag
- Increased volume of Air spinning behind the wings = Decreased air velocity (relative)
- Less air velocity (relative) = Decreased energy output
- Decreased energy output = Higher efficiency

Preliminary airfoil analysis

- Initial airfoil category : NACA 0004
- Concept Airfoil : Custom spline based on NACA 0004 airfoil
- Chord Length (Cl) : 1m
- Total Wingspan : 2m
- Simulation Temperature : 25 deg C
- Simulation Altitude : 304.8m

Preliminary airfoil analysis : Initial Calculations

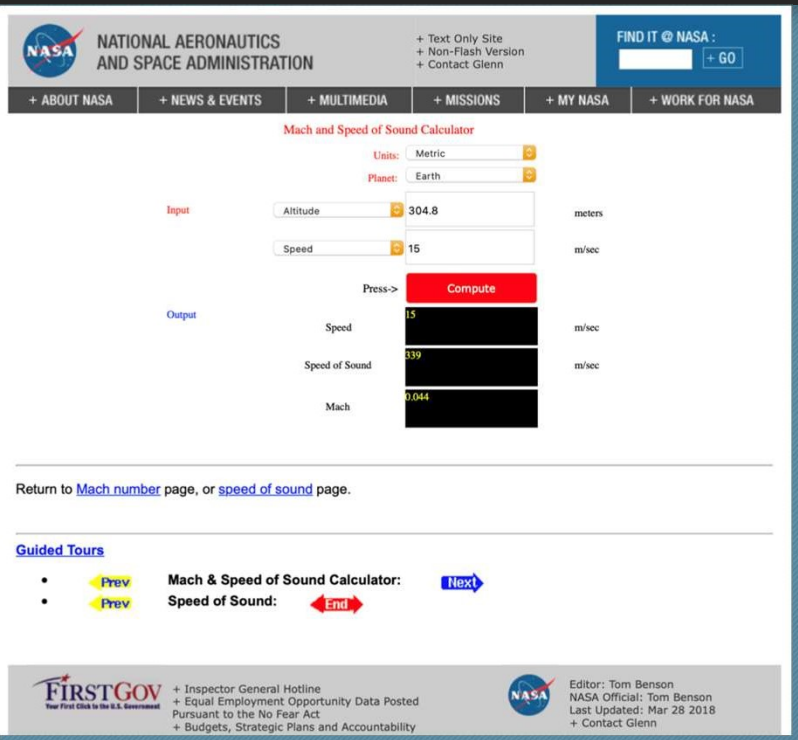


Figure (9): Speed of Sounds Calculator [5]

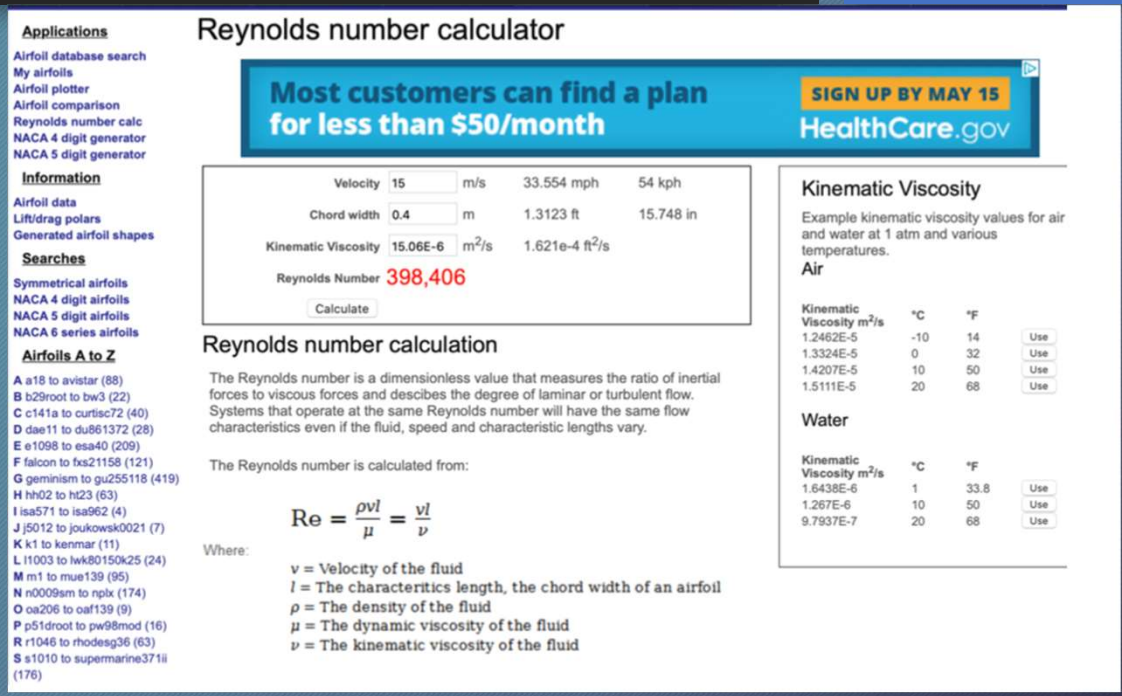


Figure (10): Screen Shot of Airfoil tools website [4]

Preliminary airfoil analysis

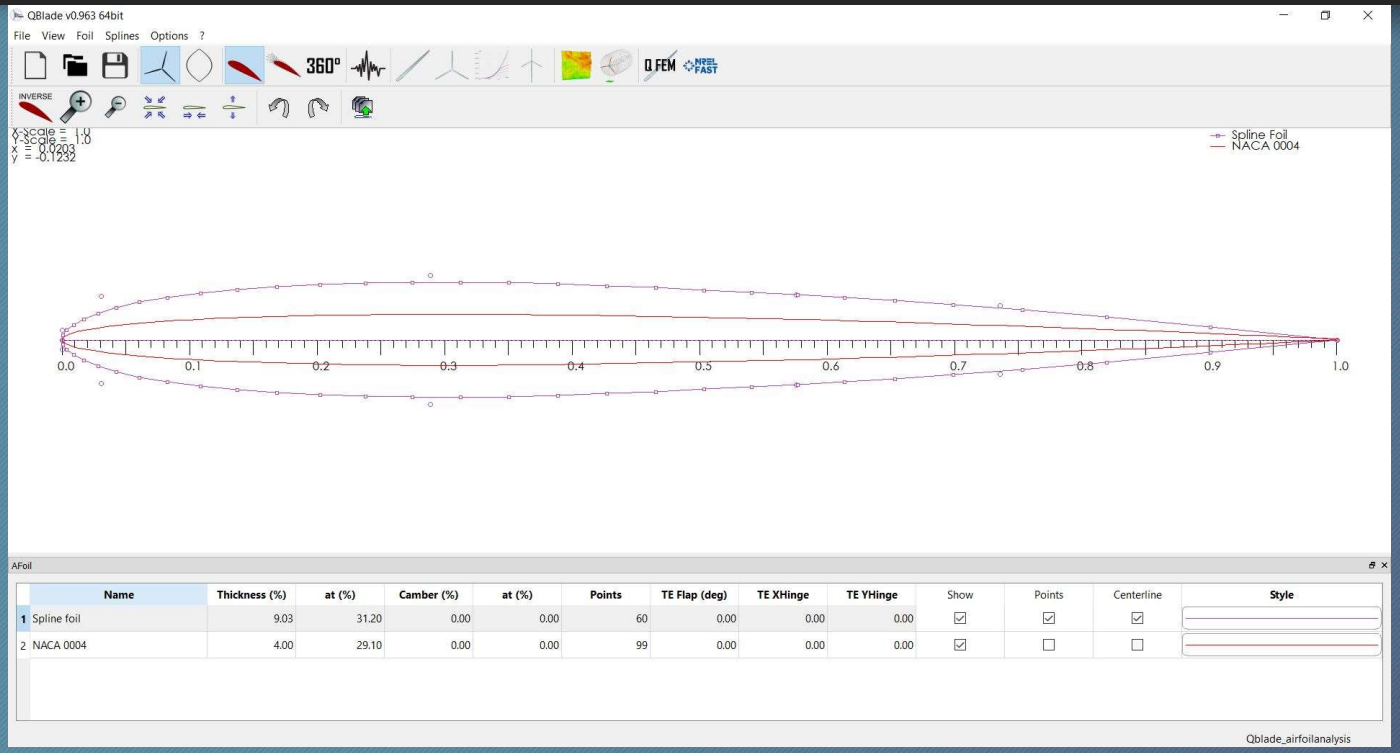


Figure (11): Airfoil Dimensioning [6]

Preliminary airfoil analysis

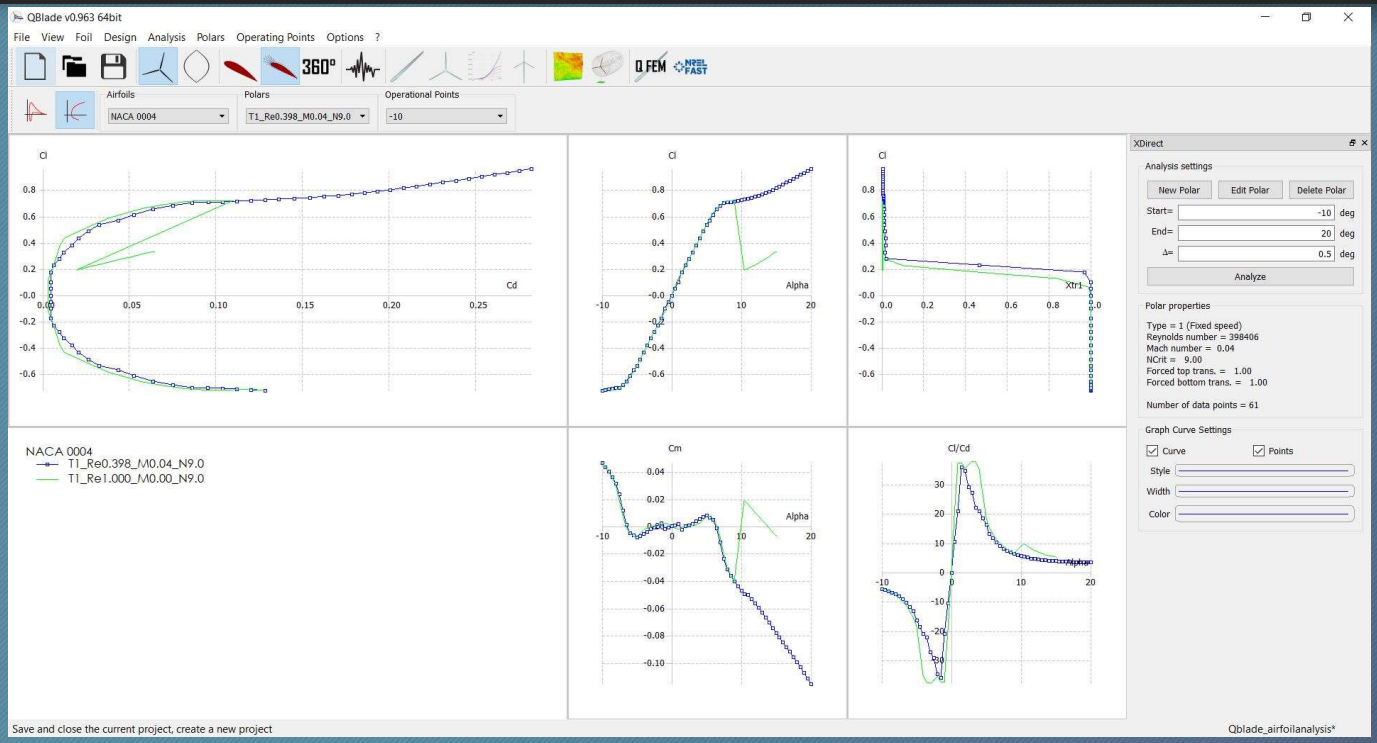


Figure (12): Coefficient Charts [6]

Preliminary airfoil analysis

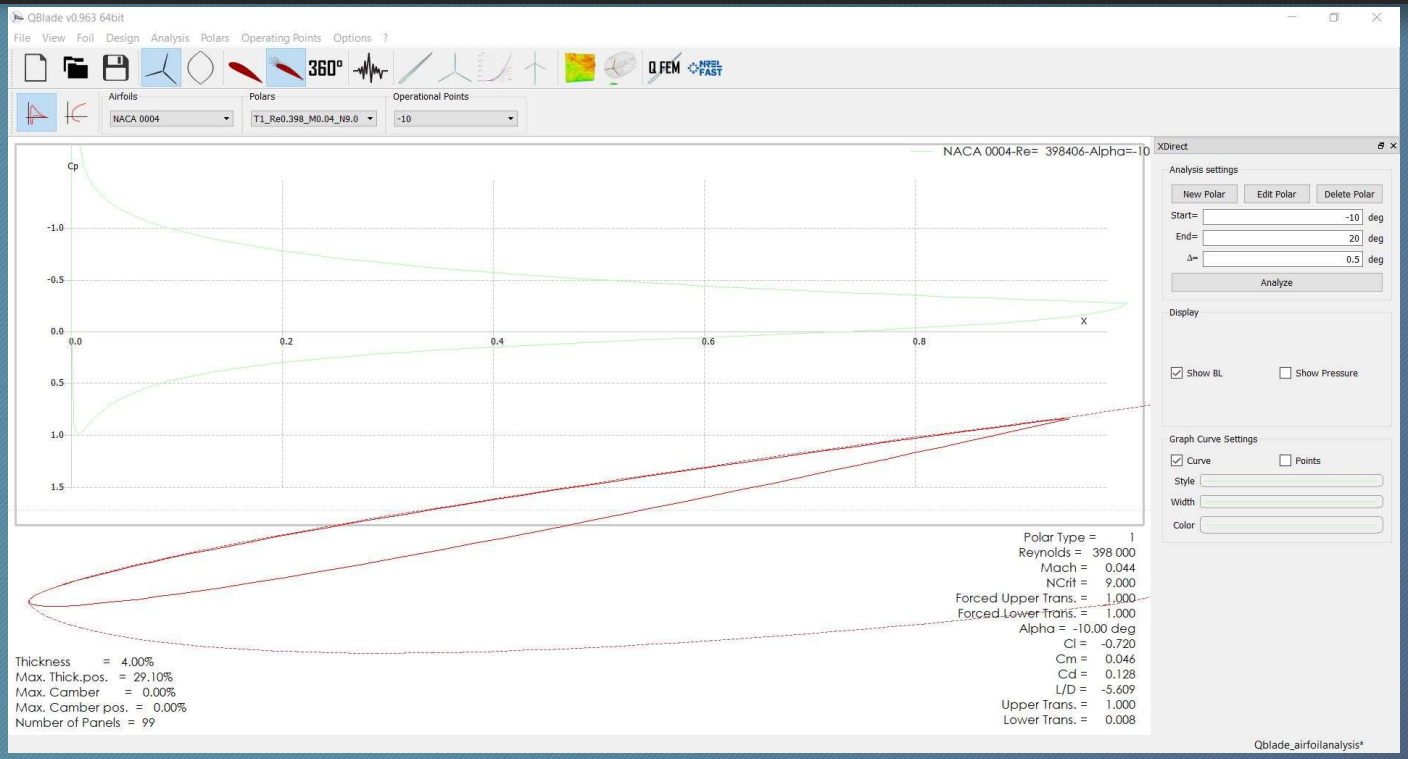


Figure (13): Boundary Layer Simulation [6]

Preliminary airfoil analysis

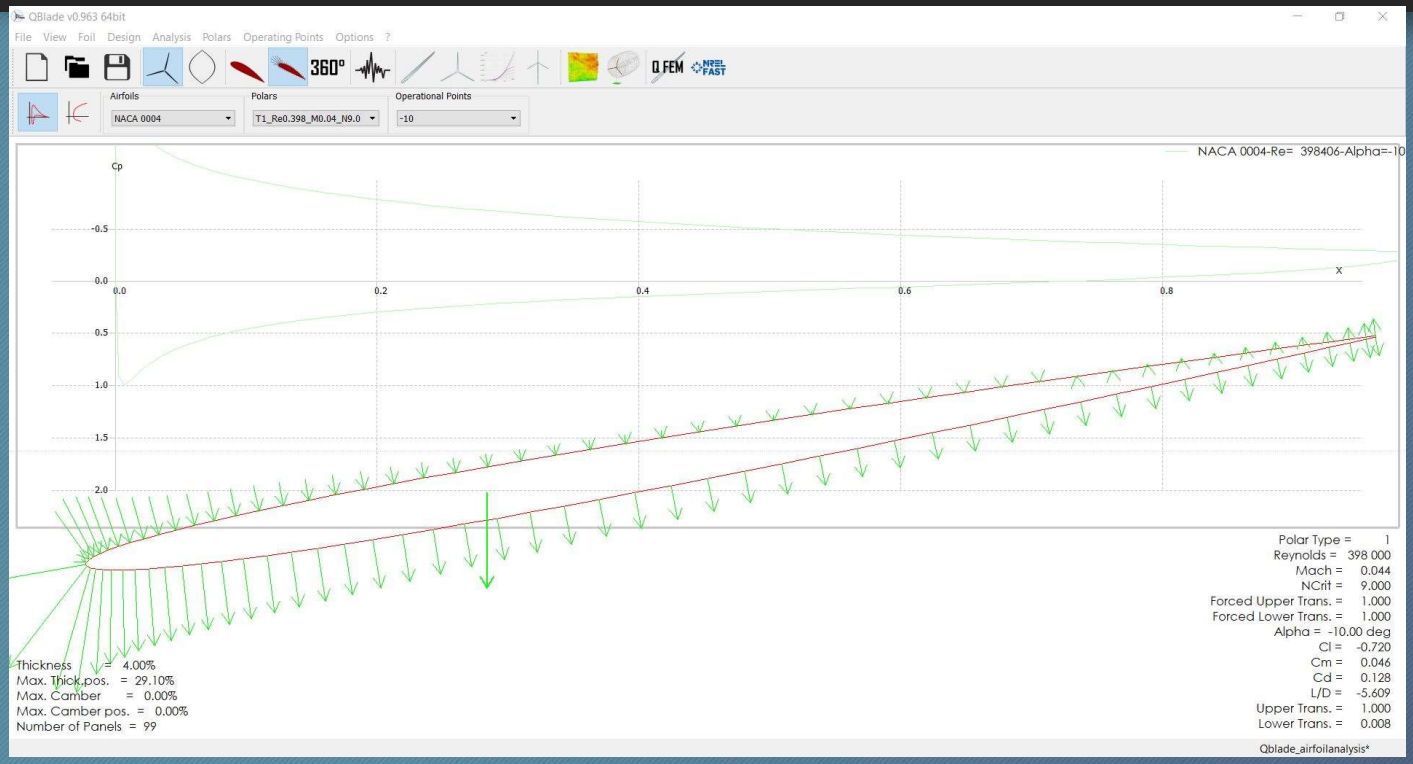


Figure (14): Pressure simulation [6]

Preliminary airfoil analysis : Wing design (work-in-progress)

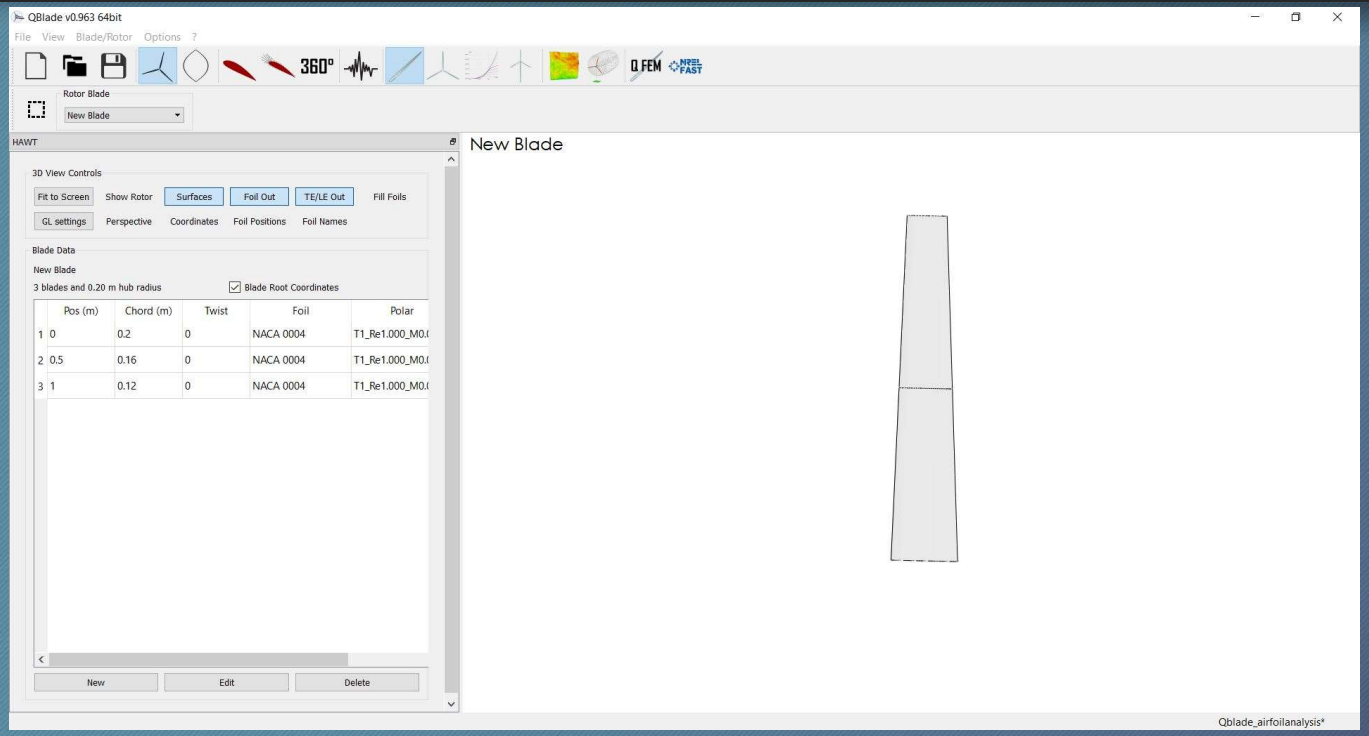


Figure (15): Work-in-progress wing design (based on NACA 0004) [6]

Preliminary airfoil analysis : Findings and future work

- Trial-and-error is key
- Chord length calculation is not perfect
- Reynolds number is compromised due to above issue
- QBLADE analyzes airfoil based on Wind Turbines
- New software should be utilized
- Good progress based on the findings of the preliminary airfoil analysis

Tail Concept Designs

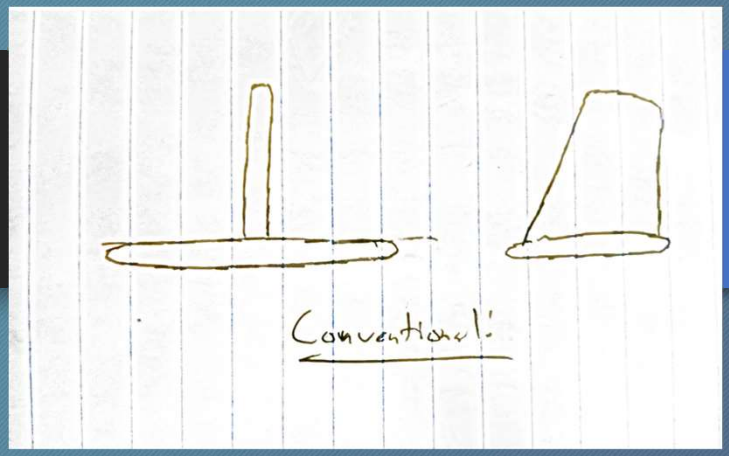


Figure (16): Conventional Tail

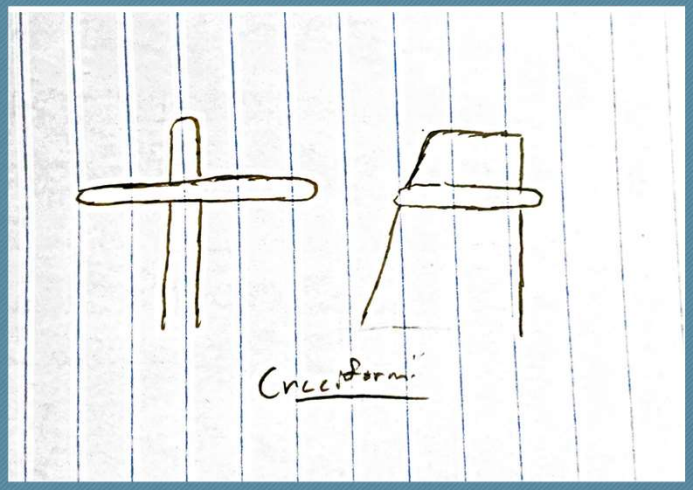


Figure (17): Cruciform Tail

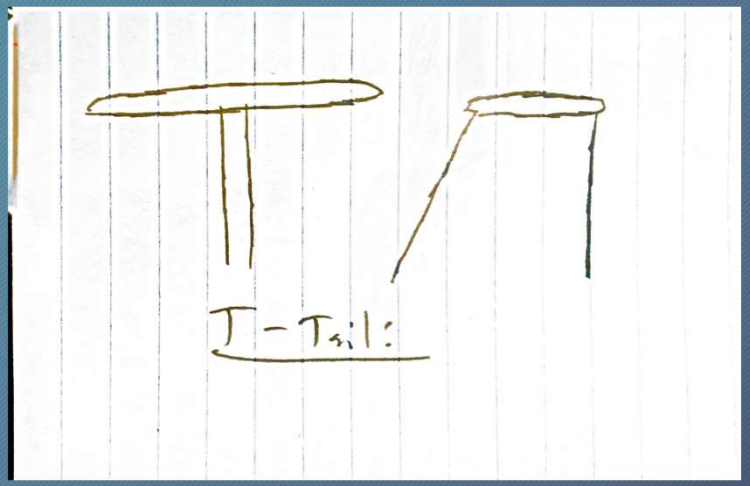


Figure (18): T-Tail

Landing Gear

- Wheeled option: $46.35-57.22
- Skied Option: $74.99
- Tail Dragger: $28.35

Wheeled option				
Part type	Rear Gear	Fixed Wheel	Landing Gear	2 3/4in wheels
Price	$20.95	$25.40	$22.28	$13.99
URL	https://www.dubro.com/collection	https://www.banggood.com/QTMc	https://hobbyking.com/en_us/carb	https://www.dubro.com/products/
Skied Option				
Part type	Skis	Tail Skid		
Price	$74.99	$2.95		
URL	https://www.hobbyprosdepot.com	https://www.dubro.com/collection		

Figure (19): Landing Gear Designs and Costs [7][8][9]

Electrical Requirements

- Unlike the airframe or landing gear there is no concepts to generate
- We are going to use off the shelf parts.
  - Time savings
  - Keep us from design our own components
    - Might not be most optimized for our use
    - There is a huge market for RC plane components

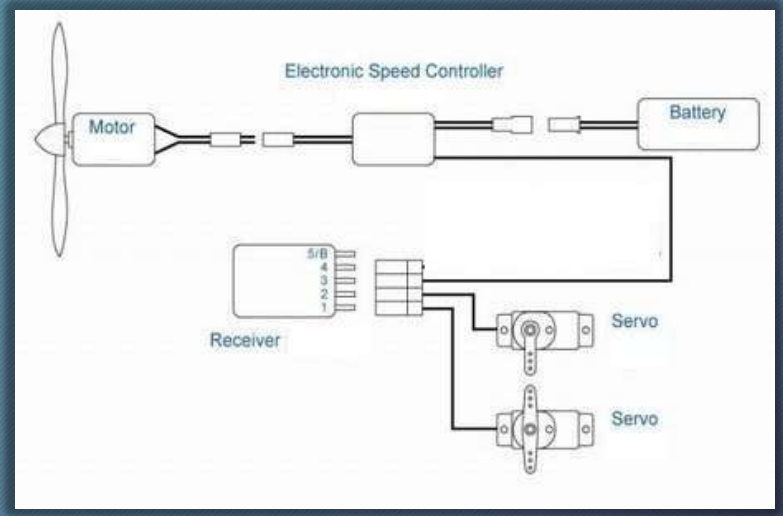
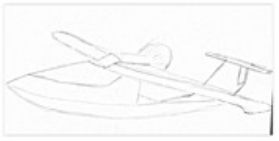


Figure (20): image of the components required for the RC plane [10]

Concept Evaluation

Design Matrix for SAE AERO

Criteria	Discription	Weight	Pushing Prop	Enlarged Belly for oversized cargo	Glider Design	
These are requirements from the competition rules. Ultimately to make the customer happy we need to perform well, and we do that by getting a good flight score at competition.	This better explains the criteria	How important is each criteria				
Wing span (under 10 ft)	Want to decrease for better score in competition	10	6	4	4	100
Increase Payload (max 55lbs)	The more payload we can carry the better the score	4	8	6	6	40
Soccer ball Payload	The more soccer balls we can carry the better our score	3	4	8	8	30
Overall Weight (airframe weight - max 55lbs)	The lighter the airframe to more cargo we can carry, and the better out flight score will be	7	1	6	7	70
Taking off (less than 100 ft)	Probability that we can get this aircraft off the ground in less than 100 ft	10	4	4	4	100
Speed	While we will not be able to make something fast a sleek design will increase speed	6	9	3	7	60
Cargo Bay	The small our cargo bay the better our flight score	10	5	9	9	100
Easy of Construction	We plan on crashing more than once so a simple design that is easy to mass produce is more important than a complicated shape	8	3	5	9	80
Power (thrust)	Which design do we think we will get the most power out of i.e. effecentcy of the propeller	9	5	6	7	90
		Weighted average	67.16%	76.12%	91.04%	670

Score is defined as a value 1 to 10 on how well it does in this criteria 10 being the best 1 being the worst
Weighted average is defined as a mathmatical formula to illistrate the most important design alterniternative
It will be scored as =(score * weight)/(total score)

Figure (21): Design Matrix for aircraft design

CAD Model

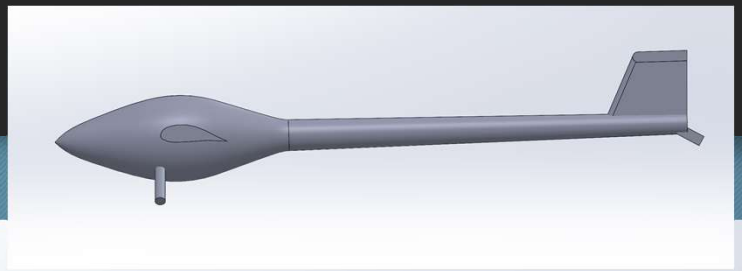


Figure (22): Side View of CAD Model

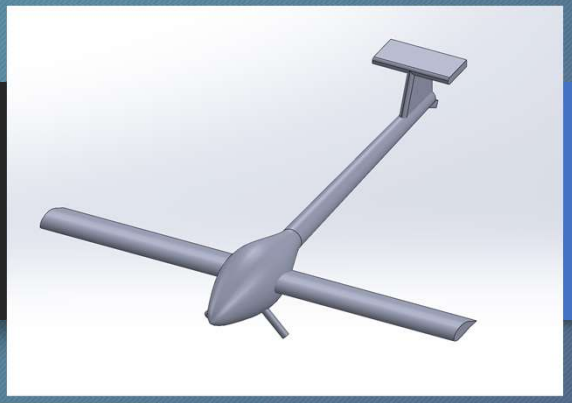


Figure (23): Trimetric View of CAD Model

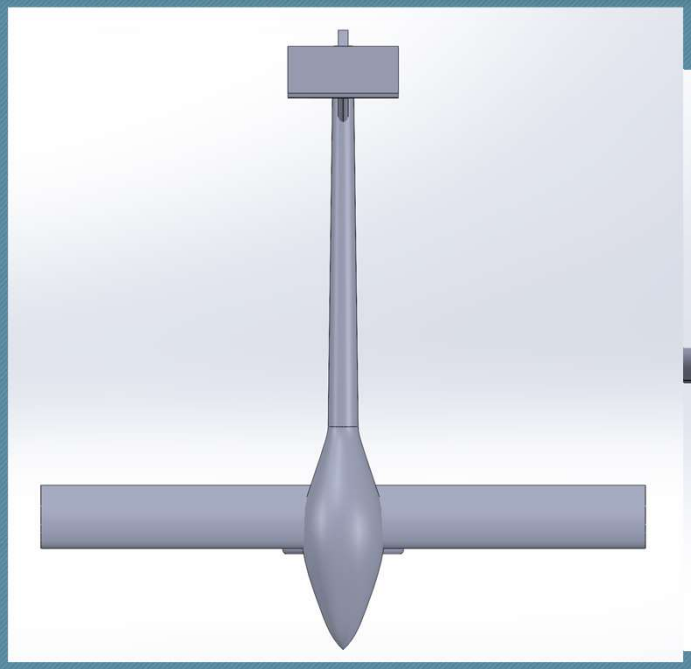


Figure (24): Top View of CAD Model

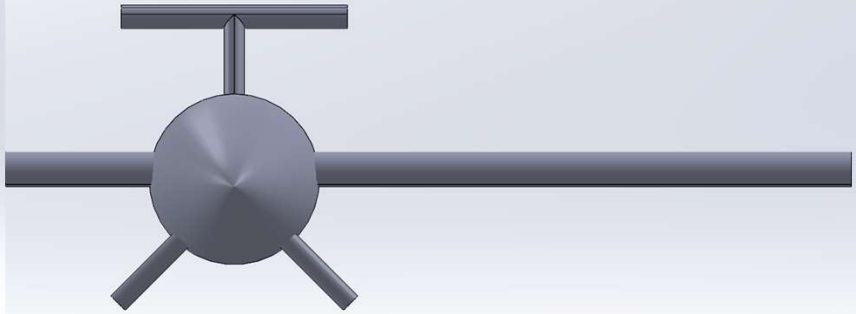


Figure (25): Front View of CAD Model

Budget Set up

- A battery pack with a minimum capacity of 1000 mAh must be used for the radio system.
- The battery pack must be a LiPo or LiFE type battery.
- All Regular Class aircraft must use a 2015 V2 or newer version 1000 watt power limiter
- Required: 6 cell (22.2 volt) Lithium Polymer (Li-Poly/Li-Po) battery pack. Minimum requirements for Li-Po battery: 3000 mAh, 25c

Cost Analysis of Electrical Parts

	Transmitter	Reciver	ESC with built in BEC	Motor	Power Limiter	Arming Plug	Battery	Servos
Product								
	NX6 6-Channel System with AR6610T Receiver	Phoenix Edge HVF 160 w/Fan 50V	Power 360 Brushless Outrunner M	1000 watt limiter	Saftey switch	22.2V 5000mAh 6S 50C Smart LiPo	HS-5645MG Standard Digital High	
Cost	$ 414.99	included	$ 347.95	529.99	$ 75.00	$ 12.95	$ 149.99	$ 63.95
Quantity	1		1	1	1	1	1	5
Website	https://www.horizonhobby.com/	product/nx6-6-channel-system-with	https://www.horizonhobby.com/p	https://www.horizonhobby.com/p	https://neumotors.cartloom.com/	https://www.f3aunlimited.com/a	https://www.horizonhobby.com/p	roduct/22.2v-5000mah-6s-50c-sm
Product								
	DX6e 6-Channel DSMX Transmitter with AR620	60-Amp Pro Switch-Mode BEC Bru	Power 32 Brushless Outrunner M	1000 watt limiter	Saftey switch	22.2V 5000mAh 6S 30C Smart LiPo	A460 Sub-Micro Analog 23g Meta	
Cost	$ 229.99	included	109.99	118.99	$ 75.00	$ 12.95	129.99	16.99
Quantity	1		1	1	1	1	1	5
Website	https://www.horizonhobby.com/	product/dx6e-6-channel-dsmx-tran	https://www.horizonhobby.com/p	https://www.horizonhobby.com/p	https://neumotors.cartloom.com/	https://www.f3aunlimited.com/a	https://www.horizonhobby.com/p	roduct/22.2v-5000mah-6s-30c-sm
Product								
	TTX660 6-Channel FHSS Transmitter		Avian 60 Amp Brushless Smart ESC	Power 32 Brushless Outrunner M	1000 watt limiter	Saftey switch	22.2V 3200mAh 6S 30C Smart LiPo	A332R Sub-Micro Analog 9g Meta
Cost	$ 183.99	32.99	64.99	94.99	$ 75.00	$ 12.95	86.99	9.99
Quantity	1	1	1	1	1	1	1	5
Website	https://www.horizonhobby.com/p	https://www.horizonhobby.com/product/tr625-fhss-6-channel-slt-re	https://www.horizonhobby.com/p	https://www.horizonhobby.com/p	https://neumotors.cartloom.com/	https://www.f3aunlimited.com/a	https://www.horizonhobby.com/p	https://www.horizonhobby.com/

Max	$	1,850.62
Middle	$	761.86
Min	$	601.85
Average	$	1,010.11

Figure (26): Cost of components required for a RC plane [12]

Budget Planning

- Total Budget $1500
- 60% Electrical Components ($900)
- 22.5% Fuselage and Wings ($337.5)
- 5% Landing gear ($75)
- 12.5% Prototyping ($187.5)

- Right now, the budget is looking on the tight side

Table 1: Cost of electronic Components

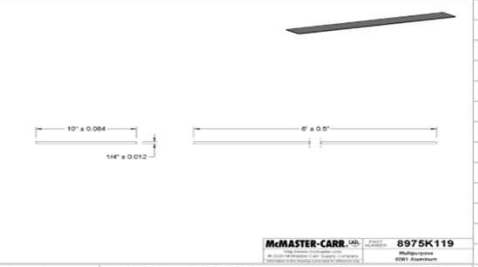
Bill of Materials (electronics)		
Parts	Cost	Quantity
Transmitter	$ 229.99	1
Reciver	included	0
ESC with built in BEC	$ 109.99	1
Motor	$ 118.99	1
Power Limiter	$ 75.00	1
Arming Plug	$ 12.95	1
Battery	$ 129.99	1
Servos	$ 16.99	5
	Total	$ 761.86

Cost Analysis of Fuselage and Wings

	Manufacturing			Aircraft Parts			
	Cost	Quantity	Total		Cost	Quantity	Total
Plywood	$10.12	4	$40.48	Adhesives	$24.14	5	$120.70
Balsa Wood	$17.60	3	$52.80	Heat Shrink f	$206.01	1	$206.01
Aluminum	$98.46	4	$393.84	Screws,Bolts	$50	-	$50
		Total	**$487.12**			**Total**	**$376.71**

Total Cost $863.83

***This cost analysis only includes fuselage and wing fabrication costs*

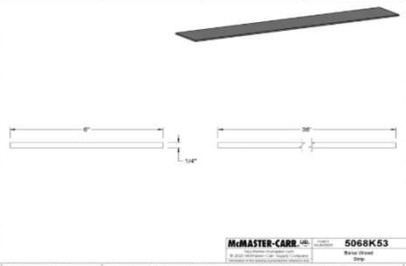


Aluminum : 1/4" Thick. (-0.012" to 0.012" Tolerance) 10" w

Supplier: https://www.mcmaster.com/8975K561-8975K119/

Adhesives: Waterproof Epoxy, J-B Weld Clearweld, 8 oz.. Tube

Supplier: https://www.mcmaster.com/7605A23/

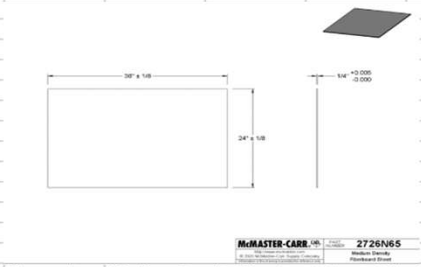


Balsa Wood: Balsa Wood Strip, 6" x 36" x 1/4"

Supplier: https://www.mcmaster.com/5068K53/

Heat Shrink f 17 Feet Wide x 110 Feet Long

Supplier: https://www.mcmaster.com/9441T1/



Plywood: Medium Density Fiberboard Sheet, 24" x 36" x 1/4"

Supplier: https://www.mcmaster.com/2726N65/

Screws, Bolts

Supplier: https://www.boltdepot.com

Figure (27): Cost of components required for the fabrication of an RC plane [11]

Schedule

SAE AERO capstone Schedule

SAE Aero Capstone

Project Start: Mon, 1/11/2021

Display Week: 5

TASK	ASSIGNED TO	PROGRESS	START	END
Week 12 Time Card	Team		3/29/2021	4/5/2021
Week 13 Time Card	Team		4/5/2021	4/12/2021
Week 14 Time Card	Team		4/12/2021	4/19/2021
Week 15 Time Card	Team		4/19/2021	4/26/2021
Team Time Line				
Project leads determined for subsystems	Team		2/1/2021	2/1/2021
Conceptual design of sub systems	Individual (subsystem leads)		2/8/2021	2/8/2021
Talk to Perry wood about laser cutter	Team		2/16/2021	2/28/2021
Get Re number calculated	Gajaba		2/16/2021	2/21/2021
Get Electrical anylisis done	Ryan		2/8/21	2/11/21
Have Concept generation done	Gajaba and Aiden		2/18/21	2/18/21
Do decision matrix	Team		2/19/21	2/19/21
Have sub assemblies designed in CAD	Individual		2/21/2021	2/26/2021
Start getting Website up to par	Ryan		2/21/2021	2/26/2021
Start purchasing items to	Individual		3/8/21	3/8/21
Evaluate all subsystems a	Team		3/22/21	3/22/21

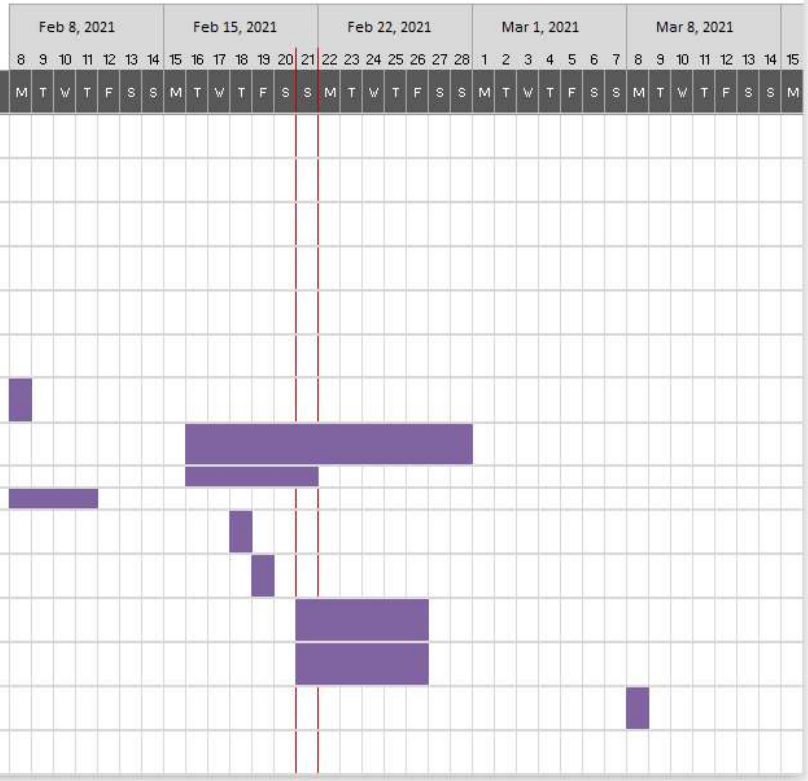


Figure (28): Sectioned Gantt Chart

References

[1] "SAE International," [Online]. Available: https://en.wikipedia.org/wiki/SAE_International. [Accessed 21 2 2021].

[2] S. A. 2. Team, "AERO_Regular_Presentation_2.pdf," 2020.

[3] "Sport Cub S 2 RTF with SAFE," Horizon Hobby , [Online]. Available: https://www.horizonhobby.com/product/sport-cub-s-2-rtf-with-safe/HBZ44000.html#. [Accessed 21 2 21].

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Appendix – Gantt Chart Complete

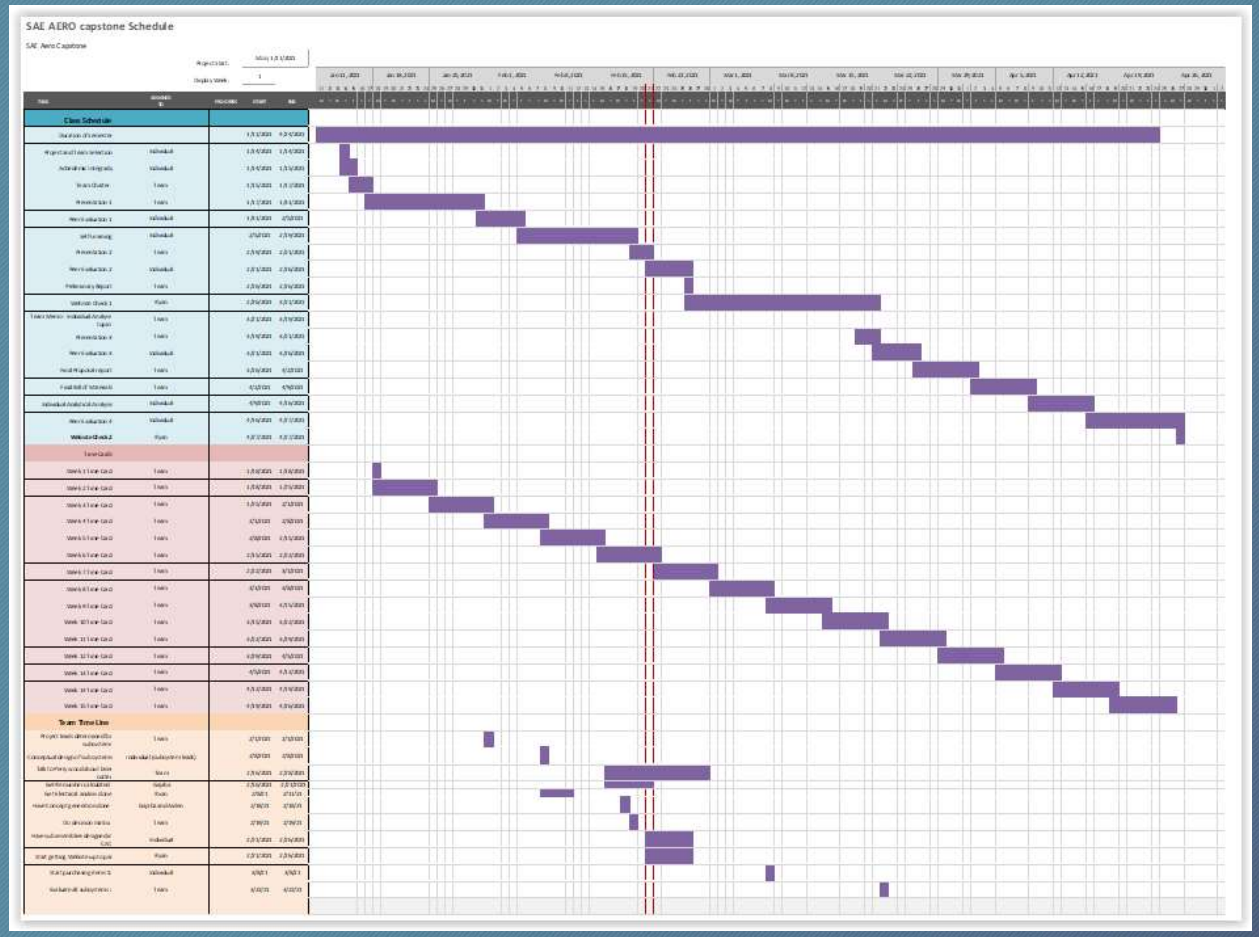

Figure (29): Full Gantt Chart