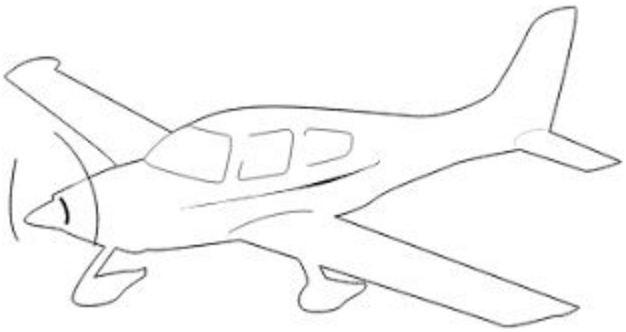


SAE Aero

James Seganti (Project Manager)
Caleb Hatcher (Budget Liaison)
Braden Weiler (Documentation Manager)
Angel Montiel (Website Developer)
Damian Lumm (Client Contact)

SAE INTERNATIONAL

Project Description

- The purpose of this team is to design and manufacture an RC aircraft to compete in the SAE West Region competition.
- Fixed wing regular class
- All electric aircraft and has to carry payload
- Stakeholders: John Tester, Sarah Oman, Northern Arizona University, Flagstaff Flyers, ASNAU
- Represent NAU in a positive manner

Figure 1: SAE Aero West Competitor

NAU SAE Aero West Regular History

5 appearances at competition in the last 10 years

Most recent in 2015, placed 13th out of 41 teams

2019 goal: place top 10

NAU NORTHERN ARIZONA UNIVERSITY

College of Engineering, Informatics, and Applied Sciences

Wings Benchmarking

- Airfoil, aspect ratio, angle of incidence, wing platform, dihedral, wing loading, angle of attack, coefficient of drag, coefficient of lift
  - NAU's aero team from '16 used a S1223 airfoil because it gave the best lift to drag ratio[7]
  - The team from '12 used the airfoil Eppler 423 because of the high lift coefficient[8]
- Solidworks used for stress analysis
- Laser cutters to make precise airfoils
- Tapered wings are more aerodynamically efficient
- UM placed 1st with a twin tail and very large wingspan

Figure 2: NAU 2016 SAE Aero capstone design [7]

Wings Design Research

- Ribbed Design
  - Minimize weight, ease of manufacturing, material constraints, used by top placing teams
- Past teams were successful in using MATLAB to assist in airfoil selection
- Flaps on the trailing edge of a wing can be used to increase lift
- Wingspan must comply with traveling conditions

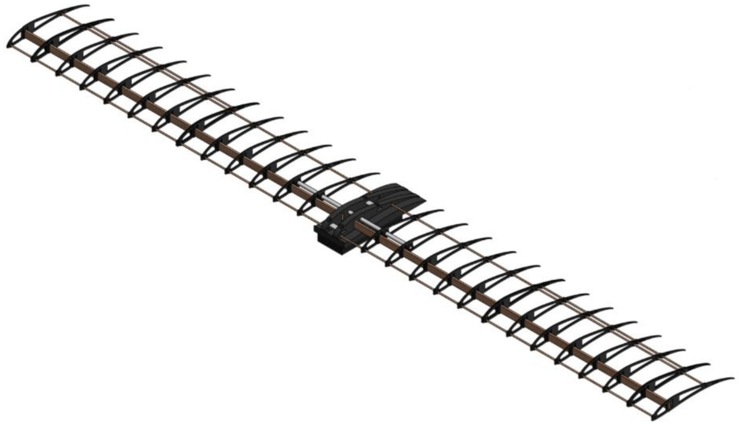


Figure 3: CAD from NAU 2016 SAE Aero capstone showing ribbed design [7]

Fuselage Benchmarking and Research

- Dimensions: Body Length
  - Typically 70-80% length of wings [6]
- Styles
  - More aerodynamic: Rounded, no hard edges on body (top)
  - Less aerodynamic: Rectangular, Geometric, hard edges (bottom)
    - Last 3 AERO teams chose this
- Materials:
  - Prior AERO team favorites
    - Balsa wood (very lightweight & fragile)
    - Plastic (lightweight & semi-durable)
    - Aluminum (heavy & durable)

Figure 8: Goldwing Edge [1]

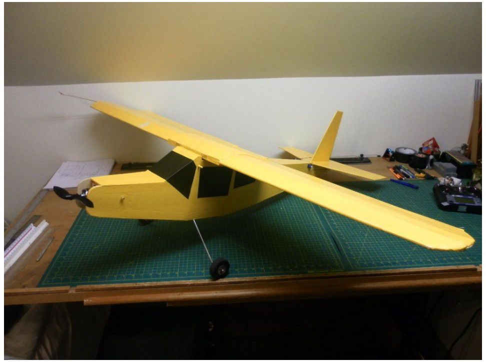
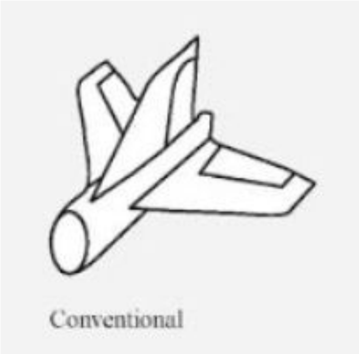
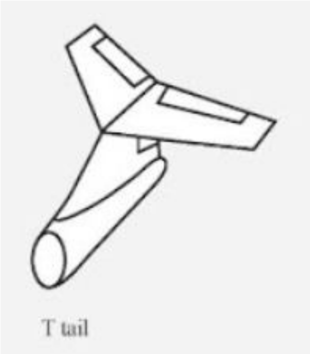


Figure 9: Homemade model [2]

Tail Benchmarking and Research

- Dimensions: Horizontal Wing
  - Typically 25% of the total wingspan [6]
  - The larger the tail, the further the CG is shifted back
  - Elevators & rutter design affects tail design heavily
- Styles:
  - SAE AERO favorites
    - Widely used for commercial and military purpose





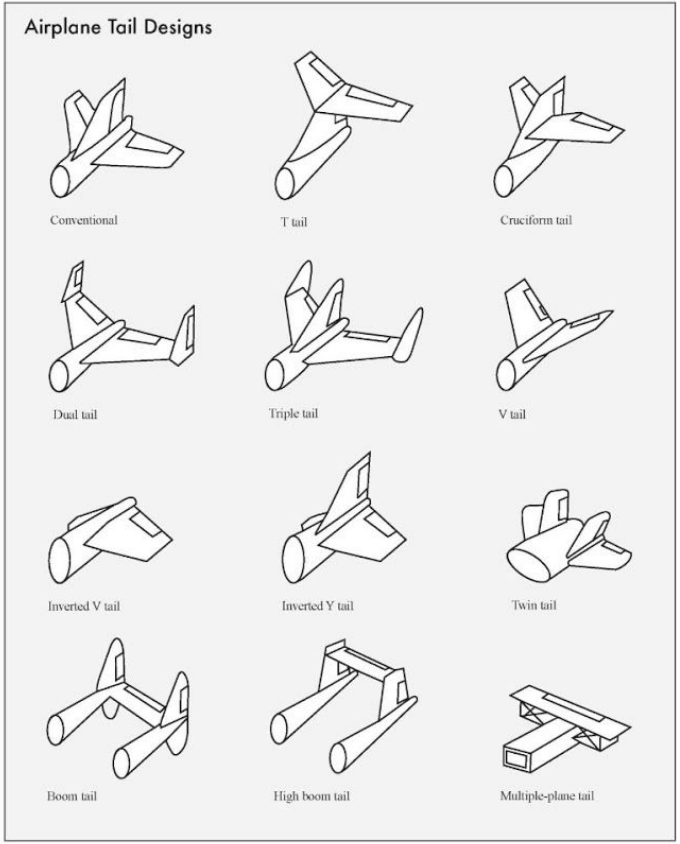


Figure 10:Airplane Tail Design Chart [9]

Propeller Benchmarking and Research

- Propellers measured using two dimensions:
  - Diameter
    - Ranges from 4.5 in. to 16 in.
  - Pitch
    - Ranges from 3 in. to 12 in.
- Two Blades
  - More blades, less efficiency
- Engine size to propeller size
- Thrust-to-Weight Ratio
- ‘15-’16 Aero Team Propeller: 18” x 12”
- ‘11-’12 Aero Team Propeller: 14” x 4”

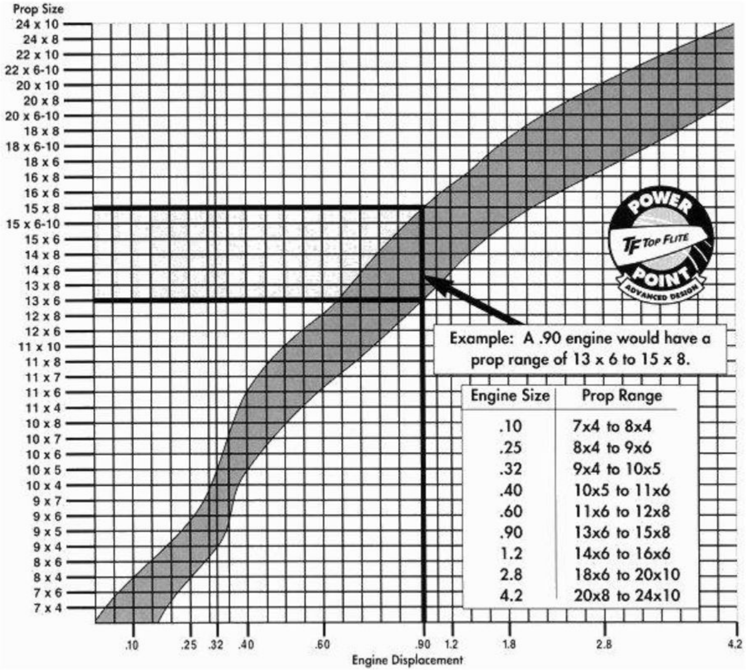


Figure 4: Top Flights power point range of props [3]

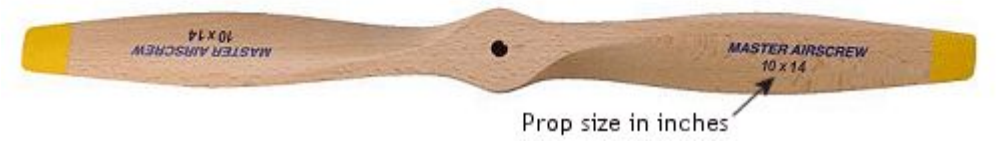


Figure 5: Propeller size labeling [3]

Servos Benchmarking and Research

- Servos for:
  - Rudder
  - Elevator
  - Nose Gear
  - Aileron
- Past Teams:
  - Extra High Torque Servo (SPMS601H)
    - Speed: 0.15 (sec/60 degrees) @ 7.4V
    - Torque: 162 (oz-in) @ 7.4V
  - TS-150
  - TS-140
  - TS1-126
    - Speed Range: 0.21 (sec/60 degrees) @ 6V - 0.15 (sec/60 degrees) @ 6V
    - Torque Range: 65 (oz-in) - 162 (oz-in)

Figure 7: Example of servo from 2016 Aero Team [5]

Motor Benchmarking and Research

- Electric motor
- Brushless motor, higher speeds
- Electronic speed controller needed
- Past Teams:
  - Brushless motor
  - The team from 2016 used an AXI 5325/16 Gold Line motor

Figure 6: Example of the motor from 2016 [7]

Landing Gear Benchmarking and Research

- Tricycle landing gear commonly used in SAE Aero
  - Front wheel controls plane on the ground
  - Main gear and nose gear
  - Simpler center of gravity
- Materials:
  - Carbon Fiber
  - Aluminum

Three common types of landing gear

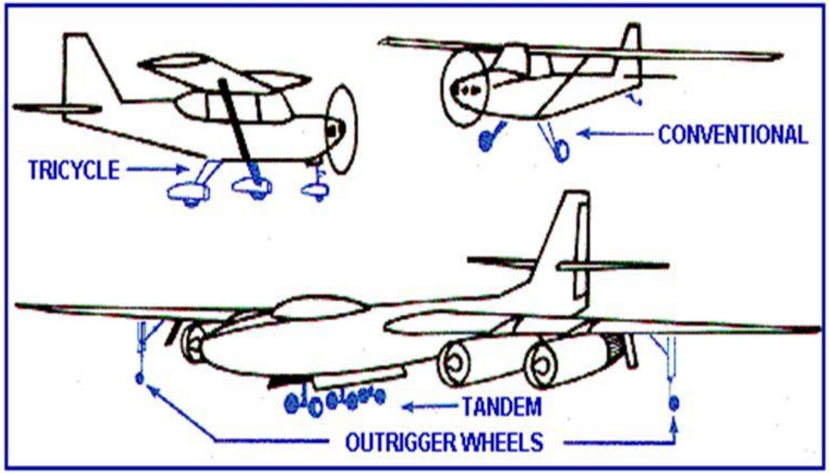


Figure 11: Common landing gear chart

Customer Requirements

- Fixed Wing Aircraft
- Must be able to take-off, fly, and land
- Must be safe
- Must be an electric motor
- Must be a cargo plane
- Must carry a payload of at least 6.5 pounds
- Original design
- Must be repeatable
- Must be durable/ repairable

Engineering Requirements

- 12’ Max Wingspan
- 2.4 GHz radio control system
- 1000 W Power Limiter
- Battery standardized (6 cell 22.2V Lithium Polymer battery pack)
- Max weight of 55 pounds
- Red arming plug present on aircraft as a safety shutoff
- Takeoff distance: 200 ft
- Landing distance: 400ft
- Straight flight distance: 400 ft
- Must fly empty and with payload

Engineering Constraints

- No use of fiber reinforced polymers [FRP] for body/wings
- No metal propellers
- Use of lead is strictly prohibited
- Aircraft must be powered by engine/motor onboard. No internal/external forms of stored potential energy
- The payload cannot contribute to structural integrity of airframe
- No multiple motors

House of Quality (HoQ)

Customer Requirement	Weight	Engineering Requirement	Wingspan	Power Limit	Weight	Takeoff Distance	Landing Distance	Stored Energy	Fuselage Capacity	Payload	Lift	Cost	Thrust
1. Low Cost	0.12		9		9			3	1			9	
2. Durable	0.1		3		3								
3. Safe	0.05			9									
4. Repeatablility	0.05		1		1						9		9
5. Take Off	0.16		9		9	9		3			9		9
6. Landing	0.16		9		3		9				3		9
7. Repairability	0.05		1									9	
8. Scoring	0.16				1	1	1		9	9	9		9
9. Transportation	0.05		9										
10. Controllabilty	0.1		9	3	9			3	3	9	9		9
Absolute Technical Importance (ATI)			5.71	0.75	4.41	1.6	1.6	1.14	1.86	2.34	4.71	1.53	5.67
Relative Technical Importance (RTI)			1	11	4	7	7	10	6	5	3	9	2
Target ER values			10	1000	45	100	100	6000	15	10	300	1000	200
Tolerances of Ers			±2	±50	±10	±50	±50	±500	±5	±4.5	±50	±300	±50
Testing Procedure (TP#)			ft	W	lbs	ft	ft	mAh	#balls	lbs	N	$	N

Approval (print name, sign, and date):

Team member 1: ______________________

Team member 2: ______________________

Team member 3: ______________________

Team member 4: ______________________

Team member 5: ______________________

Client Approval:

Schedule

Design Process Delegation

James - Flaps and Wing Design

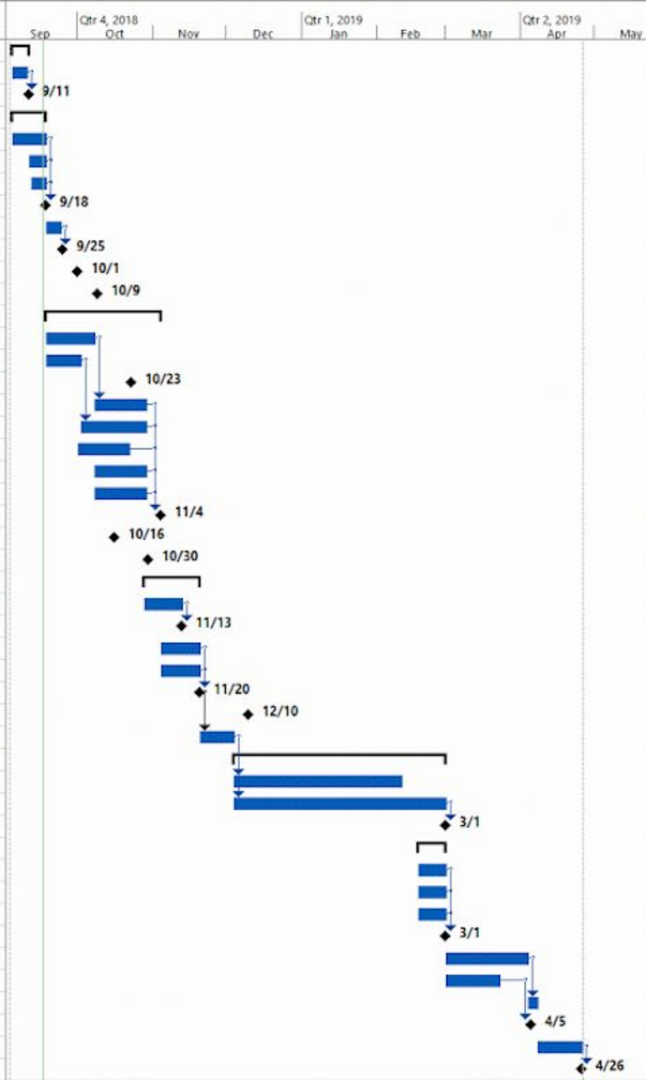
Damian - Propellor and Powertrain

Braden - Landing Gear and Powertrain

Angel - Fuselage Design

Caleb - Airfoil and Wing Design

Task Name	Duration	Start
Team Charter	**5 days**	**Tue 9/4/18**
Create Team Charter	5 days	Tue 9/4/18
Team Charter Due	0 days	Tue 9/11/18
Presentation One: Background	**10 days**	**Tue 9/4/18**
Backgroud Research and Benchmarking	10 days	Tue 9/4/18
Identify Engineering and Customer Requirements	5 days	Tue 9/11/18
Evaluate Budget	4 days	Wed 9/12/18
Presentation 1	0 days	Tue 9/18/18
Create Website	5 days	Tue 9/18/18
Website check 1	0 days	Tue 9/25/18
Register for SAE Aero West	0 days	Mon 10/1/18
Analysis Team memo due	0 days	Tue 10/9/18
Initial Design Process	**34 days**	**Tue 9/18/18**
Airfoil Selection	15 days	Tue 9/18/18
Battery, Motor, and Propellor Selection	10 days	Tue 9/18/18
Analytical Reports Due	0 days	Tue 10/23/18
Wing Design	16 days	Mon 10/8/18
Fuselage Design	20 days	Tue 10/2/18
Landing Gear Design	16 days	Mon 10/1/18
Electronics/Steering System Design	16 days	Mon 10/8/18
Tail design	16 days	Mon 10/8/18
Final Design Selected	0 days	Sun 11/4/18
Preliminary Report Due	0 days	Tue 10/16/18
Website check 2	0 days	Tue 10/30/18
Final Report	**16 days**	**Sun 10/28/18**
Compile Final Report	12 days	Sun 10/28/18
Final Report Due	0 days	Tue 11/13/18
Create BOM	12 days	Sun 11/4/18
Finalize CAD	12 days	Sun 11/4/18
Submit BOM and CAD	0 days	Tue 11/20/18
Website check 3	0 days	Mon 12/10/18
Order Materials	10 days	Tue 11/20/18
Manufacture and Assemble	**63 days**	**Tue 12/4/18**
Manufacture Parts	50 days	Tue 12/4/18
Assemble RC Airplane	63 days	Tue 12/4/18
First Flight	0 days	Fri 3/1/19
SAE Design Report	**9 days**	**Mon 2/18/19**
Finalize Technical Design Report	9 days	Mon 2/18/19
Finalize 2D Drawings	9 days	Mon 2/18/19
Finalize Tech Data Sheet	9 days	Mon 2/18/19
Submit Design Report to SAE	0 days	Fri 3/1/19
Finalize and Prepare RC Airplane for competition	24 days	Fri 3/1/19
Create Tech Presentation	16 days	Fri 3/1/19
SAE Aero West Competition	3 days	Thu 4/4/19
Tech Presentation	0 days	Fri 4/5/19
Prepare for UGRADS Presentation	14 days	Mon 4/8/19
UGRADS Presentation	0 days	Fri 4/26/19



Budget

	Item	Cost	Source of funding
	SAE membership	$ 125.00	
	Registration	$ 1,050.00	Engineering Department
reference book	Fundamentals of Aerodynamics (Anderson)	$ 111.00	
Insuring Safe Repeatable Flights	AMA Membership	$ 75.00	
	Flagstaff Flyers Membership	$ 200.00	
	RC practice plane	$ 220.00	
	material/manufacturing cost estimaes	$ 1,100.00	
travel estimates	hotel	$ 375.00	NAU SAE club / ASNAU
	gas	$ 400.00	
	total	**$ 3,656.00**	
	estimated total currently without funding source	**$ 1,831.00**	

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