

2021-2022 SAE Micro Aero Preliminary Presentation



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Project Description

- SAE Aero Micro Competition: Each team must design and manufacture an all-electric airplane [2].
 - The plane must be remote controlled and capable of carrying a specified payload.
- Stakeholders and Sponsors:
 - Dr. David Willy and CEIAS
 - CEIAS will provide funding for competition fees as well as gather an additional sponsorship from W.L Gore & Associates.
 - SAE will be an additional stakeholder as the host of the competition.

Project Description (cont.)

- Team Objectives:
 - Abide by all competition rules and requirements
 - Research and understand necessary topics
 - Aerodynamics, Aircraft Design, etc.
 - Prototype early and often
 - Test each prototype thoroughly

Importance

- Engineering Importance
 - Allows engineers and students to analyze aircraft design and aerodynamics on a micro level in order to boost their own understanding and apply it at a macro level.
- NAU Importance
 - Free advertising at the competition for NAU through logos on the plane as well as the team itself.
 - Bolsters the reputation of NAU's engineering department as well as entices potential students to consider NAU's school of engineering.

Background and Benchmarking

- Two designs are widely reviewed as the best on the market
 - Carbon Cub S2 1.3m RTF
 - Sport Cub S V2 RTF



Figure 1: Carbon Cub S2 1.3m RTF [3]



Figure 2: Sport Cub S V2 RTF [4]

Background and Benchmarking (cont.)

- Carbon Cub S2 1.3m RTF
 - Motor: 480W Brushless Outrunner
 - Battery: 3S 2200 mAh Li-Po
 - Transmitter: Spektrum DXS
 - Receiver: SPM4650C from Horizon Hobby
- Sport Cub S V2
 - Motor: HBZ4429
 - Battery: 150 mAh Li-Po
 - Transmitter: SPMRMLP6 from Horizon Hobby
 - Receiver: SPMA3178 from Horizon Hobby

Background and Benchmarking (cont.)

- NAU 2019 Micro Aero Team
 - Placed 15th overall at 2019 competition
 - Propeller: APC Electric SF 8x4.7
 - Motor: Scorpion HK-2520-1880KV
 - Battery: Lumenier 1800mAh 3s 35c Li-po Battery
 - Fuselage: 3D printed



Figure 3: 2019 NAU SAE Micro Aero Team [5]

Literature Review

Competition Handbook (Team)

2022 Collegiate Design Series SAE Aero Design Rules [2]

Knowledge Textbooks (Team)

Fundamentals of Aerodynamics

Aerodynamics for Naval Aviators

Aircraft Performance and Design

Design Programs (Team)

- Xflr5 - low Reynold's number airfoil and fuselage design [8]
- JBLADE – propeller design program [7]
- OpenVSP – aircraft geometry design tool [9]
- SolidWorks



Literature Review: Airframe Materials

- Criteria of materials for the airframe include cost, impact resistance, and light weight in order to keep the airplane light
- Desired material(s) involves reliability, ease of accessibility, and manufacturing for prototyping and ultimately successful performance
- "Carbon and metal-fiber reinforced airframe structures" by U.P. Breuer and S. Schmeer [9]
- Carbon fiber can be adopted into a particular orientation for the airframe to improve strength
- "High-force dynamic mechanical analysis of composite sandwich panels for aerospace structures" by Alec Redmann, Maria Camila Montoya-Ospinaa , Ryley Karl b , Natalie Rudolphc , Tim A. Osswalda [10]
- "Design of High Altitude Long Endurance UAV: Structural Analysis of Composite Wing using Finite Element Method" By Khodijah Kholish Rumayshah, Aditya Prayoga, and Dr. Ing. Mochammad Agoes Moelyadi [11]
- Potential airframe mainly utilizing Balsa Wood for structural integrity for an unmanned light weight aircraft with proven analysis

Literature Review: Electronics

- "A Guide to RC Basics and Where to Start" [12]
 - Lower kv motor requires a larger propeller for max thrust
 - Higher kv motor with smaller propeller leads to a faster plane
- "How to Choose A LiPo Battery for your RC Needs" [13]
 - Maximize power:weight ratio
 - 3S battery is optimal for most RC applications
- "Understanding Radio Control Gear" [14]
 - 6-channel transmitter is a worthwhile purchase
 - Throttle, right aileron, left aileron, rudder, elevator
 - Digital servos offer faster response times but are much more expensive

Literature Review: Motors/Powerplant

- "How to Choose the Perfect Motor for an RC Plane" [15]
 - When choosing a motor for an RC plane, you must account for both wing load and stall speed
 - Lighter aircrafts will have less wing load, and decreases the possibility that the plane will stall
 - It is crucial to match KV of the motor and propeller size
- "Drive Calculator Manual"[16]
 - Drive Calculator is program that allows users to input power supply, motor, gearbox and propeller to make calculations for power and efficiency
 - The manual gives an overview on what inputs are required
 - Industry standard and available inputs are available for all inputs, having known data for all possibilities
- "Brushless Motor Basics" [17]
 - Choosing the right motor requires known flying capabilities, such as park flyer, basic scale flying, sport flying, pattern racing and pattern aerobatics
 - Based on the desired flying capabilities, a ratio of watts per pound will be required, which will aid in determining what wattage motor we will need based on the flying capabilities and weight of the aircraft
 - Searching for the right motor will be simpler, as certain specifications will be given based on the ratio for what power is required

Literature Review: Aerodynamics (Conner)

- Introduction To Fluid Mechanics [18]
 - Drag is the “component of force on a body acting parallel to the direction of relative motion.”
 - Lift can be defined as “the component of fluid flow perpendicular to the motion of the fluid.”
 - The lift coefficient of an airfoil is $C_L = \frac{F_L}{\frac{1}{2}\rho V^2 A_p}$ where F_L is the drag coefficient. A sudden decrease in the lift coefficient causes a stall in the airfoil.
- Fundamentals of Aerodynamics [19]
 - Aerodynamics is defined as the flow of air. The scope of this project will be the flow of air over an airfoil.
 - Fluid flow going over an airfoil causes a pressure differential based on the high fluid velocity over the airfoil and the low fluid velocity under the airfoil. The high pressure wants to rush up to meet the low pressure, causing a normal force. This normal force is lift.
- Aircraft Performance and Design [20]
 - The angle of attack of an airfoil is the angle between the airfoil chord and the undisturbed fluid flow.
 - The Reynold’s number of the fluid over an airfoil determines how turbulent the flow is.

Literature Review: Airfoil

- "The Clark Y Airfoil is Ideal for RC Model Aircraft" [21]
 - Clark Y Airfoil is ideal for light applications such as remote-control aircraft.
 - Non-violent stall characteristics, leading to a more predictable flight model in different flight regimes.
- "About Airfoils for Flying Model Aircraft" [22]
 - Build wings with "washout" (geometric twist) in order for the root to stall first. This allows the ailerons to maintain authority at low speeds, which is where most of the flight envelope will be.
 - Do not use a truly flat bottomed airfoil due to the speed sensitivity.
- "Aerodynamics for Naval Aviators" Chapter 1: Basic Aerodynamics [23]
 - Practical explanation and interpretation of Bernoulli, Aerodynamics forces, Lift Equation, Drag, Airfoil Tendencies, and Aerodynamics Pitching Moments that will be applicable everywhere.
 - Friction effects and how viscous and inertial forces can dominate different parts of the flow on the wing. Direct correlation with Reynolds numbers and airflow separation from the low pressure side of the airfoil. Lift vs. Drag curve (Power curve) where at low speeds, induced drag is higher due to higher AOA, which means more lift. Where in faster stages of flight, induced drag is at a minimum, while parasite drag is dominant on the aircraft.

Literature Review: Propeller

- "RC airplane propellers. how to select and prepare." [24]
 - Number of blades: 2, According to blog below, two blades are most efficient.
 - Size of the propeller: based on engine displacement, also engine manufacturer's recommendation
- "How to choose RC Propellers (best models and reviews)" [25]
 - Fiberglass-reinforced nylon propellers, pure nylon propellers, carbon fiber propellers, wooden propellers
 - Wooden, has the highest rpm because light but very fragile. Fiberglass-reinforced for more durability
- "RC Propeller Balance - how to" [26]
 - When propeller isn't balanced, there is more vibration that can cause damage to frame and electronics
 - Can purchase pre-balanced ones, or a balancer and do it ourselves

Customer Requirements

- The customer requirements are the rules for this project since it is a competition-based event
- Keep the flight time from takeoff to the first turn as low as possible
- Fit and transport 2 different payloads: Metal plates (1) and Delivery boxes (2) via a cargo bay
- Follow the pattern shaped flight course
- Remain airborne for 300ft from takeoff before turning 180 degrees
- Land within 200ft of the landing zone
- Unload payload in less than 1 minute

Customer Needs	Customer Weights
Flight Time	9
Payload	9
Turning Radius/Maneuverability	3
RC Signal Strength (2.4 GHz)	3
Spare Parts	1
Launch T/O	3
Landing	3
Unloading Time	9

Table 1 – Customer Requirements

Engineering/Design Requirements

- Engineering Requirements were based on how to satisfy customer requirements and the parameters outlined in the rule book.
 - Most important constraints were the wingspan, battery, and power output.
 - Units listed where applicable as well as the target values listed in the rules.
 - Both tables are abbreviated excerpts from the QFD.

	Technical Requirements														
	Wingspan	Cost	Battery	Thrust/Motor	Cargo Bay	Lift	Drag	Thrust	Weight	T/O Re #	RC Signal Range	CG Marking	Ground Control	Flight Control	Durability
Technical Requirement Units	in	\$	#Cells	lbF/watt	s	in ³	lbf	lbf	lbf	lbf	ft	in			
Technical Requirement Targets	10		4	450	144										

Table 2: Engineering Requirements

QFD

		Technical Requirements														Customer Opinion Survey					
Customer Needs	Customer Weights	Wingspan	Cost	Battery	Thrust/Motor	Cargo Bay	Lift	Drag	Thrust	Weight	T/O Re #	RC Signal Range	CG Marking	Ground Control	Flight Control	Durability	1 Poor	2	3 Acceptable	4	5 Excellent
Flight Time	9	9	3	1	9	3	9	9	9	3	9	3		3	9			AB	C		AB
Payload	9	3		3	9	9	9	1	3	9			9		3	9	AB			C	
Turning Radius/Maneuverability	3	3			3	1	1	1	9	1	9	3			3				C		AB
RC Signal Strength (2.4 GHz)	3		1	3								9								ABC	
Spare Parts	1	1	3	1												9					
Launch T/O	3	9	1		3	1	9	9	9	9	9			9	3			C	AB		
Landing	3	9	1		1	1	3	3	3	3	3			9	3			C			AB
Unloading Time	9	1												3			AB			C	
Technical Requirement Units		in	\$	#Cells	lbF/watts	in ³	lbf	lbf	lbf	lbf		ft	in								
Technical Requirement Targets		10		4	450	144															
Absolute Technical Importance		181	39	46	183	117	201	129	171	147	144	63	81	108	135	82					
Relative Technical Importance		3	12	11	2	9	1	8	4	5	6	4	6	10	7	7					

Table 3 - House of Quality

Schedule

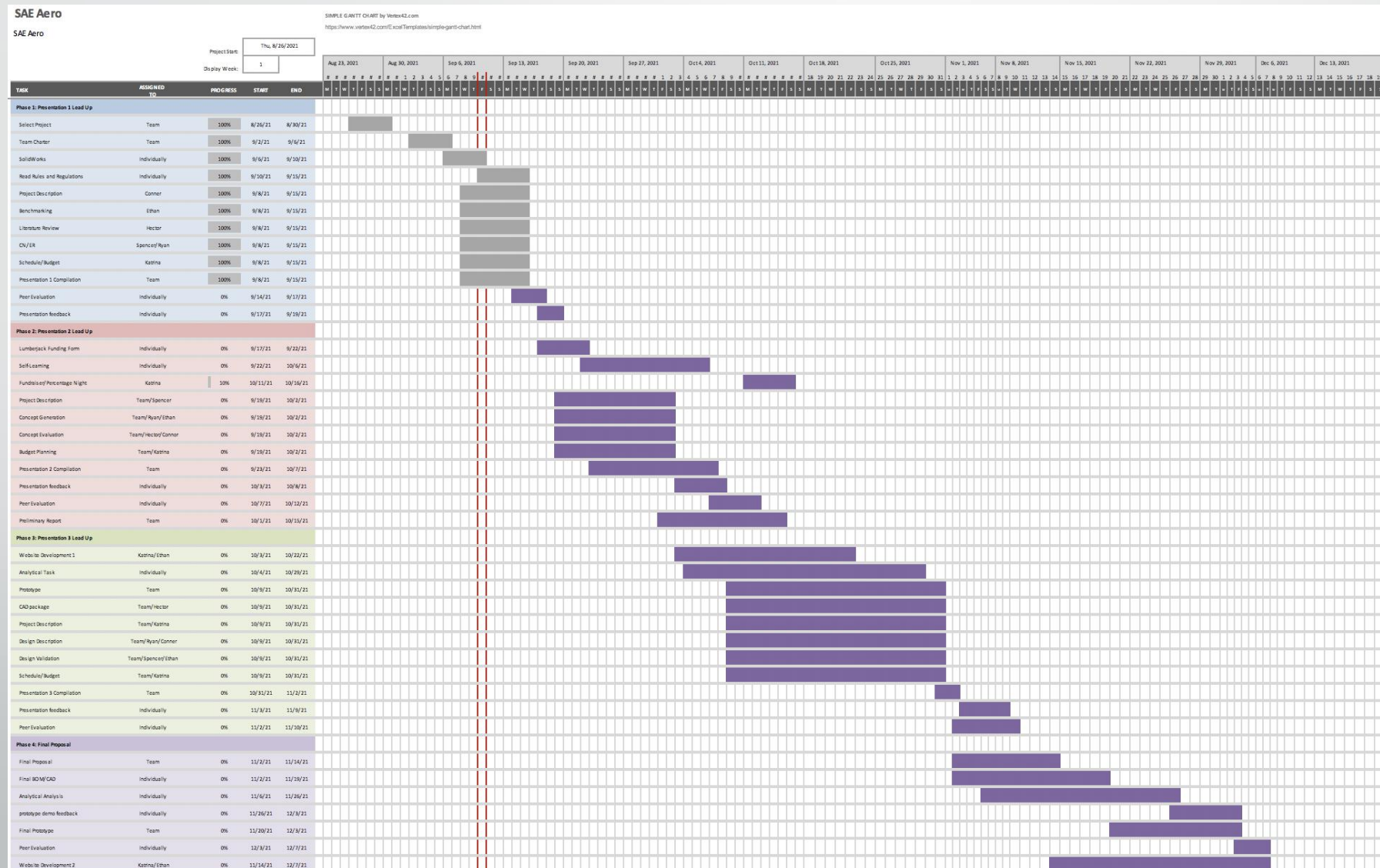
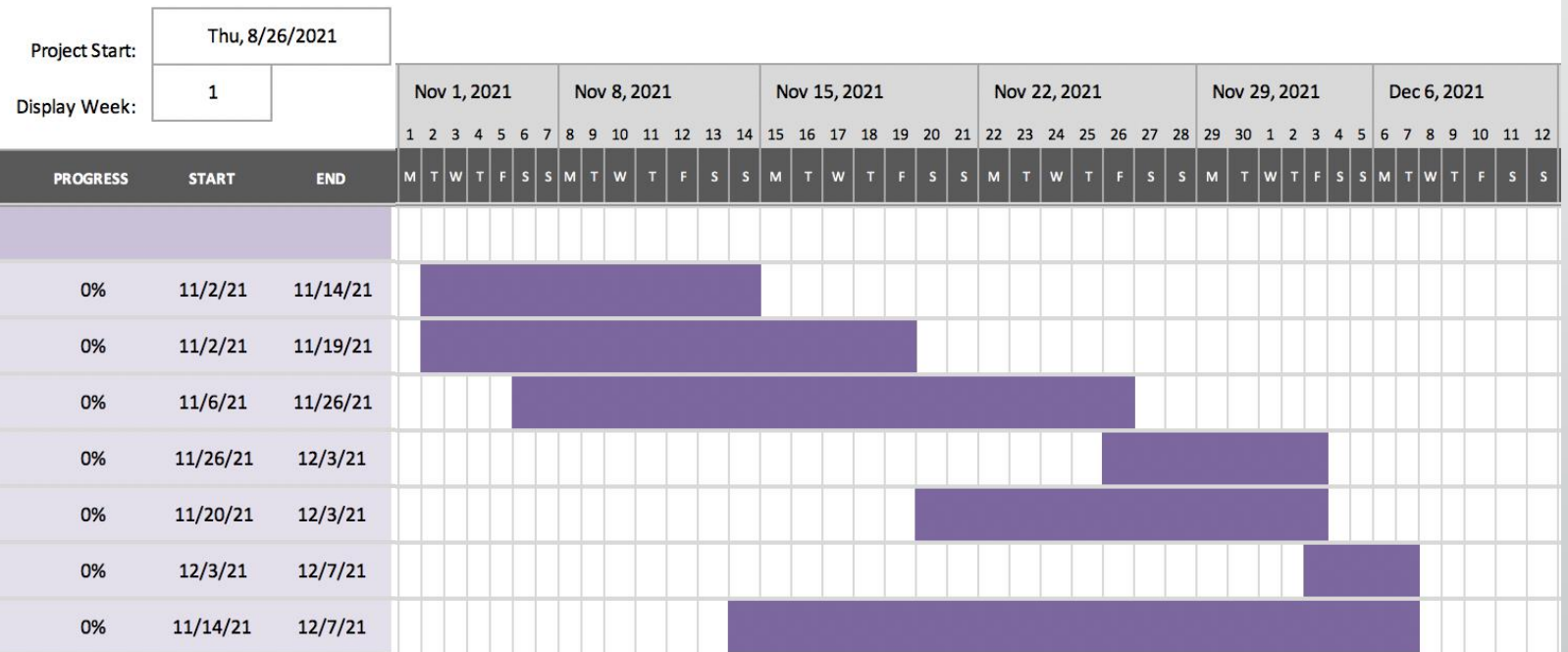


Chart adapted from [6]

Phase 4

SAE Aero

SAE Aero



Budget

- Current Budget: \$0
- Registration: \$1300 from Engineering Department
- Funding Needed: ~\$2000
 - Travel cost: ~\$1200
 - Prototyping: ~\$600
 - Safety: ~\$200
- Pending Funds:
 - Gore: \$1500
 - Chipotle percentage night: ~\$500-\$2000
 - Lumberjack fund-travel costs: ~\$200 each member

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