SAE Aero Regular: Presentation 3

Final Proposal

Jacob Cong, Chris Galus, Alex Klausenstock, Nathan Valenzuela

T1: Project Description

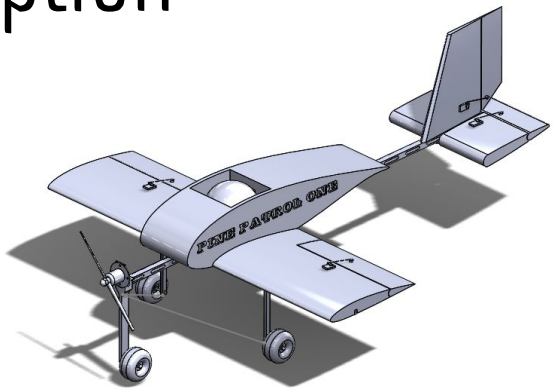
- Primary Objective: Design and manufacture an aircraft that can successfully transport payload
- Key Details
  - Must carry steel weights, and at least one (1) soccer ball
  - All payload must be enclosed in a cabin
  - Must take-off in under 100ft and land in 400ft
  - Scored across three (3) flight circuits

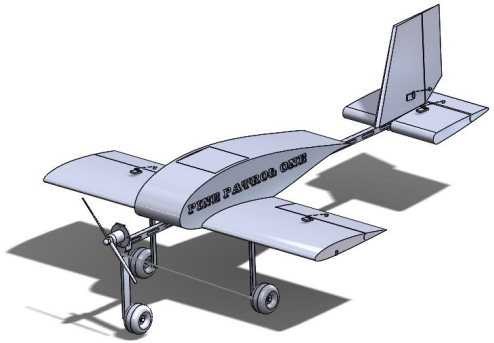
- Scoring Analysis: Create the smallest plane that can carry the most weight

$$FS = Flight\ Score = 120 * \frac{2 * S + W_{steel}}{b + L_{cargo}}$$ [1]

Jacob Cong

T2: Design Description





Functional Design:

- **Frame**: Provides *STRENGTH*
- **Motor/Propeller**: Provides *THRUST*
- **Wings/Airfoil**: Provides *LIFT*
- **Cabin**: Houses *WEIGHT*, (ours will also reduce *DRAG* and provide *LIFT*)
- **Ailerons, Rudder, Elevator**: Provide *CONTROL* (air)
- **Landing Gear**: Provides *SUPPORT* and *CONTROL* (ground)

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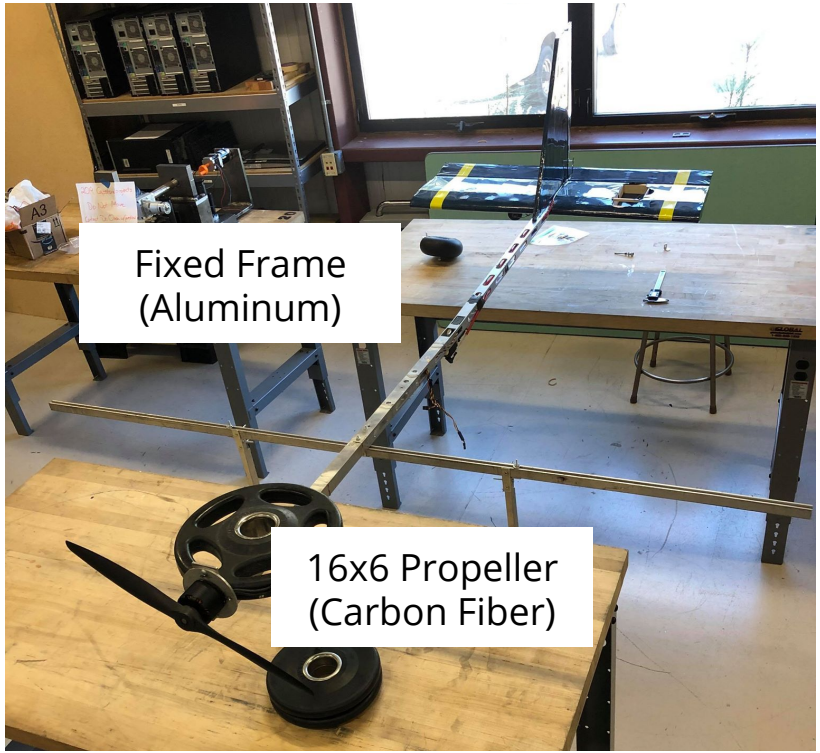
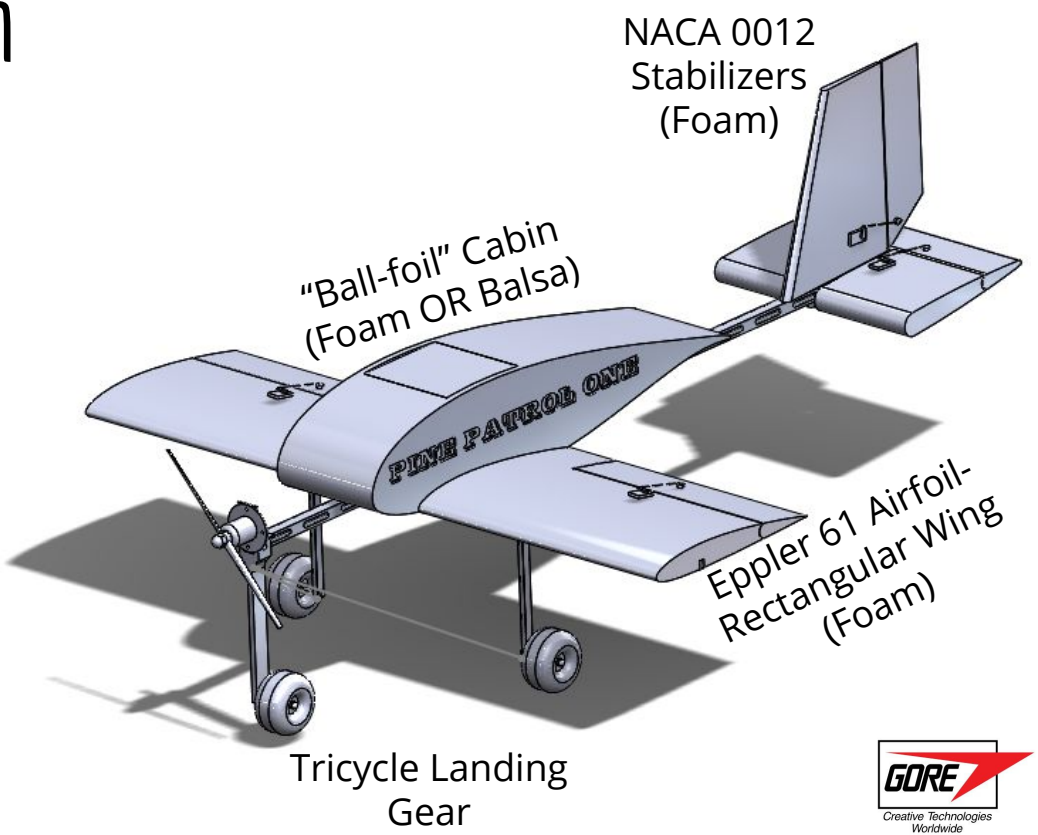
T2: Design Description





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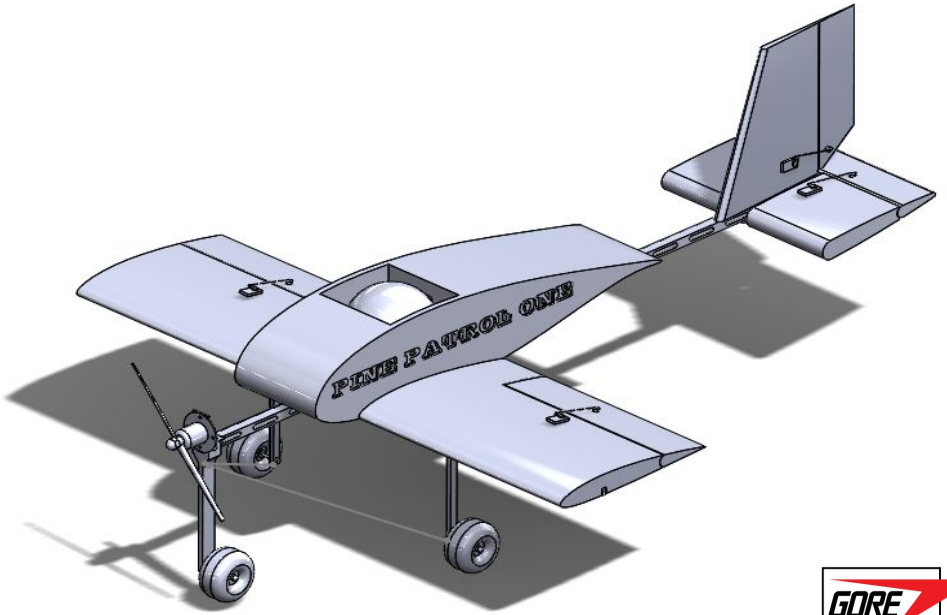
Jacob Cong

T3: Design Requirements

Customer Needs	Customer Weights
Ball Capacity	10
Steel Weight Capacity	9
Short Wing Span	9
Short Cargo Bay	9
Lack of Crash	10
Cargo Accessability	6
Robust Design	10
Reliable Design	9
Inside Budget	10
Safe to Operate	10
Takeoff & Landing Capability	10
Control Authority	7
Constructability	5



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Alex Klausenstock

T3: Design Requirements

	Technical Requirements													
	Size	Weight	Power	Cost	Lift	Low Drag	Ease of Assembly/Repair	Velocity	Turning	Load/Unload Time	Cabin Length	Wing Span	Success Rate	Factor of Safety
Technical Requirement Units	in^3	lbs	Kw	$	lb/ in	lb	min	mph	rad/s	s	in	in	%	%
Technical Requirement Targets	972	35	1	1000	40	9.4	15	15	0.8	120	8.75	120	95	115
Absolute Technical Importance	482	408	449	345	431	551	154	348	241	222	195	155	382	149
Relative Technical Importance	2	5	3	8	4	1	14	7	9	10	12	13	6	11

Engineering Requirements

Measured:

Size: 160 in^3
Wt: 14.89 lb
Power: 1 Kw
Cabin length: 8.75 in
Wing Span: 5 ft

Testing to be done:

Ease of assembly
Turning
Load/ unload time
Success rate
FOS

Calculated:

Cost: $567
Lift: 19.5 lbf
Drag: 0.3 lbf
Velocity: 31 MPH

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Alex Klausenstock

T3: Design Requirements

Acceleration, Drag & Lift						
a=(44.33*exp(-7.737e-06 * Re)- 0.5*Rho*V^2*Cd*Plan form Area)/12				Chord(m)	0.4572	
				Span (m)	1.3	
Drag= 0.5*Rho*V^2*Cd*Plan form Area				rho(kg/m^3)	1.01	
Lift= 0.5*Rho*V^2*Cl*Plan form Area				nu	0.00001543	
Re	Velocity (m/s)	Velocity (mph)	Acceleration (m/s^2)	Drag (N)	Lift (N)	
0	0	0	3.69	0.0	0.0	
29631	1	2	2.94	0.0	0.8	
385198	13	29	0.08	1.3	75.5	
414828	14	31	0.03	1.5	87.6	max velo w/ this wing
444459	15	34	-0.02	1.7	100.6	

Calculated:

Cost: $567
Lift: 19.5 lbf
Drag: 0.3 lbf
Velocity: 31 MPH

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Alex Klausenstock

T4: Design Validation: FMEA

FMEA (Failure Mode Effect Analysis)

Item / Function	Requirements	Potential Failure Mode	Potential Effects of Failure	SEV	Potential Causes / Mechanisms of Failure	Current Design Controls Prevention	OCC	Current Design Controls Detection	DET	RPN	Recommended Actions	Action Results			
												SEV	OCC	DET	RPN
Airfoils (Structural)	Support pressure differential	Poor loading, distribution of weight, or design	Foils shear under load	10	F.O.S too low: gust of wind or landing force	Structural analysis underway	3	Visual inspection only	5	150	Continue with analysis	10	3	5	150
Landing Gear (Structural)	Allows plane to take-off from ground and land	Poor loading, distribution of weight, or design	Damage to number of members, total destruction of craft.	8	Bad transfer of forces through members, hard impact, poor damping	Structural analysis underway	3	Visual inspection only	3	72	Continue with analysis	8	3	3	72
Take-off	Leave ground in under 100ft	Exceeding 100ft, departing from runway boundary	Point deduction	4	Steering gear malfunction, wind, poor control authority	Tricycle setup	3	Visual observation	5	60	Proceed with tricycle setup, extensive practice / confirmation of sufficient lift	4	3	5	60

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Nate Valenzuela

T4: Design Validation: Testing

Flagstaff Flyers Airfield [2]

Using MATLAB to provide a baseline for each test and to compare results against.

```
Command Window
  Span (in) =    72

  Chord (in) =    18

  Score:    5.5176

  Force of Lift (N):   33.1054

  Force of Drag (N):    3.3041

  Acceleration (ft/s^2):    1.2565

fx >>
```

Need:

- Airfield
- Measuring wheel
- Stopwatch
- Soccer ball
- Steel plates
- Visual Inspection

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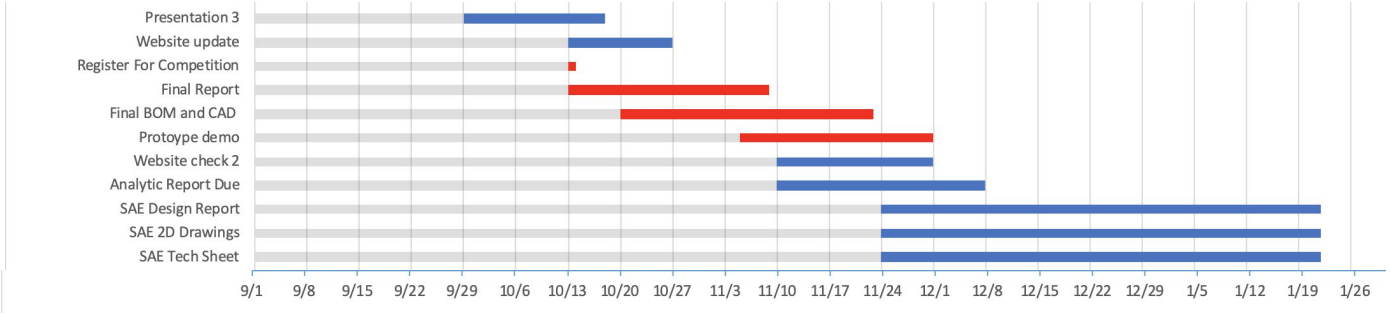
T5: Schedule and Budget

- Building first prototype ahead of schedule
- SAE deadlines soon after break - working first and last week of break
- Continue to break up each task individually
- Working on website - on track

START DATE	END DATE	Acutal Due Date	DESCRIPTION	Team Member	DURATION (days)
9/29/2019	10/18/2019	11/5/2019	Presentation 3	All members	19
10/13/2019	10/27/2019	10/29/2019	Website update	Nate,Alex	14
10/13/19	10/14/19	10/14/19	Register For Competition	All members	1
10/13/2019	11/10/2019	11/12/2019	Final Report	All members	27
10/20/2019	11/24/2019	11/26/2019	Final BOM and CAD	All members	34
11/5/2019	12/1/2019	12/3/2019	Protoype demo	All members	26
11/10/2019	12/1/2019	12/3/2019	Website check 2	Nate,Alex	21
11/10/2019	12/8/2019	12/10/2019	Analytic Report Due	All members	28
11/24/2019	1/23/2020	*	SAE Design Report	All members	59
11/24/2019	1/23/2020	*	SAE 2D Drawings	Jacob, Nate	59
11/24/2019	1/23/2020	*	SAE Tech Sheet	All members	59
1/19/2020	2/9/2020	2/11/2020	Hardware review	All members	20
2/2/2020	2/16/2020	2/18/2020	Website check 3	Nate,Alex	14
2/16/2020	3/1/2020	3/3/2020	Midpoint pres/report	All members	15
2/23/2020	3/8/2020	3/10/2020	individual analysis 2	All members	15
3/1/2020	3/15/2020	3/24/2020	Final Product	All members	14
3/1/2020	3/22/2020	3/24/2020	Device summary	All members	21
3/22/2020	3/29/2020	3/31/2020	Draft of poster	All members	7
4/3/20	4/5/20	4/5/20	Competition	All members	2
3/22/2020	4/5/2020	4/7/2020	Testing proof	All members	13
3/29/2020	4/12/2020	4/14/2020	Final Poster	All members	13
3/29/2020	4/12/2020	4/14/2020	Operation manual	All members	13
4/5/2020	4/19/2020	4/21/2020	Final Presentation	All members	14
3/29/2020	4/24/2020	4/24/2020	UGRADS	All members	25
4/5/2020	4/26/2020	4/28/2020	Final report and CAD	All members	21
4/12/2020	4/26/2020	5/3/2020	Final website	Nate,Alex	14



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T5: Schedule and Budget

BOM						
	Part	Quantity	Unit	Cost per Unit ($)	Total Cost ($)	Source URL
Electronics	Servos	4	Component	37.73	150.92	https://hitecrcd.c
	ESC	1	Component	124.95	124.95	http://www.castle
	Motor	1	Component	114.05	114.05	https://hobbyking
	Controller	1	Component	180.00	180.00	https://www.spek
	Battery Charger	1	Component	60.00	60.00	https://www.spek
	Power Limiter	1	Component	75.00	75.00	https://neumoton
	Radio receiver	1	Component	64.99	64.99	https://www.horiz
	6S Lipo Battery	1	Battery	63.92	63.92	https://hobbyking
Structural	Bass wood	2	15 sheets of 1X24"	22.26	44.52	https://www.dickl
	Balsa wood	2	10 sheets	6.99	13.98	https://www.ama
	EPS Foam	3	2"x4'x8' Sheet	21.68	65.04	https://www.hom
	Wood Glue	4	Bottle	5.97	23.88	https://www.ama
	Miscellaneous Hardware	25	Bracket/bolt/nut	2.00	50.00	https://www.hom
	Aluminum 6063 T52	4	6 ft beam	35.72	142.88	https://www.meta
	Wire	1	Roll	6.47	6.47	https://www.ama
Other	Propeller	3	Component	20.00	60.00	https://www.buds
	Soccer Balls	1	Ball	8.00	8.00	https://www.adid
	Payload Plates	10	Component	5.00	50.00	https://www.sum
	Wheel	3	Wheel	19.94	59.82	https://www.horiz
				Total cost	1358.42	
				Purchased	240.00	
				To purchase	327.81	

	NAU SAE Preliminary Budget	
	Funding	Note
	$3,000.00	Gore Donation
	Costs	Note
Gore Donation Applicable	$1,100.00	SAE Competition Entry Fee
	$327.81	BOM
	$500.00	Operating Redundancies
	$300.00	Manufacturing Equipment
	$400.00	Prototyping
	$100.00	Required Stickers and Gore Branding
Summed	$2,727.81	Gore Funding Usage. For use of plane parts, requirements, and construction only
Gore Donation Non-Applicable	$500.00	2 Nights - Hotel
	$400.00	Gas (2000 miles,15mpg, $3.00 per gallon)
	$25.00	SAE Membership (4 needed)
	$75.00	Academy of Model Aeronautics License
	$150.00	Team Shirts and Vehicle Markings
Additional Funds Required	$1,225.00	Not deductable from Gore donation, this is our target fund raising goal for memberships and travel expenses
	Leftover	Note
	$272.19	Gore Funding Usage. For use of plane parts, requirements, and construction only
	Fundraising Goal	Note
	$1,250.00	Total fund raising goal. Trip expenses

- Looking for sponsors
- Talking with SAE about travel
- Percentage nights
- Spent money on new controller, prototype materials

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Q/A

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Work Cited

[1] Society of Automotive Engineers (2019). *SAE Aero Design Rules*. 2020 Collegiate Design Series. SAE, p.18.

[2] Flagstaffflyers.com. (2019). *Flagstaff Flyers R/C Airplane Club | Charter member of the Academy of Model Aeronautics (AMA) and District X, Charter Number 2456*. [online] Available at: https://www.flagstaffflyers.com/ [Accessed 4 Nov. 2019].

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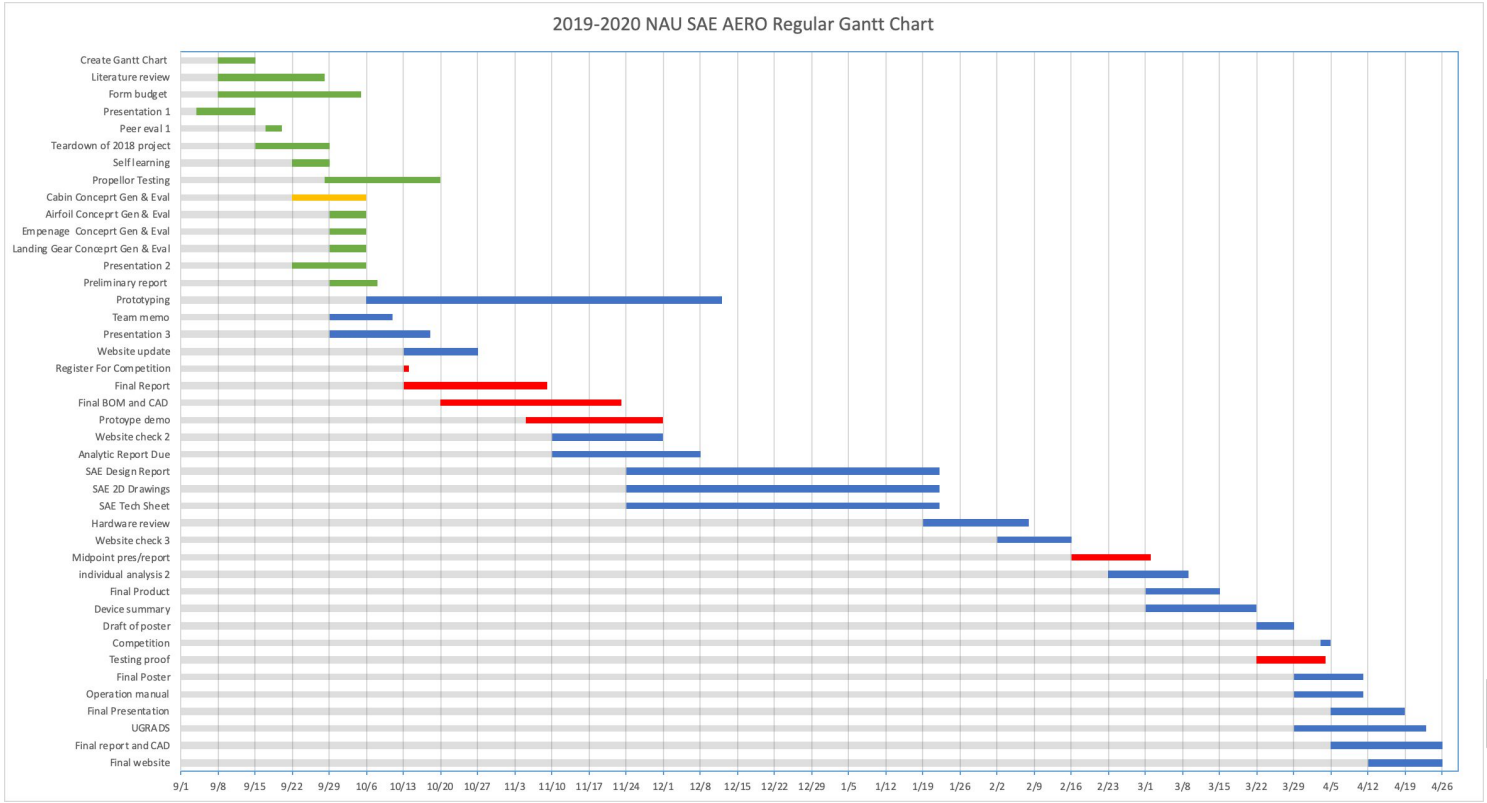
Appendix A: Gantt Chart



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Appendix A: Full FMEA

FMEA (Failure Mode Effect Analysis)

Item / Function	Requirements	Potential Failure Mode	Potential Effects of Failure	SEV	Potential Causes / Mechanisms of Failure	Current Design Controls Prevention	OCC	Current Design Controls Detection	DET	RPN	Recommended Actions	Action Results			
												SEV	OCC	DET	RPN
Propulsion	Pull plane through fluid (air)	Damaged Prop/Loose Collet, motor failure	Not enough velocity to produce sufficient lift	5	Prop connects with ground during landing / take-off. Poorly secured prop falls off.	16-inch elevation of frame/cabin off ground	1	Visual inspection of prop, pre-flight. Torqueing of collet to spec.	2	10	Inspect prop before and after every flight. Keep back-up props.	5	1	2	10
Lift	Elevate the plane	Stall angle achieved or loss of velocity	Plane cannot overcome gravity forces and loses altitude unpredictably	9	Gust of wind, bird contacting wing, unpredictable airfoil characteristics	Plane produces more lift than needed, In-depth airfoil selection.	2	Visual observation	3	54	Extensive prototype testing and hours of practice flights. Sufficient Airfoil selection	9	2	3	54
Take-off	Leave ground in under 100ft	Exceeding 100ft, departing from runway boundary	Point deduction	4	Steering gear malfunction, wind, poor control authority	Tricycle setup	3	Visual observation	5	60	Proceed with tricycle setup, extensive practice / confirmation of sufficient lift	4	3	5	60
Landing	Make contact with ground and stop (under 400ft)	Exceeding 400ft, gear failure (structure or tire), departing from runway boundary	Point deduction, damage to gear, or damage to frame and other components	5	Attempting a landing with excessive downward velocity, gear failure.	Technique, structural integrity of plane; especially landing gear	2	Visual observation	3	30	Practice landing, design gear to handle extreme landing scenarios.	5	2	3	30
Steering	Change direction of the plane (air/ground)	Servo or gear gets stuck, linkage gets damages, loss of power	Inability or poor ability to turn. Inability to complete a successful run	4	Wiring failure, linkage failure.	Simple linkage design	1	Pre/post flight test	2	8	Replace old servos with new ones for final product	4	1	2	8
Remote/Receiver	Communicate action inputs	Loss of control authority	Inability to complete a round or crash	9	Remote unsynching from plane, power loss	New remote purchased	1	Remote control alert of lack of connection.	1	9	Purchase new remote battery, purchase new receiver, verify remote connection before flight.	9	1	1	9
Batteries	Provide power to plane/remote	Loss of propulsion and control	Inability to complete a round or crash	9	Insufficient charge, disconnection	Effective wiring design, new battery charger	1	Attach battery post flight to test charge	2	18	purchase new remote battery, purchase new plane battery	9	1	2	18
Structural Integrity															
Airfoils	Support pressure differential	Poor loading, distribution of weight, or design	Foils shear under load	10	F.O.S too low: gust of wind or landing force	Structural analysis underway	3	Visual inspection only	5	150	Continue with analysis	10	3	5	150
Cabin	Contain Payload (Weight)	Poor loading, distribution of weight, or design	Damage to entire structure	10	Unsecured payload, bad transfer of forces through members	Structural analysis underway	1	Visual inspection only	3	30	Continue with analysis	10	1	3	30
Landing Gear	Allows plane to take-off from ground and land	Poor loading, distribution of weight, or design	Damage to number of members, total destruction of craft.	8	Bad transfer of forces through members, hard impact, poor damping	Structural analysis underway	3	Visual inspection only	3	72	Continue with analysis	8	3	3	72

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