2026 Design, Build, Fly Competition Summary

The 2025-26 AIAA/Textron Aviation/RTX Design, Build, Fly Competition Flyoff was held at the Textron Aviation Employees Flying Club in Wichita, KS on the weekend of April 16-19, 2026. This was the 30th year of the competition. Of the 175 proposals submitted and judged, 102 teams were invited to submit a design report for the next phase of the competition. 98 teams submitted design reports and 89 teams attended the flyoff (17 international teams). Over 1200 students, faculty, and guests were present. Of the 89 teams in attendance, 83 successfully completed tech inspection. The weather did not cooperate on Friday afternoon but conditions were great on Saturday and Sunday. Of the 197 official flight attempts, 143 resulted in a successful score with 73 teams achieving at least one successful flight score and 17 teams successfully completing all missions (one ground and three flight missions). The quality of the teams, their readiness to compete, and the execution of the flights was exceptional.

The contest theme this year was a Banner Towing Bush Plane. The first mission was a Test Flight requiring the aircraft to complete three laps within five minutes. The second mission was a Charter Flight with the score based on the number of passengers (rubber ducks) and cargo (hockey pucks) carried plus the number of laps flown and battery capacity. The final mission was a Banner Towing flight with the score dependent upon banner length, the number of laps flown and RAC (wingspan). Teams were also required to complete a ground mission demonstrating the efficiency of loading and unloading passengers and then converting the airplane into a banner towing configuration. The team’s final score is the product of the sum of the flight and ground mission scores and total report score plus participation score. More details on the mission requirements and scoring breakdown may be found at the competition website: http://www.aiaa.org/dbf.

First Place went to the **University of Ljubljana**, Second Place went to **the University of Washington-Seattle**, and Third Place went to the **University of California, Los Angeles**. A full listing of the results is included below. The Best Paper Award, sponsored by the Design Engineering TC for the highest design report score, went to the **University of Southern California** with a score of 91.98.

For the fifth year, the Stan Powell Memorial Award recognized a team that exhibited the Most Meaningful Lessons Learned during the competition. This year, it was awarded to **Washington University in St. Louis**. After crashing in their first two flight attempts with significant damage, the team maintained a very positive attitude, did not give up, put in many hours of work to rebuild their airplane and completed a successful flight with pride and excitement.

We owe our thanks for the success of the DBF competition to the efforts of many volunteers from Textron Aviation, RTX, and the AIAA sponsoring technical committees: Applied Aerodynamics, Aircraft Design, Flight Test, and Design Engineering. These volunteers collectively set the rules, judge the proposals and reports, and execute the flyoff. Thanks also to the Premier Sponsors: Textron Aviation and RTX, and to the AIAA Foundation for their financial support as well as to our Gold sponsors this year – General Atomics, Mathworks, Anduril and Reliable Robotics. Special thanks go to Textron Aviation for hosting the flyoff this year.

Finally, this event would not be nearly as successful without the hard work and enthusiasm from all the students and advisors. If it weren’t for you, we wouldn’t keep doing it!!

DBF Organizing Committee

RMIT University

AIAA 2025–2026 Design, Build, Fly (DBF) Competition Proposal

1.0 Executive Summary

This proposal outlines Royal Melbourne Institute of Technology (RMIT) University's approach to the design, manufacture, and test of its AIAA 2025–2026 DBF aircraft. The multidisciplinary team aims to deliver a competitive aircraft optimised for mission score through simplicity, manufacturability, and mission performance. The team comprises four sub-teams: Aerostructures, Avionics, Systems, and Logistics, each being responsible for specific parts of the development process. Conceptual design began with requirement breakdown and a sensitivity analysis, which showed that payload capacity and banner length are primary scoring drivers. Further analysis of three aircraft strategies led to a cargo-focussed configuration that maximises cargo and passenger capacity. Trade studies on the configuration resulted in a low-wing monoplane featuring a single tractor propellor and tail-dragger landing gear. The fuselage was sized to accommodate 81 ducks and 27 pucks, resulting in an overall aircraft length of 5.9 ft and a wing with a 5-ft span and a 15-in chord. The aircraft is expected to achieve nine laps in Mission 2, with an MTOW of 10 kg, and to tow a 300-in banner for seven laps in Mission 3. Further work will include flight testing of banners of different lengths and materials to guide the Mission-3 goal. Motor-propellor performance testing and composite-manufacturing trials will be conducted to verify a composite manufacturing "cut-and-fold" technique being developed by the team. The team will soon progress to detailed design and follow its manufacturing and testing plans to deliver a robust and competitive aircraft for the DBF event in Wichita.

2.0 Management

The RMIT 2025–2026 DBF team comprises 16 undergraduate students from varying disciplines and at levels of course completion. As indicated in Figure 1, the student-led team is divided into four sub-teams: Systems, Aerostructures, Avionics, and Logistics and Support. Sub-team leaders are responsible for meetings, deadlines, and week-by-week goals, as indicated in Table 1. Overall planning and integration amongst sub-teams are overseen by the Chief Engineer, who also carries the main logistics responsibilities, including organising full-team meetings, managing budgets, arranging travel from Australia to the US, and ensuring that tasks are completed on time. Communication is enabled through a dedicated Microsoft Teams server and the use of Windchill to handle design documents.

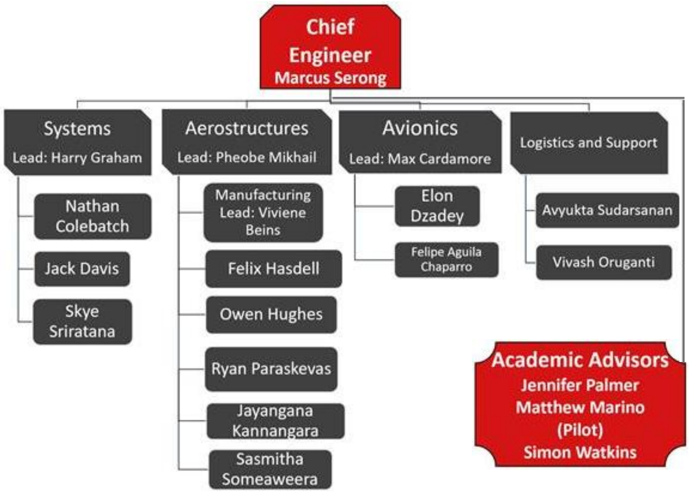


Figure 1: Team structure

2.1 Schedule

The team's schedule, displayed in Figure 2, is reviewed weekly to ensure progress is on track. Effective communication and timely collaboration amongst sub-teams are facilitated by working sessions held from 10 am to 5 pm, Monday–Thursday.

Table 1: Sub-team roles and skills

Sub-Team	Roles	Skillsets
Aerostructures	• Primary aircraft configuration studies • Conduct stability and control analyses • Conduct lift and drag simulations • Plan and execute fight- and ground-mission tests • Manufacture aerostructures	• Model-aircraft design using aerodynamic principles • Knowledgeable in the use of FEA and CFD tools • Composite and other advanced manufacturing • Skilled in SolidWorks and XFLR5
Avionics	• Conduct motor and propeller selection and testing • Avionics selection for main aircraft and banner mechanism • Aircraft avionics assembly and testing	• Understanding of aircraft propulsion systems • Aircraft stability and drop mechanism designs
Systems	• Conduct a mission sensitivity analysis • Ensure sub-teams and aircraft systems are integrated and adheres to competition requirements	• Thorough understanding of the rules • Excel and MATLAB knowledge
Documentation and logistics	• Oversee report writing, ensuring deadlines are met and quality is upheld • Assist with organising travel and logistics in the USA	• Proficiency in MS Word, MS Excel, and MATLAB • Flexible and willing to learn and help other sub-teams

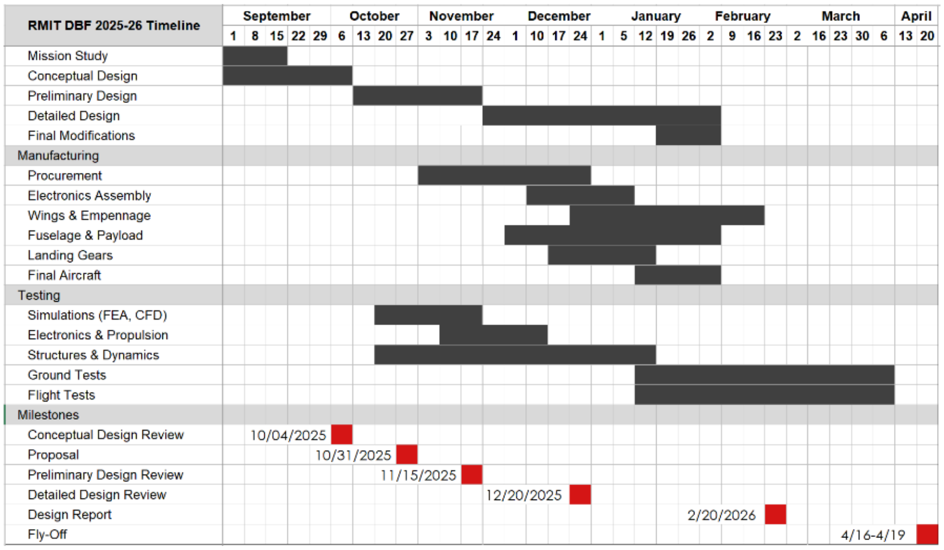


Figure 2: Schedule of R&D of RMIT's DBF entry and associated events

Table 2: DBF budget

Item	***Description***	***Cost Total***
Materials	Composite fabrics, resin, rods, adhesives	$3,990
	Balsa wood and foam	$350
	Motor, propellor, servos, ESC, batteries	$1,100
	Screws, nuts, bolts, tape, etc.	$200
Competition	Ducks, hockey pucks, and banner	$500
Travel	Workshop events	$1,350
	Melbourne-to-Wichita flights	$32,000
	Accommodation	$14,000
	Meals	$7,000
	Transportation (car hire)	$3,490
TOTAL COST (USD)		**$63,980**

2.2 Budget

The team's projected budget is outlined in Table 2. Funding will come from RMIT and external sponsors, with an expected 70:30 split. Estimates are informed by previous competition experience, with adjustments made to reflect the current team size. Travel costs represent the largest portion of the budget. Material expenses, primarily for composites, follow, as the team specialises in this method of construction. The team benefits from access to RMIT's advanced-manufacturing facilities, including CNC mills and 3D printers. The aircraft will be brought to the USA as oversized luggage, the cost of which is included in the cost of the flights.

3.0 Conceptual Design

3.1 Mission Overview

The competition consists of four missions (three flight and one ground mission) themed around a banner-towing plane that also operates as a charter service. The requirement breakdown shown in Table 3 illustrates that each mission drives different priorities. The score for Mission 2 (M2) is given by the "net income" achieved by the team (NI_{team}), as defined by competition rules, as a fraction of that achieved by the team with the highest score (NI_{best}); Mission 3 (M3) is governed by the number of laps, N_{laps}, over which a banner of length L_{banner} is towed and the "rated aircraft cost" (RAC), a competition-specific function that increases linearly with aircraft wingspan. The Ground Mission (GM) score is governed by the team's time to accomplish the mission (t_{team}) compared with the fastest team's time (t_{best}). This requirement breakdown provided the basis for a scoring sensitivity analysis to identify parameters most critical to overall mission score.

Table 3: Mission overview

Mission	***Score for Mission***	***Mission Requirements***	***Sub-System Requirements***
M1: Test Flight	1.0	• Prepare aircraft for flight in under 5 min • Complete three laps within a 5-min flight window • Must achieve a successful landing to earn a score	• Aircraft must demonstrate a stable flight configuration • The aircraft's maximum wingspan is 5 ft (1.52 m) • Same configuration used for all three missions
M2: Charter Flight	$\frac{NI_{team}}{NI_{best}}$	• Complete as many laps as possible within 5 minutes. • Carry the maximum feasible amount of payload	• Passenger compartment must restrain ≥ 3 ducks vertically in one bay • Cargo bay(s) must hold ≥1 hockey puck separated by bulkhead • All hatches rigidly attached, with no strings/friction latches • Payload compartments must allow easy loading/unloading on ground
M3: Banner Flight	$2 + \frac{\left(\frac{N_{laps}L_{banner}}{RAC}\right)_{team}}{\left(\frac{N_{laps}L_{banner}}{RAC}\right)_{best}}$	• Carry a deployable banner • Release banner remotely after crossing finish line on last lap • Banner must remain vertical in flight • Successful landing required	• Banner must be externally stowed and compact for take-off • Deployment and release controlled via transmitter • Banner length ≥ 10 in; aspect ratio ≤ 5 • Banner must not fray, tear, or touch ground during take-off
GM: Ground Mission	$\frac{t_{best}}{t_{team}}$	• Load passengers and cargo, run to start/finish line, demonstrate control checks, reload banner, demonstrate again • Airplane must stay upright on landing gear; no lifting or rotating during assembly • Must demonstrate flight-control actuation before and after each stage	• Quick-access, upright assembly on gear only • Banner loading/stowage demonstrated before completion
$Total\ Score = Total\ Report\ Score + Total\ Mission\ Score + Participation\ Score$			

3.2 Sensitivity Analysis

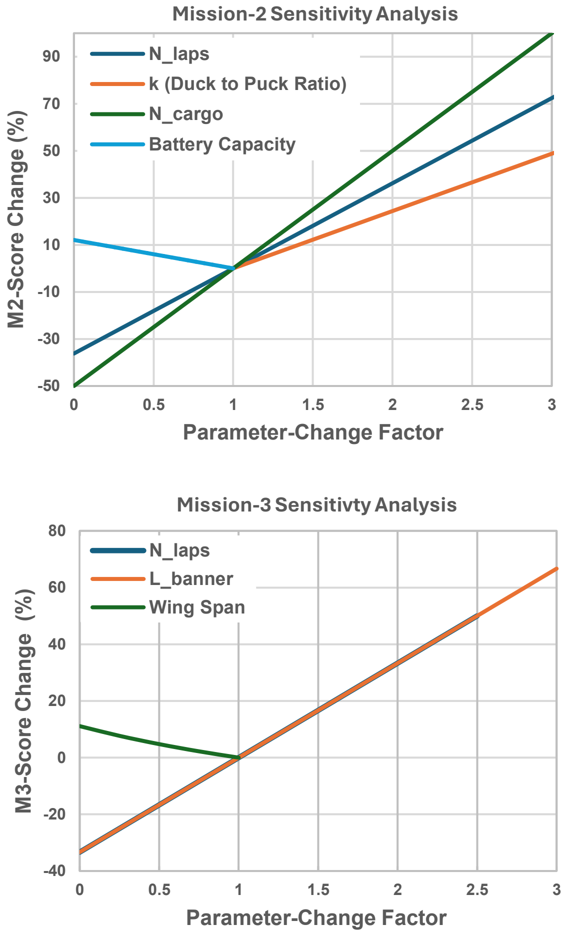


Figure 3: Mission-2 and -3 univariate analyses

After the mapping of mission requirements, a scoring-sensitivity study was conducted to analyse M2 and M3. The objective was to determine parameters that most strongly influence each mission score, guiding conceptual design choices such as wing geometry and propulsion-system design. A univariate analysis was used to evaluate the relationship between each variable and the corresponding mission score. The results are shown in Figure 3. In each graph, the horizontal axis shows the parameter-change factor from the given baseline, and the vertical axis shows the resulting change in mission score, indicating the sensitivity of the mission score to each parameter.

The key finding for M2 is that maximising cargo has the greatest impact on the score; however, the commensurate increase in fuselage volume increases induced drag, thus reducing the achievable number of laps, N_{laps}. Efficiency Factor (battery capacity normalised by 100 Wh) was found to contribute little, as reducing the battery capacity from 100 to 50 Wh only provided a 6% increase in the score. The analysis suggested that the optimal configuration maximises the number of pucks (N_{cargo}) and ducks ($N_{passeng}$) and thus fuselage volume.

The analysis for M3 showed that L_{banner} and N_{laps} have equal effects on the mission score. Decreasing wingspan, and hence RAC, from the highest permissible value to the lowest (3 ft or 0.91 m) provides just a 5% improvement in the score. This is an insufficient benefit compared to maximising wingspan (and increasing lifting ability and thus M2 score). Accordingly, for M3, the aircraft design should prioritise banner length and consistent lap performance instead of maximising RAC benefit.

GM and M2 performance are directly coupled, as loading time increases proportionally with N_{cargo} and $N_{passeneg}$. Hence an aircraft with high M2 performance would subsequently have a poor GM performance. M3 was separated from GM and M2, where only capacity to store the banner and drag are indicators of performance.

In further analysis, three configurations were compared: an all-rounder, a GM-focussed aircraft, and a cargo-focussed aircraft that sacrifices GM performance to maximise the M2 score. The parameters of these aircraft are provided in Table 4, which shows that the cargo-focussed aircraft achieves a 40% higher score compared with the all-rounder, despite the significantly worse GM score. Assuming similar M3 performance (dependent on banner length and drag), the team determined that relying on a high GM score would introduce variability. Thus, the ***optimal design will maximise payload (*** N_{cargo} ***and*** $N_{passeng}$ ***) within acceptable limits of feasibility, manufacturability, and transportability***.

Table 4: Aircraft configurations

Aircraft	*Cargo*	*Passengers*	*Laps*	*Battery (Wh)*	*GM t (s)*	*NI*
All rounder	6	18	7	100	33	540
Cargo-focussed	27	81	6	100	121	2700
GM-focussed	1	3	10	100	17	33

3.3 Design Approach

Based on the outcomes of the sensitivity analysis, the design approach focussed on developing a configuration optimised for maximum payload capacity within the limits of manufacturability, transportability, and weight. After physically sizing the fuselage to verify the required internal volume for the payload (three ducks per puck), the team decided that a configuration carrying 81 ducks and 27 pucks was at the upper limit of feasibility because of the resulting mass. This corresponds to an estimated MTOW of 22 lbs (10 kg), consisting of a 14-lb (6.2-kg) payload and an empty weight of ~8.3 lbs (3.8 kg). The team employed a matching plot to establish the feasible design space for a 22-lb (10-kg) aircraft. The analysis ensured that the chosen configuration simultaneously satisfied the take-off roll, stall-speed, and cruise-speed requirements, which then indicated appropriate wing- and power-loading values for early design iterations. To complement this, the aspect ratio (AR) of the wing was computed as a function of N_{laps} to explore how changes in AR will influence feasible laps for an MTOW of 22 lbs (10 kg). The data displayed in Figure 4, along with the matching plot, effectively guided the design, ensuring the selected geometry would achieve the desired mission performance.

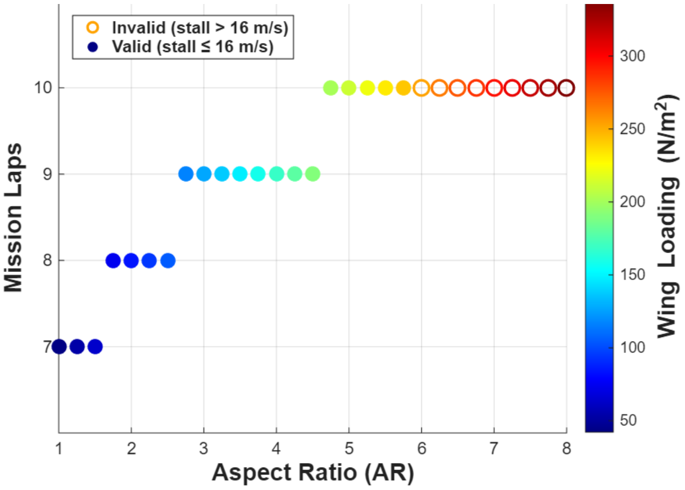


Figure 4 Laps vs aspect ratio validated against stall speed

3.4 Trade Studies

Table 5 shows the options for wing configuration and planform considered and the criteria used to assess them. A monoplane was selected, as no alternative wing configuration offered significant advantages, whereas a rectangular wing planform would minimise wing loading created by a high M2 MTOW (due to the constrained wingspan). It would also assist with aerodynamic efficiency and manufacturability, an important consideration in the choice of wing configuration.

Table 5: Wing-configuration and -planform trade-study results

		Wing Configuration			Wing Planform		
							
Figure of Merit	**Factor**	**Biplane**	**Monoplane**	**Flying Wing**	**Tapered**	**Rectangular**	**Swept-Back**
Manufacturability	3	0.8	1.0	0.5	0.6	1.0	0.4
Manoeuvrability	2	1.3	1.0	1.1	1.0	1.0	0.8
Stability	2	1.0	1.0	0.8	1.2	1.0	0.7
Aerodynamic efficiency	3	0.8	1.0	1.3	1.3	1.0	0.8
Total Score		9.2	10.0	9.1	9.9	10.0	6.4

As GM performance is a key scoring component, selecting a wing location that enables top loading of passengers is the simplest option for reducing loading time. A low-wing configuration keeps the top of the aircraft unobstructed and allows for a large hatch, whilst offering comparable manufacturability, structural integrity, and efficiency as high- and mid-wing configurations. A conventional tail was selected for its simplicity, stability, and proven effectiveness in previous competitions. The options considered in trade studies of wing location and tail configuration are described in Table 6.

Table 6: Wing-location and tail-configuration trade-study results

		Wing Location			Tail Configuration		
							
Figure of Merit	**Factor**	**High-Wing**	**Low-Wing**	**Mid-Wing**	**T-Tail**	**Conventional Tail**	**V-Tail**
Manufacturability	2	1.1	1.0	0.6	0.7	1.0	0.8
Manoeuvrability	2	0.7	1.0	0.9	1.3	1.0	0.6
Stability	2	1.5	1.0	1.3	0.8	1.0	0.6
Structural integrity	1	0.9	1.0	1.0	0.7	1.0	1.0
Aerodynamic efficiency	3	0.9	1.0	1.1	1.1	1.0	1.4
Ergonomics	3	0.5	1.0	0.8	0.8	1.0	0.8
Total Score		11.7	**13.0**	12.3	12.0	**13.0**	11.7

Manufacturability, weight, and ergonomics were key factors in choosing a propeller configuration, as highlighted in Table 7. A single motor tractor configuration was chosen for its manufacturability and comparatively low mass whilst providing similar efficiency to a single pusher configuration. The trade study for the landing-gear configuration led to a tail-dagger design, which effectively reduces the bending moment at the wing root, enhancing structural efficiency and fuselage strength in comparison to a tricycle configuration, while reducing drag.

Table 7: Propeller and landing-gear configuration trade-study results

		Propeller Configuration			***Landing-Gear Configuration***	
						
Figure of Merit	***Factor***	***Pusher***	***Tractor***	***Dual***	***Tricycle***	***Tail dragger***
Manufacturing	*3*	*0.7*	*1.0*	*0.8*	*0.7*	*1.0*
Weight	*3*	*0.9*	*1.0*	*0.3*	*0.6*	*1.0*
Ergonomics	*2*	*1.4*	*1.0*	*0.6*	*1.2*	*1.0*
Stability	*2*	*0.0*	*0.0*	*0.0*	*1.3*	*1.0*
Drag	*2*	*1.1*	*1.0*	*0.8*	*0.6*	*1.0*
Thrust	*2*	*0.9*	*1.0*	*1.3*	*–*	*–*
Total Score		*11.6*	***12.0***	*8.5*	*10.0*	***12.0***

3.5 Preliminary Design

Following the sensitivity analysis and configuration trade studies, the aircraft design was defined to meet all mission objectives. It features a single tractor motor, taildragger landing gear, and a low-wing monoplane with a conventional tail. The fuselage, depicted in Figure 5, provides sufficient capacity for 81 ducks and 27 pucks. The banner location, indicated by the red, rectangular pod on the bottom of the aircraft, was selected to minimise parasitic drag and ensure deployment and release during the GM. The specifications of the aircraft are provided in Table 8.

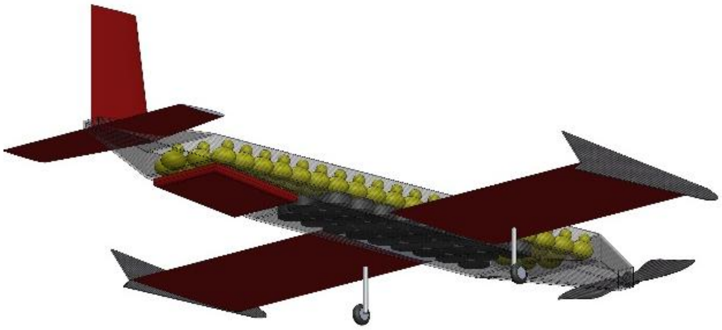


Figure 5: CAD renderings of RMIT's DBF aircraft design

After evaluating several airfoils in XFLR5, the NACA 2410 was selected for its low drag, balanced lift-to-drag ratio, and consistent pitching-moment coefficient as a function of angle of attack at low speed (i.e., low Reynolds number). The leading-edge radius of the wing was refined to optimise performance at design speeds. The fuselage was shaped around the payload, emphasising aerodynamic efficiency and structural simplicity. Due to the restricted wingspan, the aspect ratio was lowered to reduce wing loading. Consequently, winglets were integrated into the design to reduce the expected wingtip vortices. The battery was selected to be as close to the 100-Wh limit as possible and to have the highest possible cell count. The optimal motor–propeller configuration was selected using manufacturers' data and verified through eCalc.

A hexagonal payload layout was chosen for higher packing density (a volumetric load fraction of 0.91 vs 0.79 for a squared fuselage) and reduced fuselage width. To lower the centre of gravity, the puck bay sits below the passenger compartment, isolated by a bulkhead. The preliminary banner dimensions were determined analytically. It will be fabricated from lightweight rip-stop nylon. The resulting fuselage dimensions are 71 × 8.7 × 3.9 in (1800 × 220 × 100 mm). The team plans a tail-volume coefficient (V_H) of 0.5. Assuming that the aspect ratio of the tail is ⅔ that of the main wing, the tail volume can be calculated as $V_H = lS_h/(S_w c)$, where l is the tail length, S_h and S_w are the areas of the tail and main wing, respectively, and c is the wing's chord. For a 24-in (0.60-m) tail span and a tail length (i.e., moment arm) of 32 in (0.82 m), the mean aerodynamic chord (MAC) of the tail is then 8.8 in (0.22 m).

Table 8: Preliminary aircraft parameters

Mission Parameter		***Propulsion***		***Wing Dimensions***		***Tail Dimensions***	
M2 laps	9	**Propeller**	16×12 (bi-blade)	**Wing area**	6.22 ft^2 (0.578 m^2)	**Horizontal-tail span**	1.97 ft (0.60 m)
M2 payload	27 pucks, 81 ducks	**Motor**	4125-540kv	**Aspect ratio**	4	**Horizontal-tail MAC**	0.72 ft (0.22 m)
M3 laps	7	**Battery**	8S 3300 mAh	**Wingspan**	4.99 ft (1520 mm)	**Vertical-tail span**	0.98 ft (0.30 m)
M3 banner length	300 in (7.26 m)	**Power loading**	375 W/lb (170 W/kg)	**Mean chord**	1.25 ft (380 mm)	**Vertical-tail MAC**	0.72 ft (0.22 m)
RAC	1	**Maximum thrust**	19.8 lbs (88N)	**Airfoil**	NACA 2410	**Tail-arm length**	2.69 ft (0.82 m)
GM t (s)	270					**Airfoil**	NACA 0005

4.0 Manufacturing

Manufacturing is a critical part of the DBF Competition, particularly for the fuselage. RMIT has become confident in manufacturing light and strong wings with composite ribs and spars that are then covered with vinyl. Figure 6 details the production process, along with materials testing and manufacturing verification processes, that will occur alongside the detailed design. This will permit manufacturing to begin as soon as the design is complete. Once each component is completed it can be tested before integration into the aircraft.

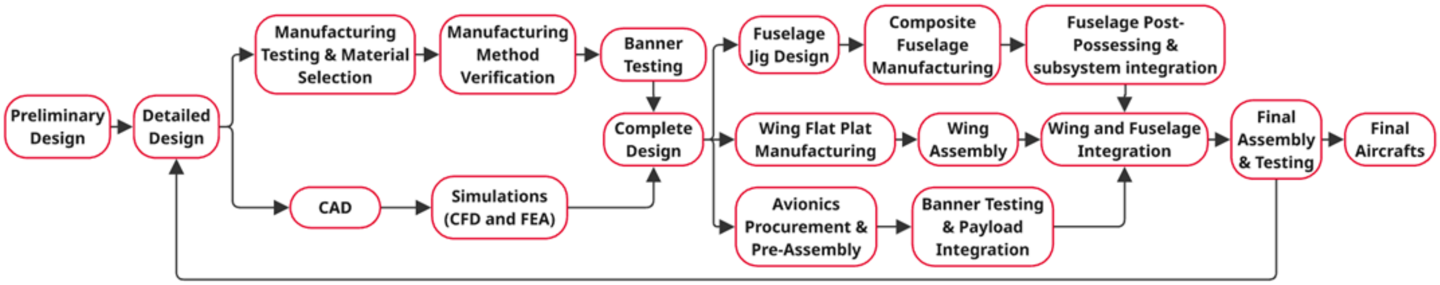


Figure 6: RMIT DBF aircraft manufacturing plan

The team is focussing on composite materials to produce a lightweight, strong airframe meeting mission requirements. Building on the team's 2025 experience with resin infusion and sandwich structures, the 2026 design will utilise lighter carbon fabrics, particularly low-density spread-tow fabrics and honeycomb laminates that can be cut and folded into the fuselage to reduce weight and manufacturing time. The feasibility of this "cut-and-fold" approach will be validated during detailed design, with resin-infused carbon structures serving as a reliable fallback.

5.0 Testing Plan

As outlined in Table 9, numerous tests are scheduled for the aircraft and its components and subsystems prior to integration. A key step is testing the banner tow, deployment, and drop mechanism, which are critical for success in M3. RMIT's 2025 "X-1" glider mechanism failed in both testing and competition, so extensive trials are planned by use of a high-speed test aircraft. The platform will permit evaluation of different banner materials, wing aspect ratios, and release systems ahead of final integration, ensuring the reliability of the deployment mechanism prior to the competition. Once all subsystems are ground tested, the aircraft will be flight tested. Supported by aircraft sensors and pilot feedback, its overall performance will be assessed and improvements identified.

Table 9: Testing plan

Sub-Team	***Test***	***Objective***	***Method***	***Due Date***
Propulsion Tests				
Avionics	Static-Thrust Test	Select the most applicable and efficient propeller, motor, and battery for the aircraft propulsion. Results will be compared with theoretical values from eCalc.	Use a motor test stand in a wind tunnel to determine propulsion and power capabilities.	18 Nov 2025
Ground Tests				
Aerostructures	Structural Tests	Verify that the wing, fuselage, and landing gear can withstand high-g loading and pass the competition technical inspection.	Lift the aircraft by its wing-tips at MTOW and check for damage. Drop the aircraft from short heights and check for damage.	1 Jan 2026
Aerostructures	Centre-of-Gravity (CG) Test	Verify the CG is at the intended location.	Lift the aircraft from its wing-tips for each mission configuration and determine CG.	1 Jan 2026
Aerostructures	Payload Test	Verify that duck and puck loading mechanisms can withstand flight	Apply 1.5 × max load on the puck and duck mechanisms and check for damage.	30 Dec 2025
Systems	Banner Test	Verify that the banner deploys, unravels and does not bunch in flight and ensure it separates from the aircraft after deployment.	Deploy the banner from test aircrafts and observe response.	30 Dec 2025
Systems	GM Test	Minimise the passenger and payload loading time for the GM.	Simulate the GM. Repeat to minimise time.	31 Mar 2026
Avionics	Electronics Test	Ensure the electronics function correctly, including receiver-transmitter connection at range.	Connect the electronics as required in flight and test its functionality as needed.	1 Jan 2026
Flight Tests				
Full Team	First Flight	Ensure the aircraft can take-off, cruise, and land. Determine the required trim for the aircraft.	Fly the aircraft for the desired objective and observe its structural response. Use an altimeter and pitot tube to measure performance and find improvements. Implement improvements in subsequent mission tests, ensuring requirements are met and projected increasing score, if possible.	20 Jan 2026
Full Team	M1 Test	Complete M1, verifying stability and control of the aircraft.		28 Feb 2026
Full Team	M2 Test	Complete M2, verifying flight with intended payload and flight performance. Improving for a higher score where possible.		28 Feb 2026
Full Team	M3 Test	Complete M3, verifyin g predicted flight performance and banner deployment and detachment works as intended.		28 Feb 2026

1. Executive Summary

This proposal summarizes the University of California (UC), San Diego Design/Build/Fly (DBF) team's plans to engineer a radio-controlled aircraft for the American Institute of Aeronautics and Astronautics (AIAA) 2026 DBF competition. The competition involves distinct flight missions where the aircraft transports cargo and diverse passengers (M2) and tows a banner displaying the university logo (M3), and a ground mission where all payloads are installed and removed (GM). The scoring formulae reward payload capacity, payload accessibility, and the number of laps flown within 5 minutes.

UC San Diego's DBF team consists of four technical sub-teams and a logistical sub-team that collaborate to achieve the competition milestones. Using a score sensitivity analysis, the team identified payload capacity and cruise efficiency as the primary subsystem-level design objectives. A sequence of trade studies motivated a low-wing, single-engine, conventional aircraft configuration with a fuselage sized around passenger and cargo compartments that are stacked vertically. A multidisciplinary optimization code that integrates pilot experience and prior DBF scoring statistics produced the following performance targets: 38 passengers and 12 cargo will be carried for 8 laps in M2, a 28-ft-long banner will be towed for 5 laps in M3, and GM will be carried out in 133 seconds. An optimal wing loading of 2.03 lb/ft^2 was found to compromise between cruise efficiency and stall avoidance amidst Kansas gusts, yielding a wing aspect ratio of 3.33. The wingspan and battery capacity were maximized to 5 ft and 97.68 Wh, respectively, to maximize lap count. A robust workflow has been developed to optimize the outer mold line and propulsion system, alongside computer-aided design (CAD), fabrication, and structural testing of an airframe that strategically integrates composite and wooden materials.

2. Management Summary

Organizational Structure » DBF at UC San Diego is a club run by 2 graduate members, 5 undergraduate members and 49 recruits. The organizational structure of the team is outlined in Figure 2.1. Faculty and alumni offer guidance through monthly design reviews. The project manager is responsible for managing the team's communications and finances, with the aid of 3 recruits in the logistics sub-team. The chief engineer oversees design optimization, manufacturing processes and system integration. Each technical sub-team is led by a member who hosts weekly meetings where they distribute project tasks among recruits and provide training to ensure the continued transfer of knowledge and succession for future leadership. The specific responsibilities and contributions of each sub-team are detailed in Table 2.1. Members report progress to the project manager and chief engineer during weekly 'work-hour' meetings, which serve as the primary forum for interdisciplinary collaboration and finalization of design decisions.

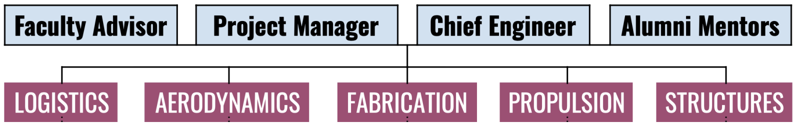
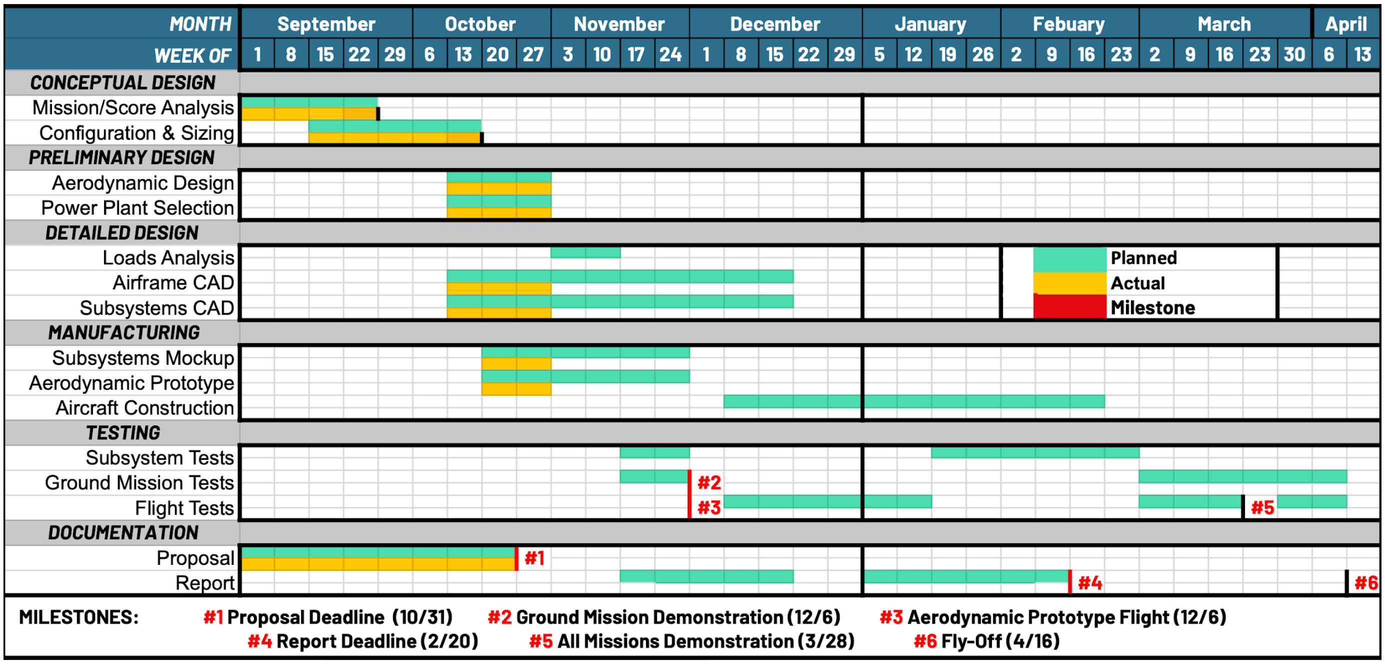


Figure 2.1) Team Organizational Structure

Sub-team	Responsibilities	Skillsets
Aerodynamics	Optimize the outer mold line through aerodynamic analyses of lift, drag and stability for each mission.	• Lift and stability analyses using XFLR5/AVL. • Mission-specific drag estimation using OpenVSP.
Propulsion	Select the optimal propeller and motor using database searches, bench tests and flight telemetry.	• Power system selection using eCalc/MotoCalc. • Thrust-stand data analysis using MATLAB.
Structures	Analyze load cases, size and design the structural layout, and produce a CAD package for fabrication.	• Load path analysis and structural optimization. • Component and assembly design using SolidWorks. • Finite element analysis for component optimization.
Fabrication	Construct and test prototypes of critical mechanical subsystems, and assemble the competition aircraft.	• R/C model-aircraft construction knowledge. • Hand/power tools and specialized equipment.
Logistics	Support the Project Manager, advisor and mentors in non-technical tasks essential to the team's function.	• Finance: Budget balancing and sponsorship application. • Media: Promotional content and website maintenance. • Documentation: Formatting of proposal and design report.

Table 2.1) Sub-team Functions and Skillsets

Schedule » The team's projected schedule for the 2025–2026 academic year is visualized in Table 2.2 using a living Gantt chart, which represents the workflows of the five sub-teams in the context of major milestones. During monthly design reviews, the team and faculty advisor will adjust the schedule as needed to meet the report and fly-off deadlines.



MILESTONES: **#1** Proposal Deadline (10/31) **#2** Ground Mission Demonstration (12/6) **#3** Aerodynamic Prototype Flight (12/6) **#4** Report Deadline (2/20) **#5** All Missions Demonstration (3/28) **#6** Fly-Off (4/16)

Table 2.2) Project Timeline for the 2025–2026 Academic Year

Budget » The team's projected expenses for 2025–2026, assembled using extensive market research and prior competition experience, are enumerated in Table 2.3. The budget is divided into 3 categories: manufacturing (21%), electronics (13%), and competition/travel expenses (66%). Funds to cover this budget are derived from a combination of residual assets, corporate sponsorships (General Atomics Aeronautical Systems GA-ASI, FrSky North America, nTop, and Anduril), and a contribution from UC San Diego's Jacobs School of Engineering. Large manufacturing facilities including 3D printers, laser cutters, and milling machines are provided by the university.

Category	Items	Cost
Manufacturing	Balsa Wood, Monokote Film	$328
Total: $2,511	3D Printing Filament	$90
	Composite Fabrication Materials (Fabrics, Resin, Tooling, Rods)	$1,583
	Banner Materials	$50
	Adhesives (Glue, Tape)	$98
	Safety Gear, Tools, Fasteners	$362
Electronics	Batteries	$525
Total: $1,484	Motors, Propellers	$609
	Servos, ESCs, Wiring	$350
Competition	DBF Fly-Off Registration Fee	$550
Total: $7,708	Lodging	$1,700
	Transport (Rental Car, Flights)	$5,458
Total Expenses (USD)		**$11,703**

Table 2.3) Team Expenses

3. Conceptual Design Approach

Mission Overview » A comprehensive analysis of the mission ('M') requirements, summarized in Table 3.1, revealed potentially competing subsystem-level objectives that influenced the team's design strategy: namely, payload carrying capacity (M2) and payload installation/removal speed (GM), and aerodynamic/propulsive efficiency for two airspeeds (Reynolds numbers) that are likely to differ greatly due to the towing of a competitively long, high-drag banner in M3.

Mission	Scoring Formula	Competition/Mission Requirements	Deduced Subsystem Requirements
M1) Test	$M_1 = 0 \text{ or } 1$	• Prepare aircraft in a 5-min. staging period. • Complete laps in a 5-min. flight window. • Max wingspan & weight: 5 ft & 54.9 lb.	• Hatches/switches are easily accessible. • Aircraft must be sufficiently strong, fast, stable and reliable to fly 3 laps in 5 min.
M2) Charter	$M_2 = 1 + \frac{Net\ Income}{Max(Net\ Income)}$ $Net\ Income = N_p[6 + N_{laps}(2 - 0.5EF)] + N_c[10 + N_{laps}(8 - 2EF)] - 10N_{laps}EF$	• Load propulsion battery, passengers and cargo within 5 min. • Store at least 3 passengers per cargo unit. • Fly as many laps as possible in 5 min. • Land without bouncing off the runway.	• Payload storage systems must be light and compact to reduce weight and drag. • Wing/fuselage must be strong enough to support failure loads at max gross weight. • Propulsion system must be optimized to balance static thrust and cruise efficiency.

M3) Banner	$M_3 = 2 + \frac{N_{laps} L_b / RAC}{Max(N_{laps} L_b / RAC)}$	● Load propulsion battery and stow banner (length > 10" & aspect ratio < 5) within 5 min. ● Fly as many laps as possible in 5 min while towing banner in vertical orientation. ● Deploy and release banner remotely. ● Banner must be undamaged after impact.	● High static thrust and airframe tensile strength required to support banner drag. ● Banner material must be optimized for low drag, low weight and tear resistance. ● Sufficient ballast is required to keep the banner bottom-heavy in flight.
GM) Ground Mission	$GM = \frac{Min(t_{GM})}{t_{GM}}$	● Flight controls must remain operational. ● Aircraft must remain upright on the ground. ● Load/restrain/unload passengers and cargo. ● Stow/restrain the banner externally. ● Suspend aircraft. Deploy/release the banner. ● Complete tasks in the shortest time possible.	● All payload systems must be designed for reliable and fast loading/unloading. ● Payload doors must allow easy access without compromising structural integrity. ● Banner assembly must deploy/release rapidly under its own partial weight.
Total	$TMS = M_1 + M_2 + M_3 + GM$		

Table 3.1) Summary of Requirements

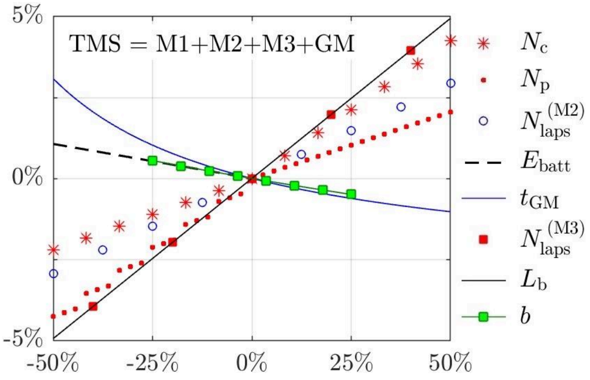


Figure 3.1) TMS Sensitivity Plot

Sensitivity Analysis » The relative influence of critical scoring variables on the total mission score (TMS), visualized in Figure 3.1, was investigated to inform the team's design strategy. Predictions for maximum mission performance were extrapolated from prior technical reports supplied on the AIAA website. The M2 score was found to rise faster with cargo count N_c than with lap count N_{laps}, which is conducive to prioritizing payload weight over cruise speed (V) due to the associated growth rates of induced drag energy (linear vs. quadratic). Thus, increasing the number of the low-density passengers, N_p, was expected to induce a negligible drag penalty due to the growth rate of the sub-dominant parasitic drag with fuselage volume (two-thirds power). The M3 score rewards banner length L_b and V similarly. However, prioritizing L_b was preferred due to the lower growth rate of required power (quadratic), up to a critical point beyond which induced drag due to banner weight would reduce the score. The scoring functions thus motivate (i) maximizing payload amount while compromising loading/unloading times, (ii) maximizing wing aspect ratio (AR) and energy capacity (E_{batt}), which improves range through aerodynamic efficiency and endurance, and (iii) maximizing wing loading (WL), which reduces the maximum power requirement. Thus, the ≈1% score increase earned by reducing the wingspan b or E_{batt} was expected to be negligible relative to a non-trivial deficit in range (N_{laps}) incurred for either mission.

Configuration Selection » Based on the scoring analysis, the team identified eight key design decisions that define the aircraft's configuration. The decisions were organized into a logical sequence of trade studies, represented in Tables 3.2–3.4, wherein suitable designs were compared using ranked figures of merit deduced from subsystem requirements. Primarily, the choice for airframe configuration was driven by the high sensitivity of M_2 and M_3 to payload volume and towed banner length. A conventional airframe was selected due to its excellent record in similar prior DBF competitions as well as its superior structural efficiency and payload accessibility relative to twin-boom or blended-body geometries.

Category	*Weight*	Monoplane	Blended Wing Body	Twin Boom	*Category*	*Weight*	Rectangle	Rounded Rectangle	Tapered Down
Structure/Weight	**5**	5	4	3	*Manufacturability*	**5**	5	4	3
Aerodynamics	**5**	4	5	3	*Payload Space*	**5**	5	3	5
Serviceability	**4**	5	4	4	*Structure/Weight*	**4**	4	5	4
Total	**/ 70**	**65**	**61**	**46**	*Total*	**/ 70**	**66**	**55**	**56**

Table 3.2) Trade Studies for Aircraft Type (Left) and Fuselage Cross-section Shape (Right)

A rectangular cross section was selected for the fuselage, prioritizing manufacturability and payload space over structural and aerodynamic efficiency. This shape also simplifies integration of the banner, which will be stowed longitudinally beneath the belly to minimize drag during climb-out and to ensure reliable deployment. A single cargo bay will be installed beneath the passenger compartment to reduce the fuselage bending moment and to preserve pitch authority.

Category	*Weight*	High	Mid	Low
Serviceability	**5**	3	2	5
Structure/Weight	**4**	4	3	5
Aerodynamics	**4**	5	4	3
Total	**/ 65**	**51**	**38**	**57**

Category	*Weight*	Single Tractor	Dual Tractor	Single Pusher
Efficiency	**5**	5	4	3
Structure/Weight	**5**	5	4	3
Stability/Control	**4**	4	5	0
Total	**/ 70**	**66**	**60**	**30**

Table 3.3) Trade Studies for Wing Location (Left) and Propulsion Configuration (Right)

A low-wing design was chosen to maximize passenger access and reduce the structural weight of the wing joint and landing gear. Pilot training will be focused on managing the increased stall speed and reduced pendulum stability. A single tractor motor will be utilized due to the focus of both M2 and M3 on endurance over takeoff thrust and top speed.

Category	*Weight*	Tail Dragger	Tricycle	Retractable
Serviceability	**5**	3	5	5
Structure/Weight	**4**	5	4	2
Stability/Control	**4**	3	5	5
Total	**/ 65**	**47**	**61**	**53**

Category	*Weight*	Standard	H-tail	T-tail	V-tail
Stability/Control	**5**	4	5	5	2
Structure/Weight	**4**	5	3	3	4
Tow Interference	**4**	4	4	5	5
Total	**/ 65**	**56**	**53**	**57**	**46**

Table 3.4) Trade Studies for Landing Gear Configuration (Left) and Tail Configuration (Right)

A tricycle landing gear configuration will be used to establish a near-horizontal incidence angle in order to diversify payload access points. Retractable gear will not be pursued as both flight mission scores favor structural efficiency over cruise speed. Finally, despite other tail configurations offering superior stability/control and reduced tow wire interference, the standard tail was selected due to its structural efficiency and ease of manufacturing. The resulting aircraft configuration is visualized in Figure 3.2.

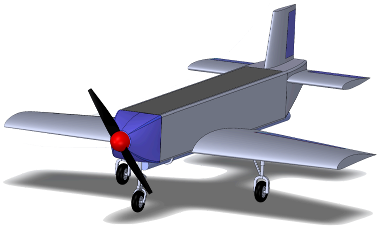


Figure 3.2) Concept Sketch

Design Approach » Building on the sensitivity analysis and selected configuration, the team assembled an Accelerated Multi-Mission Design Optimization Framework (*AMDOF*) to determine preliminary sizing estimates. The *AMDOF* deploys a nonlinear multidisciplinary optimization problem that incorporates (i) an objective function that computes TMS using semi-empirical models of electric flight physics and membrane aerodynamics, (ii) bounded design variables representing payloads (N_c, N_p, L_b), sizing (WL, AR, E_{batt}) and performance (V and turn radius), and (iii) score constraints extrapolated from prior DBF data using principles of Bayesian game theory. Data from the 2022 and ’24 competitions are used due to the similar dependence of $GM+M_2$ on payload amount and the vulnerability of M_2+M_3 to asymmetrical moves by nature, i.e., varying Kansas winds. The problem was solved in the MATLAB software using an interior-point algorithm backed by a scatter-search routine. Results were validated using a genetic algorithm tailored for a non-smooth solution topography. As shown using a Pareto front in Figure 3.3, the *AMDOF* optimized $\{N_p, N_c\}$ by maximizing M_2 while preserving a GM score within a 99% confidence interval built around top scores from prior competitions. This multi-objective optimum will be pursued by prioritizing both accessibility and low empty weight when designing payload systems. The optimal WL compromised between lowering power consumption in M2 and minimizing turn radius in M3 with a high L_b (keeping a banner height $H_b = L_b/5$ to minimize wetted area), with a lower priority for M3 due to the higher vulnerability to wind. Finally, the *AMDOF* confirmed that reducing E_{batt} or b (AR) from its upper bound to increase M_2 or M_3, respectively, sacrifices N_{laps} in the opposite mission and reduces TMS. Preliminary sizing and performance targets are enumerated below in Table 3.5.

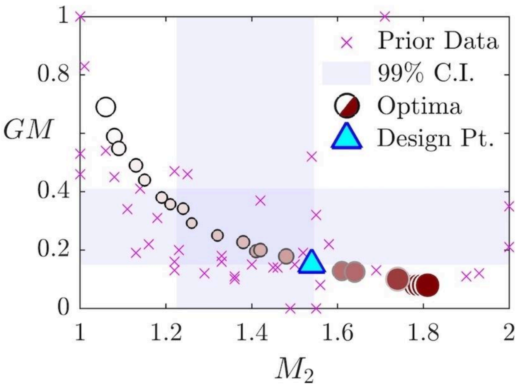


Fig 3.3) Trade-off Study: Circle Size = $M_2 + GM$, Shade = $N_p + N_c$

Performance		Payloads		Aircraft Sizing		Wing Geometry		Propulsion System	
N_{laps} ***(M2)***	8	N_c	12	AR	3.33	b	5 ft	***Propeller***	APC 14x6
N_{laps} ***(M3)***	5	N_p	38	WL	2.03 lb/ft^2	***Mean chord***	1.5 ft	***Motor***	4025-520kV
GM time	2:13	L_b	28 ft	E_{batt}	97.68 Wh	***Airfoil***	SD7034	***Battery***	6S 4400 mAh
TMS	5.41	H_b	5.6 ft	***Gross Weight***	15.24 lb	***Taper Ratio***	0.64	***Thrust/Weight***	0.71

Table 3.5) Preliminary Performance and Sizing Targets

Preliminary Design » Upon receiving the performance requirements, the technical subteams collaborated to produce a preliminary aircraft design, which is visualized in Figures 3.4 and 3.5. A survey of the Airfoil Tools database revealed the SD7034 as a suitable airfoil due to its high lift-to-drag ratios at the cruise Reynolds numbers (Re) for both M2 and M3, and its low, stable moment coefficient. Further refinement will be pursued using the *AMDOF* by iteratively testing various blends of airfoils found to be suitable for each Re. Simulations in the XFLR5 software were used to design a trailing-edge-tapered wing planform with a taper ratio of 0.64 to minimize the turn radius while preserving manufacturability. Further simulations that integrate MIL-SPEC standards and data from prior DBF reports will be used to size low-drag tail and control surfaces that provide sufficient stability and control in both M2 and M3. The semi-empirical eCalc and MotoCalc software were used to identify propulsion systems that meet the performance requirements for critical maneuvers in both missions. The Scorpion SII-4025-520kV motor was selected since it also provides excess thrust to combat high winds without overheating.

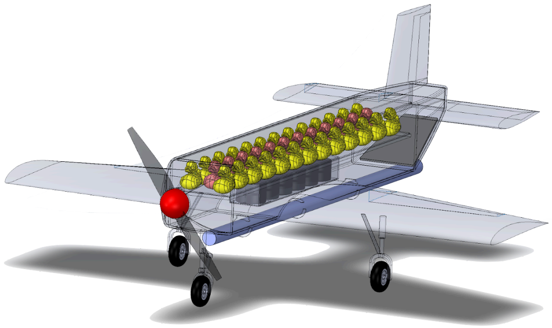


Figure 3.4) Isometric View of CAD Model

Due to the high priority given to payload accessibility and cruise efficiency, the fuselage will be sized around a compact passenger compartment that features a honey-comb arrangement of rubber ducks separated by thin plastic barriers. A removable ceiling lined with light, elastic, high-friction melamine foam will secure the ducks from above while accommodating for the variability in their heights and shapes. A side-hinged door will be installed along the top of the fuselage for rapid access to this compartment. A removable cargo tray will be placed directly below the passenger compartment, with access provided from a hinged door along the fuselage rear. Its position will be adjusted to establish the proper aircraft center of gravity (CG) in M2. Spring-loaded ‘push-push’ mechanisms will be designed and 3D-printed for locking all restraints and doors, to minimize the ground-mission time. In M3, a banner made of low-density polyethylene (LDPE) will be towed using 50-lb nylon fishing line. Literature review and initial flight tests suggest that, despite its higher weight and form drag due to flutter, LDPE is preferable to lighter and stiffer nylon fabrics (e.g. sheer stretch/ripstop) whose porosity or roughness increases skin friction at the high Reynolds numbers of interest. The banner will be stowed below the fuselage using a set of actuated claws that open for deployment and close flush with the fuselage to minimize cruise drag. A worm-gear mechanism with continuous-rotation servos will be utilized to prevent an avionics overheat due to excessive torque from the inertial load of the stowed banner. The tow point will be located aft of the wing, both to ensure moment equilibrium during cruise and to minimize the banner installation time. The tow wire will be secured to an actuated release pin using a nylon washer to reduce static friction and ensure a timely release.

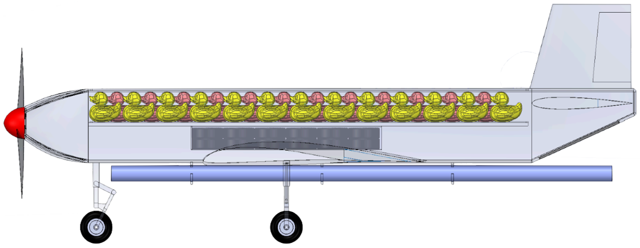


Figure 3.5) Side View of CAD Model

4. Manufacturing Plan

Given the importance of optimizing payload subsystems for accessibility and low weight, the team's manufacturing process is divided into two phases, beginning with rapid prototyping before advancing to structural optimization and systems integration. As illustrated in Figure 4.1, as part of Phase I, the team develops (i) a ground-based 'iron bird' rig for testing payload access mechanisms, (ii) a vehicular drag measurement platform for testing banner materials of interest, and (iii) an aerodynamic prototype for verifying stability in high winds with all required payloads. The ground and flight prototypes are fabricated using inexpensive paper-backed foam, since the team has extensive experience using this pseudo-composite for rapidly molding complex structures. Feedback from Phase I is used to develop the outer mold line and detailed internal design of the competition aircraft. Phase II involves implementing the design using a strategic combination of materials that balances structural efficiency with design versatility. Since the team has prior experience constructing low aspect-ratio balsa wings and foam-core wrapped carbon fiber tail surfaces, the most critical processes involved in Phase II are the design, analysis, fabrication, and strength testing of a fuselage that integrates ply/balsa sheeting with targeted carbon fiber reinforcement to optimize load paths for inertial, propulsive, and towing forces. The team is collaborating closely with its sponsors nTop and GA-ASI for exercising the required design and fabrication skills.

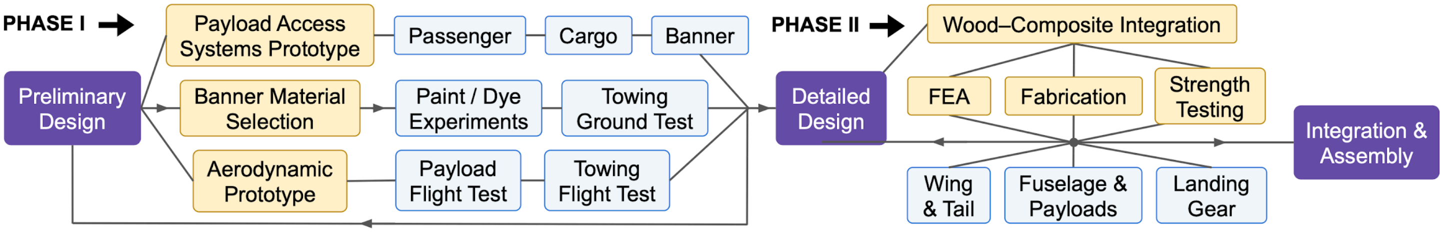


Figure 4.1) Design, Manufacturing and Testing Workflow

5. Test Planning

The team's test plan, detailed in Table 5.1, is designed to obtain critical data that will be used to refine the aircraft design to meet the desired level of performance at the fly-off and refine the *AMDOF* for future years. Static tests will be conducted at early stages to ensure the reliability of key structural components as well as the propulsion system under the worst expected conditions in each mission. Feedback from the assembly crew after ground mission trials will be used to refine the design of payload integration systems for improved accessibility. Telemetry data and pilot feedback from flight tests will be used to verify the stability and performance of the aircraft in a wide variety of environmental conditions.

Test	Objective	Task	Deadline
Static			
GM Trials	Optimize passenger, cargo and banner integration subsystems for speed and *consistency* of access.	Run ground-mission trials using the iron bird. Record the mean and *variance* of the time taken by the crew for each subtask.	12/06/25
Thrust Stand	Verify functionality of the propulsion system and select the optimal propeller for each flight mission.	Compare data from eCalc and bench tests. Measure the thrust, current, motor/battery temperature and endurance at full throttle.	11/30/25
Static Loads	Resize–or refine the material selection for–critical components that do not endure their failure loads.	Measure the deflection/failure mode of the wing spar, landing gear and fuselage under calculated bending and impact loads.	01/11/26
Avionics	Verify consistent functionality of the radio system and of the installed servomotors under load.	Perform a range check. Measure and verify the stall torque and current of all servos used for flight controls and mechanisms.	11/30/25
Dynamic			
Banner Tow	Select the optimal banner material to reduce drag for the relevant range of cruise Reynolds numbers. Predict the max. banner length for the desired Nlaps.	Tow plastic/nylon banners with lengths 25–35 ft from a car moving at speeds 20–40 mph. Measure the air properties and tow-wire tension using an anemometer and load cell.	12/06/25
Prototype Test Flights	Optimize the preliminary aircraft design to achieve the desired performance. Determine the optimal CG.	Use flight telemetry to record time series of ground speed, motor/servo current and battery voltage as functions of the average throttle setting. Repeat with the payloads for M2 and M3. Adjust the tail sizes and battery/payload locations for stable flight based on pilot feedback under both low and high winds.	12/06/25
Final Aircraft Test Flights	Verify the functionality and reliability of the final competition aircraft. Rehearse all flight missions.		03/28/26

Table 5.1) Test Planning Chart

1.0 Executive Summary

This proposal outlines the plan for designing, building, and testing team Slobbering' Hogs' radio-controlled Pewee Pig aircraft for the 2025-26 AIAA DBF Competition. **The objective is to design a banner towing bush plane** capable of passenger and cargo charter flights through three flight missions and one ground mission.

To achieve the highest competition score, optimization indicated that focusing on banner length, lap time (mission 3), and ground mission speed was more effective than prioritizing passengers and cargo (mission 2). This scoring and physics-based analysis yielded a target banner length of 20 ft (6.096m) with an average lap time of 55 seconds. The ground mission time is expected to be an average of 8 seconds by carrying the minimum number of passengers and cargo. The concept aircraft was then synthesized via trade studies resulting with a high-wing monoplane with tractor propulsion, a conventional tail, and tricycle landing gear. Peewee Pig utilizes a rectangular wing configuration with a 3ft (0.91m) wingspan and a 16.5in (0.42m) chord length.

2.0 Management Summary

2.1 Description

Team Slobberin' Hogs is a student-led group comprised of 12 undergraduates at the University of Arkansas, Fayetteville campus. This team is **co-led by the Team and Engineering Leads** for the organizational and technical aspects of the team, respectively. The faculty advisor oversees the team in the curricular capacity via weekly all-hands meetings. The team is divided into **three main subgroups**: Aerodynamics, Structures, and Payload as depicted in Figure 1. Subgroup leaders organize their respective meetings. A detailed breakdown of the subgroup requirements is shown in **Table 1.** Some members, especially subgroup leaders, overlap across subgroups to facilitate communication and design consistency. The entire team meets twice a week, once with the faculty advisor and once without.

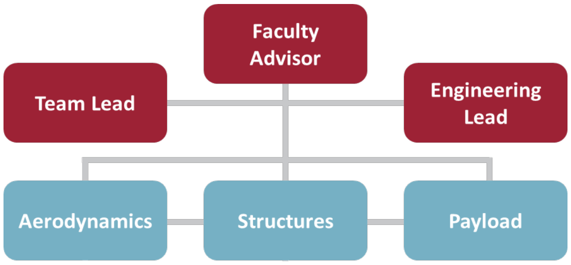


Figure 1: Team Organizational Structure

Table 1: Slobberin' Hogs Management Outline

Sub team	General Tasks	Areas of Design	Member Skills
Aerodynamics	• Aircraft stability analysis • Lift vs. Drag optimization • Motor and battery calculations and selections • Aerodynamic design and score optimization	• Wing • Tail • Control surfaces	• Strong understanding of aerodynamics and propulsion • XFLR5 • Ansys CFD simulation
Structures	• Fabrication • Composites research and development (R&D) • Stress concentration identification • Mass, structure, and manufacturing optimization	• Fuselage • Nose • Landing gear • Wing and tail internal structure	• Carbon fiber layups, laser cutting and additive manufacturing • Fusion 360 CAD and FEA Simulation • Structural design and analysis
Payload	• Banner material and size R&D • Banner storage and release • Passenger and cargo loading and unloading • Minimization of ground mission time	• Passenger/cargo compartments • Passenger/cargo loading and unloading systems • Banner storage and release	• Payload systems R&D • Iterative prototyping • Fusion 360 CAD

2.2 Schedule

The proposed schedule is outlined in **Figure 2** below. The team and engineering leads ensure deadlines are met throughout the year, working with subgroup leaders to set consistent deadlines to contribute to the timely completion of the design, manufacturing, testing, and competition milestones.

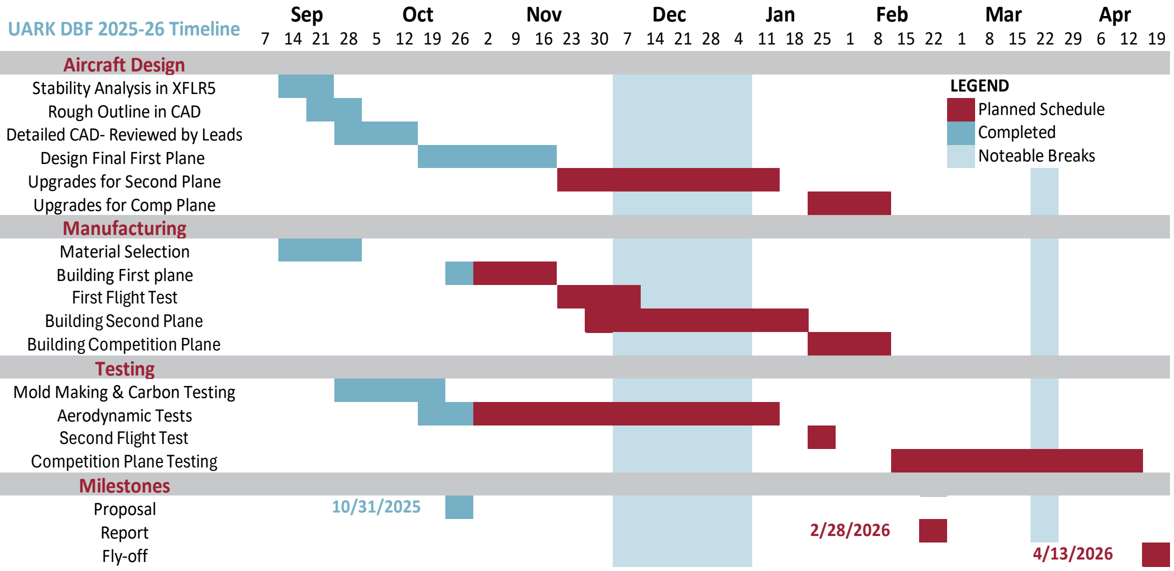


Figure 2: 2025-2026 planned timeline with relevant milestones

2.3 Budget

The Slobberin' Hogs were provided with a $10,000 operating budget from the University of Arkansas Mechanical Engineering Department. Half of the budget will be used for building materials, tools, and the manufacturing equipment necessary for the design, prototyping, fabrication, and testing of the aircraft. The remainder is reserved for travel costs to the Wichita, Kansas flyoff. The itemized budget is shown in **Table 2**. The department provided an additional $550 for the flyoff fee and a $3,000 contingency as preparation for unexpected costs, totaling to **$13,550.00.**

Table 2: Slobberin' Hogs budget

Category	Description	Cost
Manufacturing Materials	Balsa wood	$230.00
	Carbon	$1,785.00
	Landing Gear	$35.00
	Propellers	$175.00
	Filament	$280.00
	Shrink Wrap	$345.00
	Epoxies	$140.00
	Banner Materials	$115.00
	Tools	$150.00
	Prototypes & Tests	$400.00
Electronics	Motors, Servos, etc.	$955.00
Travel	Lodging	$2,000.00
	Food	$1,440.00
	Rental Cars & Gas	$1,950.00
Flyoff Fee		$550.00
Contingency		$3,000.00
		$13,550.00

3.0 Conceptual Design Approach

3.1 Mission Requirements

This competition simulates a banner towing bush plane business supported by additional passenger/cargo charter flights. There are 4 missions: three flight-based and one ground-based mission. The requirements of each mission and the constraints they impose on aircraft design are reported in **Table 3.** The optimal design, discussed later in this proposal, is based on these mission and subsystem requirements dervied from the number of passengers (P), cargo (C), labs (L), the efficiency factor (EF), and the Rated Airplane Cost (RAC).

Table 3: Mission Description and Requirements

Mission	Scoring	Mission Requirements	Sub-System Requirements
M1	$M1 = 1.0$	• Completing 3 laps in 5 minutes • Successful landing (true for all flight missions)	• The aircraft must be simple to configure • The aircraft must be reliable to achieve stable flight
M2	$M2 = 1 + \frac{N_{net\ income}}{Max_{net\ income}}$ $Income = (P * (6 + 2 * L)) + (C\ (10 + 8 * L))$ $Cost = \mathrm{L} * (10 + (0.5 * \mathrm{P}) + (2 * \mathrm{C})) * \mathrm{EF}$	• Carrying passengers and/or cargo • Installing the propulsion battery packs and payloads, check flight controls, and prepare for flight within 5 minutes	• The aircraft must securely hold the desired amount of passengers and cargo • The efficiency of the aircraft must be considered to reduce battery capacity
M3	$M3 = 2 + \frac{N_{income}}{Max_{income}}$ $Income = \frac{L * Banner\ length}{RAC}$	• Deploy banner by remote command • Release banner by remote command • Installing the propulsion battery packs and banner, check flight controls, and prepare for flight within 5 minutes	• The aircraft must be durable and capable of a larger amount of thrust to pull a large amount of drag due to the banner
GM	$GM = \frac{Min_{mission\ time}}{N_{mission\ time}}$	• Install max number of declared payload and the banner • Plane in the upright position on its landing gear • Demonstrate flight controls • Removing the passengers and cargo • Banner deployment and release with the plane in a vertical position, held with the tail down	• The payload integration must allow for fast hand loading of pucks and ducks • The banner fixture must allow a fast but reliable connection to the aircraft

3.2 Scoring Optimization

Figure 3: Banner drag test photo

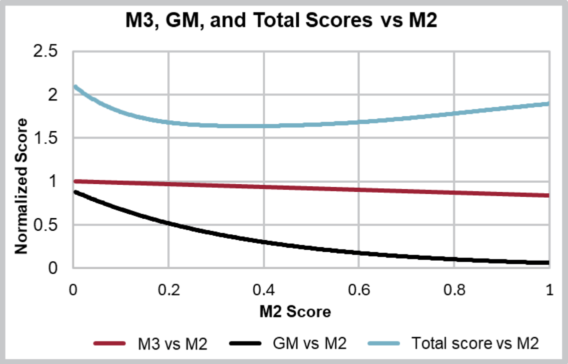


Figure 4: Graphical score optimization results

A score optimization analysis was conducted to determine the most advantageous scoring configuration. A MATLAB program was developed to correlate key design parameters with overall score, using aerodynamic data from XFLR5 and experimental results for two mission parameters: ground mission time and banner drag. A mock ground mission trial established the relationship between payload amount and loading time. A banner test was conducted to quantify the relationship between banner length, velocity, and drag (**Figure 3** depicts a 4 ft by 20 ft banner at 36 ft/s). The program runs through possible scoring configurations varying the passengers/cargo, banner length, and RAC. Each combination was compared to a predicted maximum score for each mission. The program predicted maximum scores based on the defined RAC constraints outlined in the rules and a maximum passenger/cargo assumption. Changes to this assumption had a minimal impact on optimization results. Based on the analysis, the number of passengers/cargo is the most sensitive parameter, so each predicted score is plotted with respect to predicted M2 score as shown in **Figure 4.** The M1 and non-relative portions of each mission are excluded from the graph because it is assumed the plane will be capable of flight and complete every mission with a score.

This study concluded with two optimal design configurations with predicted competition scores within 2.167% of each other. One design has a 3 ft wingspan to prioritize GM and M3 while sacrificing M2 and the other has a 5 ft wingspan to maximize M2 while sacrificing GM and partially M3. The smaller wingspan plane is more sensitive to the highest score of all teams; however, **Wichita's high-gust conditions make the small plane the optimal design** because its scoring is less affected by the wind. GM is unaffected by the wind and the larger plane designed to carry the required weight for M2 must fly M3 at a lower wing loading, making it more susceptible to gusts. By designing for GM and M3, the aircraft will be more resistant to unpredictable environmental factors.

3.3 Sensitivity Study

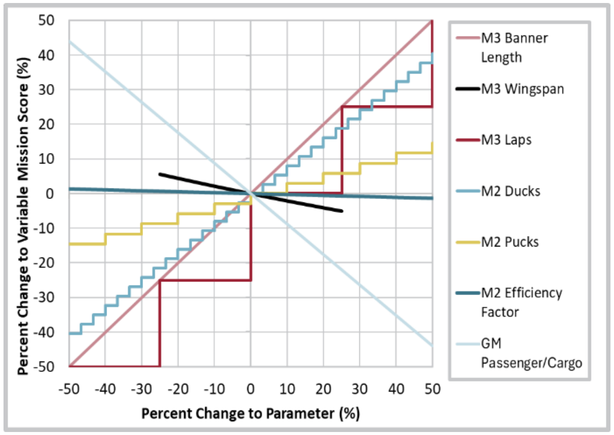


Figure 5: Sensitivity Study

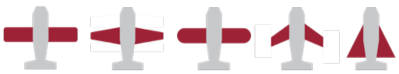
A sensitivity study (**Figure 5**) was conducted to determine which mission parameters have the largest effect on mission scores. For M2, the variable mission score is a function of the number of passengers, amount of cargo, and efficiency factor (derived from battery capacity). M3 is a function of wingspan, banner length, and number of laps. The variable section of mission score is worth up to one point in addition to fixed points given for completing each mission. Parameters were given a base value that correlates to 50% of the maximum based on the scoring optimization code and then scaled to ±50%. This **reaffirms the conclusions drawn from the optimization analysis** – changes to the passengers/cargo, banner length, and lap count have the greatest impact on score.

3.4 Trade Study

A series of trade studies shown in **Tables 4-9** were conducted using the optimal scoring configuration to establish a baseline aircraft design. Key parameters were rated out of ten for various configurations. Parameter weights were assigned for each mission indicated in the parenthesis with the format of weights for parameters (1,2,3) as fractions out of 10. These weights were multiplied by all parameters for all configurations, resulting in a total score for each mission. The highest total mission scores are highlighted. Mission 1 was omitted because the mission has no unique parameters. The optimal wingspans were assumed for M2 and M3 (5 ft and 3 ft respectively). When the study concluded two different configurations for M2 and M3, M3 was prioritized because of the strategy determined by the scoring optimization. Most design choices have little to no impact on GM so generally, design manufacturability determined the best GM configurations.

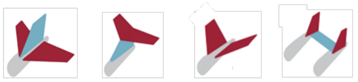
	Above	Below	Under Wing
1. Aerodynamics	9	10	6
2. Accessibility	10	5	5
3. Drop Mechanics	5	10	10
Total M2 (8,1,1)	87	95	63
Total M3 (4,1,5)	71	95	79
Total GM (1,8,1)	94	60	56

Table 4: Wing Configuration



	Rect.	Tapered	Elliptical	Swept	Delta
1. Structural	10	10	7	4	10
2. Aero. Efficiency	8	9	10	8	6
3. Manufacturability	10	8	5	8	8
Total M2 (3,6,1)	88	92	86	68	74
Total M3 (4,2,4)	94	90	68	64	84
Total GM (1,1,8)	98	83	57	76	80

Table 5: Tail Configuration



	Conv.	T-Tail	V-Tail	Twin Boom
1. Structural	9	7	5	10
2. Aero. Efficiency	9	10	10	8
3. Manufacturability	10	8	7	4
Total M2 (3,6,1)	91	89	82	82
Total M3 (4,2,4)	94	80	68	72
Total GM (1,1,8)	98	81	71	50

Table 6: Banner Storage Location

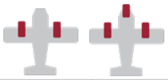
Although placing the banner above the fuselage would be optimal for GM, it is too impractical to drop the banner from the top making it better to store below. This is kept in mind for the following studies. The wing and tail configurations were weighted by manufacturing and structure for simplicity and rigidity. Aerodynamics has a larger weight for M2 than M3 because the drag from the banner makes the drag of the plane less significant. Because of this, a tapered wing is optimal for M2 while a **rectangular wing** is better for M3. A **conventional tail** was chosen for its aerodynamic efficiency, structure, and control, offering the most well-rounded performance as opposed to the other styles which provided no significant advantage.

	Tractor	Pusher	Dual
1. Stability	8	5	10
2. Manufacturability	10	5	8
3. Efficiency	10	9	8
Total M2 (3,2,5)	94	70	86
Total M3 (5,2,3)	90	62	90
Total GM (1,8,1)	98	54	82

Table 7: Propeller Configuration

High Wing	Mid Wing	Low Wing
10	9.5	9
10	5	10
N/A	N/A	N/A
50	38.5	47
50	38.5	47
90	54.5	89

Table 8: Wing Placement



	Tail Dragger	Tricycle
1. Aerodynamics	10	8
2. Mass	10	8
3. Ground Clearance	3	10
Total M2 (4,4,2)	86	84
Total M3 (4,2,4)	72	88
Total GM (1,1,8)	44	96

Table 9: Landing Gear

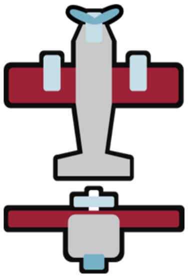


Figure 6: Final config.

A **high wing** was selected for its simple manufacturability, stability, and banner attachment clearance. **Tricycle landing gear** is the best option for improving ground mission loading efficiency and more design freedom in banner placement. A **tractor-style propulsion system** was chosen for its mount simplicity, centralized force through the banner towing line, and thrust efficiency, but it scored the same as the dual motor on M3 because of stability concerns with a 3 ft wingspan. For a single prop design, the optimal propeller size is large relative to a 3 ft wingspan which can make the plane susceptible to a rolling torque during acceleration. For the first design iteration, a tractor propulsion system will be used. However, if the aircraft has control issues, the design will shift to dual propellers instead.

3.5 Preliminary Design

Figure 7: Full Plane CAD with wing lightening holes and tail ribs/spars shown.

3.5.1 Banner Attachment and Deployment

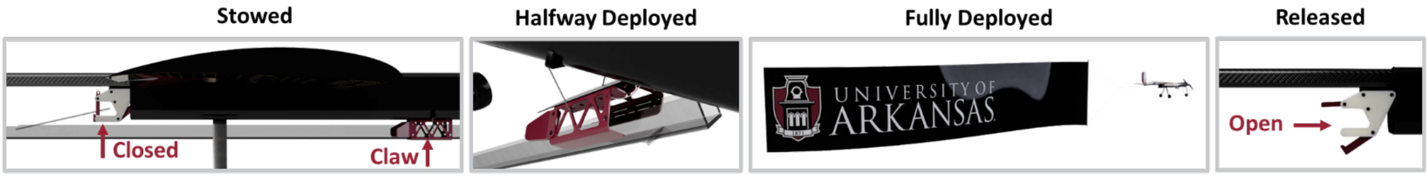


Figure 8: Banner deployment CAD

To meet M2 and GM objectives, the banner mechanism must be simple to attach and reliable in deployment. To do so, a **one-motion attachment method** was devised. The banner is folded into its own backbone and is attached using a spring-actuated claw on the passenger door while the cord is connected to a releasing carabiner shown in **Figure 8.** The passenger door will open, releasing the banner from the claw while the cord stays locked in place. As the plane crosses the finish line, the cord will be released by actuating the lever using a servo, moving it to the open position.

3.5.3 Passenger and Cargo Storage

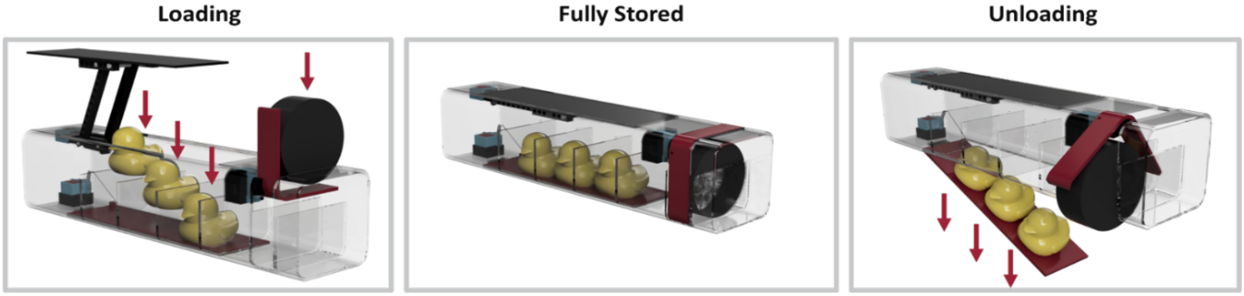


Figure 9: Payload storage CAD

Figure 9 shows the section of the fuselage that will house the M2 payloads. To reduce the time spent loading the passengers and cargo, the **doors have been automated** to be controlled by the pilot. A servo opens the passenger hatch as the ground crew moves toward the plane to eliminate unnecessary time opening the compartments. After everything is loaded, the doors will close as ground crew moves back to the start. The passengers are unloaded by a servo-controlled trap door. The cargo will be automatically pushed out of its compartment by a single rotating door.

3.5.4 Material Selection

The fuselage must support a large shock when the banner is first deployed as well as a sustained force from the banner throughout M3. To ensure the fuselage's structural integrity, it will be laid up out of carbon fiber. A carbon fiber monocoque also allows for greater usable area inside, giving the internal mechanisms more design flexibility. The rest of the plane (i.e. the wing and tail) will be made from balsa wood with reinforcing carbon fiber rods as spars. The balsa wood provides a high strength to weight ratio that is ideal for defining the wing and tail geometries while the carbon fiber spars will provide the additional strength needed for the wing structural integrity.

3.7 Predicted Scoring

Table 10: Predicted Scoring Outlined by Mission Based on Optimization Analysis

GM	Time	Score	M2	Lap Count	Passengers	Cargo	Battery Capacity	Score	Total: 6.02
	8 s	1		8	3	1	100 wh	1.02	
M1	Laps	Score	M3	Lap Count	Banner Length	RAC	Avg. Velocity	Score	
	3	1		5	20’	0.9	45 ft/s	3	

4.0 Manufacturing Plan

4.1 Preliminary manufacturing flow.

As can be seen from the trade studies, manufacturability is integral throughout the design process. **Figure 10** shows the design process from preliminary design to final assembly. Flight stability, control, and structural integrity will be confirmed in the initial prototype. The second prototype will incorporate the complete payload and banner stowage/deployment systems. The final competition aircraft will refine the assembly process and further improve quality.

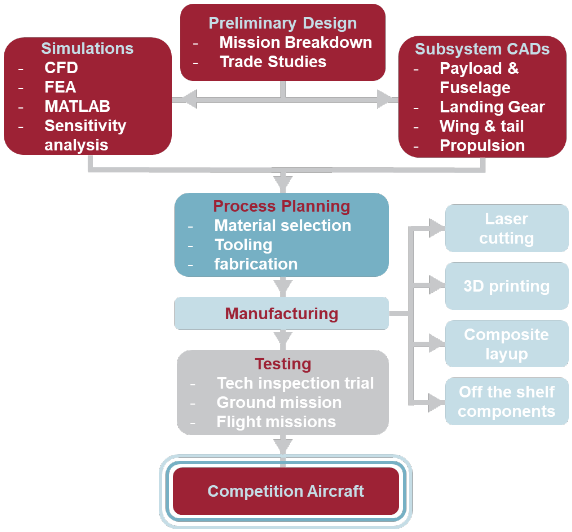


Figure 10: Manufacturing flow

4.2 Critical Processes and Technologies

The primary fabrication methodology will be laser cutting, additive manufacturing, and carbon-fiber layups. Laser cutting provides precision fabrication of balsa geometries. Additive manufacturing enables fabrication of custom or complex geometries such as servo mounts, payload restraints, and banner systems. Carbon-fiber layups will be used for the fuselage for structural integrity. Heat shrink film for the wing and tail surfaces will achieve a lightweight, strong, and smooth aerodynamic finish. Collectively, all these techniques provide strength and consistent build quality.

5.0 Testing Plan

To validate and iterate throughout the aircraft design process, several tests, shown in **Table 11,** will be performed. Categorized by Ground, Component, Flight, and Structures tests; all tests will be carried out using their respective methods by their identified sub team. Rows highlighted in blue are tests that have been initiated.

Table 11: Slobberin’ Hogs Testing Plan

Test Category	Test	Goal	Method	Sub-Team
Ground	Full GM test	Find a relationship between amount of payload and time	Run mock GM tests with varying amounts of passengers and cargo	Payload
	Initial Loading tests	Determine the optimal storing method	Compare timed trials of various prototypes	Payload
Component	Banner Material	Establish the best banner material	Compare drag of three banner materials	Payload
	Banner Size	Find a relationship between banner size and drag	Use a truck and load cell to quantify banner drag for three sizes	Payload
	Banner Orientation	Find the best method for keeping the banner vertical	Investigate parachute, weights, and fringe on the banner	Payload
Flight	Banner Flight Effects	Determine the effect on the plane maneuverability and stability while towing the banner	Pilot feedback from flying the plane while towing the banner	Aero
	Propulsion	Quantify thrust generation from propellers	Static Prop test using Arduino and load cell	Aero
	Cruise Speed	Quantify cruise speed with and without banner attached	Collect data from airspeed sensors attached to plane	Aero
	Turn Stability	Evaluate stability, speed and control of plane during turns	Apply distributed weights or pull tests on wings and tail to ensure safety factor >1.5 under load conditions	Aero
	Control Surfaces	Validate servo response and deflection accuracy	Use protractor/angle gauge to measure control surface deflection vs transmitter input	Aero
	Center of Gravity	Verify proper balance for stable flight	Measure CG location using balancing fixture and compare to design target	Aero
Structure	Material Testing	Develop methods of manufacturing	Test carbon fiber wet lay and balsa forming methods	Structures
	Landing Gear	Confirm that landing gear will not break upon impact	Load the plane with its max payload and preform a 4ft drop test	Structures
	Structural Analysis	Verify aircraft structure can withstand flight and towing	Use FEA to quantify expected load effect on the plane's structure	Structures