University of Houston – Space City Aeronautics

2025 – 2026 AIAA Design, Build, Fly Proposal

1. Executive Summary

This proposal outlines the Space City Aeronautics team's plan to design, build, and fly a radio-controlled aircraft, "Max Velocity 1" (MV-1), for the 2025–2026 AIAA Design/Build/Fly (DBF) competition, representing the University of Houston's AIAA Chapter. The objective of this year's challenge is to design a bush plane capable of performing a sequence of missions simulating the transport of payloads, banner towing, and rapid ground configuration changes. The sensitivity analysis identified payload quantity as the most critical parameter for Mission 2, and lap count for Mission 3. These findings guided a series of trade studies, resulting in the selection of a high-wing monoplane with a conventional tail and single electric propulsion system, optimized for stability, simplicity, and aerodynamic efficiency. The wing features a 51 in. span and 15 in. chord with SD 7032 airfoil and a rectangular planform providing a lift-to-drag ratio of 13.7 at 3° AoA. The propulsion system is powered by a SunnySky X5320 motor with a 20 × 8 propeller and a 4500 mAh 99.9 Wh battery, chosen for thrust and endurance balance across all missions. The airframe, built from laser-cut balsa and basswood ribs reinforced with carbon fiber spars and covered in Monokote, provides a lightweight yet strong structure. In Mission 2, the aircraft will carry four hockey pucks and fourteen rubber ducks internally. In Mission 3, the 90×18 in. lightweight polyester banner will be deployed via a servo-actuated dual-hook release mechanism, ensuring fast and reliable performance. A prototype and a final competition aircraft will be constructed over the year using an iterative manufacturing process supported by CFD, FEA, and flight tests. The Space City Aeronautics team consists of 17 undergraduate students, organized into four sub-teams: Aerodynamics, Structures, Avionics, and Banner Systems.

2. Management Summary

2.1. Team Organization

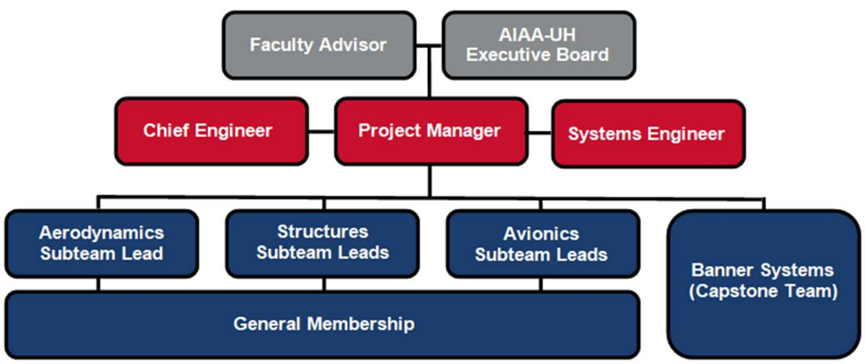


Figure 1. Team Organizational Structure

Space City Aeronautics is a competitive team within the University of Houston Chapter of the American Institute of Aeronautics and Astronautics. AIAA-UH acts as the team's administrative and financial parent organization. The team consists of 17 undergraduate students and is advised by Alumni, Faculty, and graduate students. The team is led by a Project Manager, Chief Engineer, and Systems Engineer, who oversee project development across logistical, technical, and integration areas, respectively, and any decision conflicts are decided by employing a tie-breaker rule. The pilot is a student member with previous DBF fly-off experience. Space City Aeronautics is organized into three sub-teams: Aerodynamics, Structures, and Avionics, each led by one or two experienced members responsible for technical execution, documentation, and mentorship of new members. The fourth sub-team covers the Banner Systems and is composed of 4 UH Mechanical Engineering Capstone students. Sub-team leads meet weekly to report progress, coordinate integration plans, and discuss procurement and testing needs. General team meetings occur twice a week to share updates and carry out design, manufacturing, and testing activities. Detailed roles and associated skills are further described in Table 1.

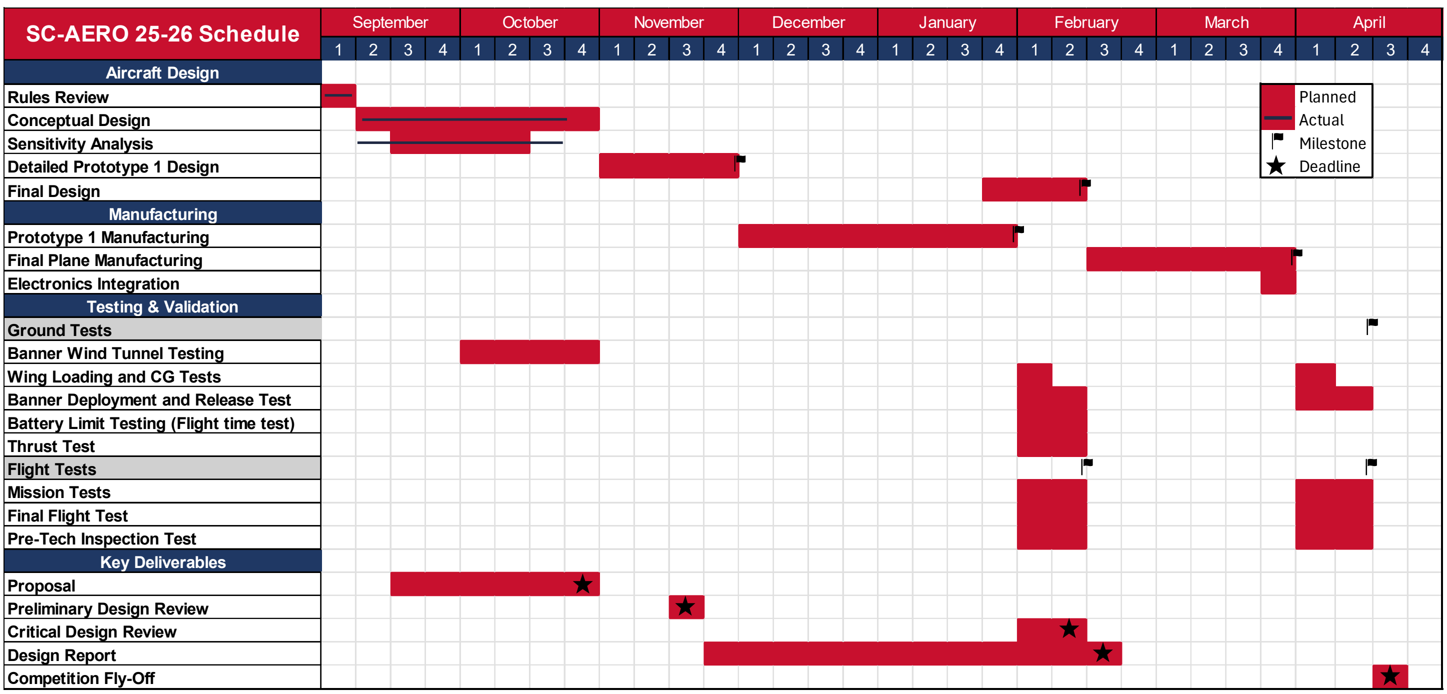
Table 1. Sub-team roles and skills

Sub-Teams	Roles	Skill Sets
Aerodynamics	Designs, analyzes, and manufactures wings, empennage, and control surfaces. Performs aerodynamic and stability analysis using computational and experimental methods.	Aerodynamic Analysis (XFLR5), CFD simulation, MATLAB, CAD modeling
Avionics	Determines and applies electrical and signal components in the aircraft. Integrates and tests electronic components, including motor control, sensors, and telemetry. Supports flight testing and data acquisition.	Circuit design, soldering, wiring, CAD modeling
Structures	Designs, analysis, and manufactures fuselage, landing gear, and other physical aspects of the airframe. Ensures structural integrity and optimizes weight and spatial distribution through analysis and testing.	CAD modeling, structural Finite Element Analysis, CAM, composite materials, fabrication, 3D printing, laser cutting
Banner Systems	Designs, implements, and tests banner deployment system, ensuring compliance with mission-specific requirements.	CAD modeling, wiring, system integration, wind tunnel testing

2.2. Schedule

The proposed schedule is represented by the Gantt Chart shown in Table 2.

Table 2. Gantt Chart



2.3. Budget

The anticipated budget for the 2025-2026 competition is detailed in Table 3 and will be financed through a combination of sponsorships, fundraising, and support from Alumni and the University of Houston. This will enable the team to bring 10 students to the competition using student vehicles. Tools, equipment, and software are not included in the costs as they are available to the team at no cost through university resources. The team receives funding primarily from the Fluor Corporation and the UH Mechanical and Aerospace Engineering Department.

Table 3. 2025-2026 Competition Budget Breakdown

BUDGET					
Avionics		Structures / Banner Systems		Logistics	
Component	Price	Component	Price	Component	Price
Receiver	$130	Basswood Sheets	$172	Fly-Off Registration Fee	$550
Servos (x7)	$87	Carbon Fiber Rod & Spar	$132		
Motor	$139	Landing Gear	$75	Transportation (Fuel)	$600
Battery	$85	Balsawood Sheets	$146		
Transmitter	$320	Filament	$48		
Propeller	$67	Monokote Wrap	$240	Lodging	$1,200
ESC	$125	Banner Material	$20		
Wiring	$30	Fishing Wire	$12	Food	$1,250
Misc. (Fuses, Switches, etc.)	$40	Misc. (Glue, hinges, etc.)	$60		
Total Cost	$1,023	Total Cost	$905	Total Cost	$3,600
				Total Project Cost	**$5,528**
				+15% Contingency	**$6,357**

3. Conceptual Design

3.1. Analysis of Mission Requirements

The theme of this year's competition is to design a banner bush towing plane and simulate the cost and requirements of starting a towing business. The Mission requirements are outlined below in Table 4.

Table 4. Mission Requirements Breakdown

Mission	Scoring Criteria	Mission Description	Subsystem Requirements
Mission 1	1	• Ready aircraft in five minutes • Complete three laps in five minutes	• The aircraft wingspan be within 5 ft • Aircraft must be easily configured for flight • The aircraft must be durable, reliable, and capable of achieving stable flight
Mission 2	$1+\frac{(Net\ Income)}{(Net\ Income)_{max}}$	• Ready aircraft and load ducks and hockey pucks in five minutes • Complete as many laps as possible in five minutes • Carry the maximum amount of ducks and hockey pucks with the smallest battery capacity	• Aircraft must have space to carry a large amount of ducks and hockey pucks • Aircraft must be structurally strong enough to carry the heavy payload under high Gs • Propulsion system must provide enough power for additional weight of payload • Propulsion system must be efficient to allow smallest battery capacity and maximum laps
Mission 3	$2+\frac{\left(\frac{\#\ laps \cdot Banner\ length}{RAC}\right)}{\left(\frac{\#\ laps \cdot Banner\ length}{RAC}\right)_{max}}$	• Ready aircraft and load banner in five minutes • Deploy banner after upward turn • Complete as many laps as possible within five minutes • Release banner on final lap • Carry longest banner possible	• Banner system must be permanently installed on the aircraft to minimize staging time • Banner must be as long as possible with optimal length to width ratio • Aircraft must maximize thrust and lift to overcome banner drag • Banner deployment and release mechanisms must be reliable
Ground Mission	$\frac{(Mission\ time)_{min}}{Mission\ time}$	• Minimize time to load ducks and pucks • Unload ducks and hockey pucks and install banner in least time possible • Verify flight control systems are active • Verify deployment and release of banner	• Ducks and hockey pucks must have quick and easy loading process • Banner must have easy loading process
Total Score = (0.15 x Proposal Score + 0.85 x Design Report Score) x (GM + M1 + M2 + M3) + Participation Score			

3.2. Sensitivity Analysis

A sensitivity analysis was performed in MATLAB to identify the parameters with the greatest influence on each Mission output, enabling design optimization by prioritizing the most impactful variables. Using the optimization code the team developed, in both Mission 2 and 3, each baseline parameter influencing the score was altered by ± 30% while keeping other parameters constant. The resulting score changes were calculated and plotted in Figure 2. For Mission 2, the number of hockey pucks was determined to have the highest positive influence on the score, despite the corresponding weight increase. The rubber duck count and the number of laps completed within five minutes also showed positive correlations, while increasing the efficiency factor produced a negative correlation as it decreased the lap time. For Mission 3, the lap count within five minutes was found to be the most sensitive parameter. While increasing banner length initially improved the score, the resulting increase in drag led to faster battery depletion and fewer achievable laps. Additionally, a decrease in RAC was observed to yield a higher score at greater flight velocities; however, this approach was not preferred, considering increased banner drag during Mission 3.

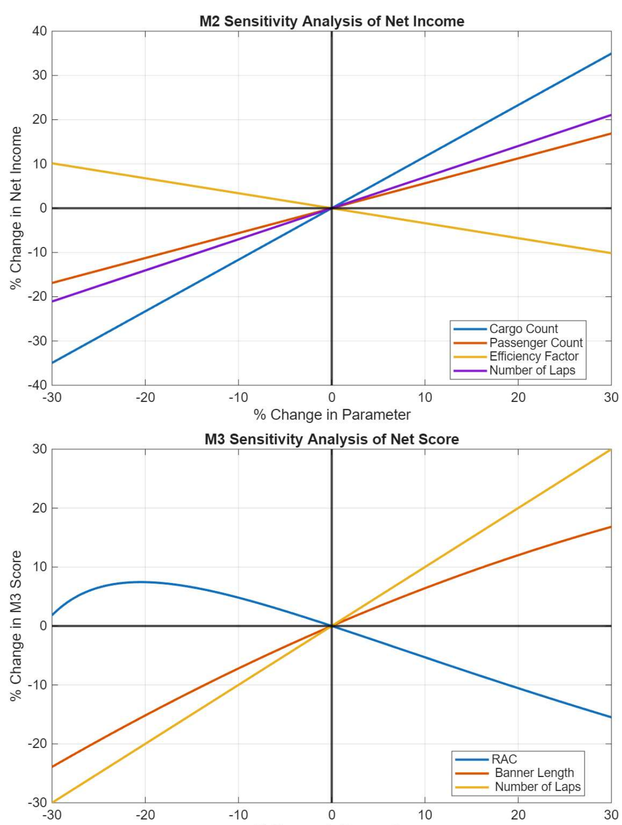


Figure 2. M2 and M3 Sensitivity Analysis.

3.3. Trade Studies

A series of trade studies were conducted prior to the optimization of the aircraft's design. Each option was critiqued under varying criteria and rated on a scale from 1-10, with 10 being the highest performance. The results of these trade studies are summarized in Table 5.

Table 5: Trade Studies

Wing Configuration				
Criteria	Weighting Factor	High	Mid	Low
Manufacturability	6	5	7	2
Payload Space	8	8	5	9
Aircraft Stability	9	9	7	5
Banner Interference	-	-	-	-
Total Score		175	145	129

Tail Configuration				
Criteria	Weighting Factor	Conventional	T-Tail	H-Tail
Manufacturability	7	9	4	6
Controllability	8	7	6	8
Aircraft Stability	9	8	4	9
Banner Mount Interference	5	8	9	5
Total Score		231	157	212

Landing Gear Configuration				
Criteria	Weighting Factor	Tail Dragger	Tricycle	Quadricycle
Structural Integrity	7	7	5	7
Landing Characteristics	8	8	6	5
Ground Stability	5	8	5	3
Banner Interference	9	1	8	6
Total Score		162	180	158

Wing Shape				
Criteria	Weighting Factor	Sweep	Rectangular	Taper
Aerodynamic Efficiency	9	7	9	8
Stall	7	8	8	9
Lift Curve Slope	9	8	9	9
Manufacturability	8	4	9	7
Total Score		223	290	272

Fuselage Type				
Criteria	Weighting Factor	Integrated	Tail boom	Double Boom
Payload Space	7	9	5	4
Manufacturability	6	5	8	6
Banner Interference	7	7	5	2
Structural Integrity	8	8	7	5
Total Score		206	174	118

Propulsion System Configuration				
Criteria	Weighting Factor	Single Tractor	Dual Tractor	Single Pusher
Cost	8	9	4	8
Thrust	7	6	9	7
Efficiency	8	7	6	6
Aircraft Stability	9	6	8	5
Total Score		224	215	206

3.3.1. Landing Gear Configuration

When considering the requirements for successful takeoff and landing while keeping the banner deployment system from getting damaged, landing characteristics and banner interference were the main factors. The tricycle configuration was chosen because it minimizes interference with the banner deployment while maintaining favorable landing characteristics.

3.3.2. Fuselage and Empennage Configuration

Fuselage geometry was analyzed to maximize internal volume for payload capacity while minimizing structural weight. A conventional fuselage layout was chosen because it provides greater usable space without increasing fuselage length. For the tail, a conventional tail was chosen due to its ease of manufacturing, minimal interference with the banner, and lower weight than the other options.

3.3.3. *Wing Shape and Configuration*

When determining the shape of the wing, key factors include aerodynamic stability, stall angle, tendency towards a higher lift curve slope at the cruise condition, and manufacturability. A rectangular wing planform was chosen for its high lifting surface area, predictable root-stall behavior, and structural simplicity. To enhance roll stability during banner towing, a high-wing configuration was selected, providing improved lateral stability and easier control at low speeds.

3.3.4. Propulsion System Configuration

Sensitivity analysis and team factors determined the criteria for the propulsions system to be cost, thrust, overall efficiency, and stability of the aircraft. While a dual-tractor setup offered more thrust and aircraft stability benefits for Mission 3's banner towing challenge, it was deemed less favorable due to added weight, complexity, and cost. The single-tractor configuration was ultimately selected for its simplicity, reliability, and sufficient performance across all missions.

3.4. Preliminary Design

To counteract the increased weight and increased drag from their respective missions, it was determined that the airfoil required a Coefficient of Lift/Coefficient of Drag (C_l/C_d) between 12-15, a pitch moment near zero during non-turbulent flight, a reasonable stall angle, and feasible manufacturability. For the airfoil selection, a custom MATLAB script was developed to automate CFD simulations in COMSOL across a database of 100 airfoils to optimize for C_l/C_d at the expected flight velocity. The four best-performing airfoils were then further analyzed in XFLR5 for aerodynamic stability, manufacturability, and stall behavior. SD 7032 was selected as the optimal choice due to its 13.7 C_l/C_d ratio, 17° stall angle at cruise conditions, and stable pitch moments during non-turbulent flights. Although the optimization code suggested a shorter wingspan for a higher RAC score, a slightly longer 51 in. wingspan was chosen to maintain a higher aspect ratio and ensure improved stability in banner flight while providing the additional lift needed for Mission 2's higher payload. A longer chord length of 15 in. was selected to compensate for expected lift loss. For the empennage, NACA 0012 was chosen for its expected flight performance at low Reynolds numbers, reliability and ease of manufacturability. For the vertical and horizontal stabilizers, a span of 7 in. and 24 in. with a uniform chord of 8 in. were selected to ensure a positive static margin and provide sufficient elevator and rudder authority at cruise conditions. The sizing was determined based on the battery width, the fuselage length required to maximize passenger capacity without compromising aircraft stability, and the height needed to stack the cargo and avionics bay vertically without affecting the center of gravity between missions. Based on these requirements, the dimensions were determined to be 51 in. long, 6 in. wide, and 8 in. tall, at maximum. The propulsion system consists of a transmitter, 8-channel receiver, 7 servos, a 4500 mAh 6S battery, a 370 kV X5320 motor paired with a 20×8 propeller and a 100 A electronic speed controller (ESC) to provide a max thrust of 8200 gF with min efficiency of 3.89 g/W. Although the sensitivity analysis suggested a lower battery capacity for scoring efficiency, the team selected a 99 Wh battery to account for drag uncertainties in Mission 3 and extend flight endurance capabilities. The hockey puck cargo will be placed in an enclosed bay, separate from the passenger compartment, and held in by an external hatch. The rubber ducks will be placed in a 3D printed holder, secured by a Velcro on the bottom of the passenger section that restricts movement during flight operations as shown in Figure 3.

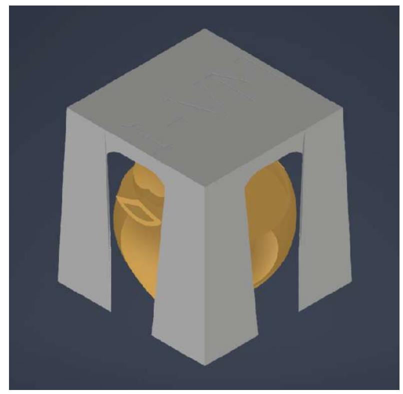


Figure 3 - Duck Holder

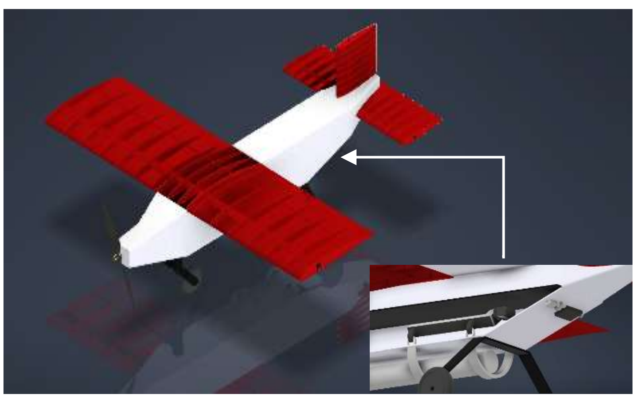


Figure 4. CAD overview of MV-1 and banner system

Using iterative wind tunnel testing on different materials, the banner material was determined to be a lightweight polyester due to its low drag coefficient, allowing for a longer banner with minimal aerodynamic resistance. Using the optimization code, the banner dimensions were determined to be 90 in. × 18 in. The banner will be rolled and secured beneath the fuselage using two straps, as illustrated in Figure 4. For deployment, a servo connected to two release hooks will rotate upward, disengaging the straps and allowing the banner to drop and unfurl naturally under gravity. During flight, the banner will be towed using fishing line attached to a pole with added weight on its end for verticality. Upon completion of the final lap, a second servo located at the rear of the aircraft will actuate a linear pin release mechanism, retracting the pin to free the tow line.

3.5. Mission Targets

In M1, the MV-1 will successfully fly 3 laps in 131 seconds. Based on optimization code, in M2, the MV-1 will fly 7 laps with 14 ducks and 4 hockey pucks in 279 seconds. In M3, while towing a banner, MV-1 will successfully complete 6 laps in 260 seconds. The ground crew will finish GM within 240 seconds. Expected mission parameters are tabulated in Table 6.

Table 6: Mission and Design Parameters

Mission Parameter		Propulsion		Wing		Tail		Mission Specifics	
M2 Flight Velocity	77.23 ft/s	Propeller	20 x 8	Wing Area	765 in²	Horizontal Tail Span	24 in	Duck Amount	14
M2 Laps	7	Motor	370 KV	Aspect Ratio	3.4			Puck Amount	4
M2 Takeoff Weight	5.41 lb	Battery	4500 mAh; 99.9 Wh	Wingspan	51 in	Vertical Tail Span	7 in	Banner Length	90 in
M3 Flight Velocity	62.33 ft/s			Chord Length	15 in	Integrated Tail Length	48 in	Banner Height	18 in
M3 Laps	6	Max thrust	8200 gF	Airfoil	SD 7032	Airfoil	NACA 0012	RAC	3.3
M3 Takeoff Weight	4.86 lb			Mounting Angle of Attack	3°			Efficiency Factor	0.99

4. Manufacturing Plan

4.1. Manufacturing Overview

The team will construct two aircraft over the course of the year: one prototype and one final competition aircraft. The initial prototype will undergo extensive testing to identify and address structural or aerodynamic deficiencies prior to producing the final aircraft. Outlined in Figure 4, the iterative nature of the manufacturing process, in conjunction with a second manufacturing phase, lends itself to a final craft that will have the benefit of having undergone both digital and physical testing twice.

4.2. Critical Processes

Prior to manufacturing, CFD and FEA analyses will allow the team to evaluate aerodynamic performance and structural integrity. Major components such as the wings and fuselage will be laser-cut for precision and repeatability. The team will also use 3D printing and foam manufacturing for minor components, such as nose cone and control surfaces, as well as any complex parts unable to be manufactured with laser cutting. Additionally, composite rods will reinforce high-load regions such as wing spars and landing gear mounts to increase strength without significant added weight. A lightweight plastic shrink film with heat-activated adhesive will be applied to the airframe surfaces to reduce skin friction drag and provide a clean aerodynamic finish.

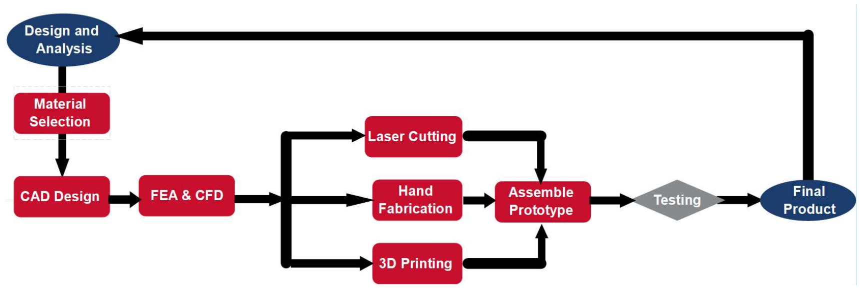


Figure 5. Manufacturing Process

5. Test Planning

The team plans to conduct three types of tests to validate the performance of the aircraft as seen in Table 7. Propulsion tests will validate expected flight time and max thrust, while ground tests will demonstrate the performance of subsystems. Finally, flight tests will test the performance of the aircraft during flights in different mission configurations.

Table 7 - Test Planning

Test Type		Objective	Method	Sub-Team
Propulsion Tests	Thrust Generation Test	Find a propeller that maximizes thrust, efficiency, and estimated flight time for our motor.	Append motor and propeller on student made test stand to test performance.	Avionics
	Battery Drain Test	Determine the maximum lifespan of a single battery at cruising speed.	Use motor prop test stand to determine the performance of propulsion battery.	Avionics
Ground Tests	Wing Loading Test	Determine how much force the wing can withstand.	Affix one end of the wing to a surface and add weights to the other end of the wing.	Structures, Aerodynamics
	CG Test	Determine the center of gravity of the aircraft.	Balance the plane manually using a CG stand and verify analysis data.	Structures, Aerodynamics
	Electronics Bench Test	Validate propulsion and electronic systems.	Assemble propulsion and electronic systems. Provide power to systems and test functionality of each electronic component.	Avionics
	Controls test	Verify that all control surfaces are able to move.	Ensure control servos are connected to reciever and powered. Using Transmitter, find maximum deflection of each control surface.	Full Team
	Banner Drag Test	Determine amount of drag the banner imposes on the plane.	Secure banner to force gauge inside of wind tunnel. Measure drag force of banner under maximum flight speed conditions.	Banner Systems
	Assembly Test	Determine the most efficient method of assembly to achieve a faser time for the competition.	Iteratively configure the aircraft for Ground Mission while timing attempts until desired time is achieved.	Full Team
Flight Tests	Standard Flight Test	Verify that the aircraft is able to properly take off, cruise and land, while validating the optimization data.	The plane will be taken to a hobby airspace and flown twice to allow the team to test takeoff, stability of aircraft and landing capability.	Full Team
	M1 Mock test	Complete M1.	Use stopwatch to measure total time aircraft takes to complete three competition laps.	Full Team
	M2 Mock Test	Complete M2.	Configure aircraft for Mission 2, and fly planned number of competition laps within five minutes.	Full Team
	M3 Mock Test	Complete M3.	Configure aircraft for Mission 3. Deploy banner in flight and complete expected number of laps, then release banner.	Full Team