Queen's University

2025 – 2026 AIAA Design, Build, Fly Proposal

1. Executive Summary

This proposal outlines the Queen's Aerospace Design Team's plan for designing, manufacturing, and testing its aircraft to compete in the 2025-2026 AIAA Design, Build, Fly (DBF) Competition. The objective is for the Queen's Aerospace AIAA Division to design, build, and test a remote-controlled fixed-wing aircraft to simulate a banner towing bush plane through three flight missions and a ground mission.

The proposed aircraft will be a mid-wing design consisting of a standard tubular fuselage, tapering into a conventional tail. The wingspan will be 5 feet, which is the maximum allowed and chosen according to our in-house optimization code. The aircraft will be driven via two brushless motors mounted on the leading edge of each wing, powered by a single 6S Lipo battery placed in the belly of the aircraft. The aircraft will be fully carbon fiber and be manufactured in house via wet layups for the skin, and water-jet cut internal structure, to create a semi-monocoque airframe.

This proposed design in this document is the first of two iterations we plan to create. The overall configuration was based on the findings of the trade studies conducted. Each design parameter has been made via sensitivity analysis and optimization done based on the mission requirements. A full budget, design and fabrication schedule, and testing plan is outlined below in detail to ensure our teams success at competition this year.

2. Management Summary

2.1 Organizational Structure

The Queen's Aerospace Design Team (QADT) is a student run design team with over 40 years of heritage and experience competing across several Canadian and International competitions. Approximately 160 members spread across 5 different branches, including two technical branches, a business branch in charge of marketing and finance, a research branch, and the Aeroschool branch in charge of coordinating technical and professional development workshops for member development.

The QADT AIAA Division is a new technical branch of the team, created to compete in the AIAA DBF Competition for the 2025-2026 school year. This new division is led by the AIAA Co-Captain, and is comprised of 3 distinct sub-teams, each consisting of 10 general members from all years and disciplines, led by a manager who coordinates the weekly meetings and ensures a proper distribution of assigned work. The managers report to directors who are in charge of the administrative tasks, and supporting the managers in technical assignments. The Captain is responsible for facilitating communication between sub-teams and members, while ensuring overarching goal alignment within the team. Faculty and student advisors are available to support the executive team when needed.

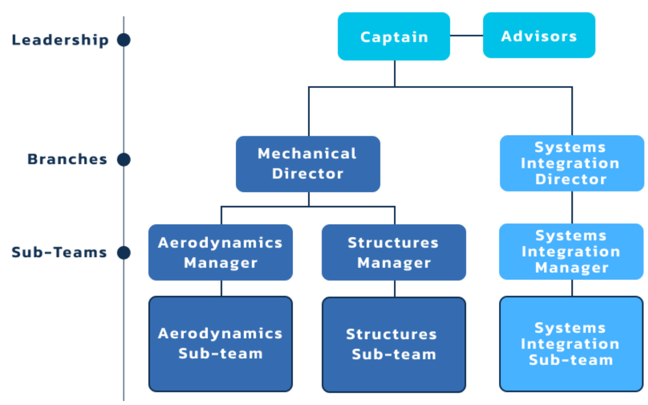

Figure 1: Team Structure

Sub-team	Responsibilities	Required Skills
Aerodynamics	OML design and optimization	CFD, XFLR5, ANSYS
Structures	Airframe design and analysis, mold design, and fabrication	FEA, CAD, Composites, 3D Printing
Systems Integration	Avionics, payload, and power systems integration	Component Selection, Soldering, PCB Design, Systems Design and Testing

Table 1: Sub-team Responsibilities and Skills

2.2 Schedule

The team's proposed schedule is shown in Figure 2 on page 2. The executive team has been and will continue to meet weekly to ensure that all tasks and objectives are met in a timely fashion. There is no scheduled work during school breaks to provide a buffer period for any incomplete work.

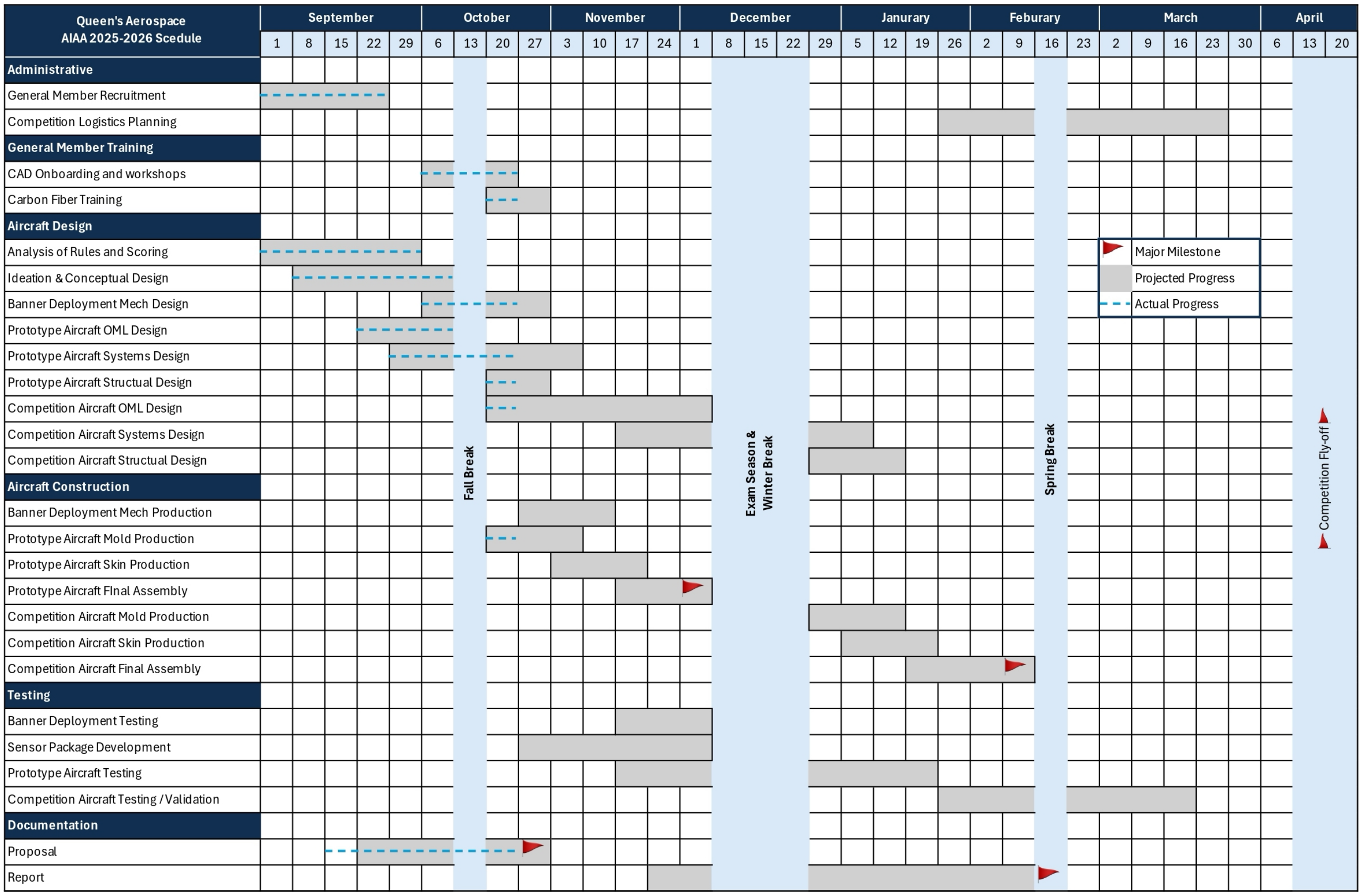

Figure 2: 2025-2026 Gantt Chart

2.3 Budget

The project's total estimated budget for the 2025–26 season is approximately $15,543, with the majority allocated toward travel and competition logistics. QADT has budgeted for 10 members to travel to competition with the team. We believe that for the future success of the team, it is important that general members gain competition experience. The project will be funded through the Smith Engineering Deans Donation Fund and external sponsorships.

Material and fabrication costs remain significant due to the extensive use of composite structures. The team aims to minimize expenses by leveraging in-house manufacturing capabilities and
reusing components from previous builds.

Though some numbers are rough estimates, many of the components have already been purchased and the exact costs are listed. Unless otherwise specified, all costs are listed in Canadian Dollars.

Expenses	Item	Cost
Materials & Fabrication	Carbon Fiber (6oz Twill weave, 50" × 10 YD)	$597
	Layup Material (Vacuum bags, Resin, etc.)	$650
	3D Printing Filament (PLA and PETG)	$250
	Carbon Tubes and Sheets	$350
	Miscellaneous	$220
Electronics Components	Motors (Badass 3515 – 580 KV × 2)	$185
	ESCs (Badass 65 A ESC × 2)	$140
	Rate Gyro (Eagle A3 Rate Gyro)	$50
	Servos (TGY-813 × 5)	$416
	Batteries (Zeee 6S + CNHL 4S LiPo)	$135
Competition Logistics	Airfare ($850 × 10 members)	$8,500
	Train, Bus, Taxis	$900
	Accommodations ($700 × 3 rooms)	$2,100
	AIAA Membership ($33 USD × 10 = $450 CAD)	$450
	Insurance (Based on prior years spending)	$600
Total		**$15,543**

Table 2: Estimated budget for 2025–26.

3. Conceptual Design Approach

3.1 Analysis of Mission Requirements

The challenge for this year's competition consists of four missions, including three flights and one ground mission. The ground mission requires the team to load and unload passengers and cargo. Additionally, the mission requires the installation, deployment and release of the banner in the shortest time possible. The first flight mission requires the team to fly the aircraft unloaded for three laps in under five minutes. The second flight mission is a charter flight mission, the team must load the passengers and cargo into the plane and maximize net income by flying laps with maximum cargo while using minimal battery capacity. The final mission is the banner flight which requires the team to deploy a banner mid-flight and release it to the ground. To maximize points, the team must increase the laps flown and banner length, while reducing the wingspan.

Mission	Scoring	Mission Requirements	Subsystem Requirements
M1	1.0	• Complete 3 laps within 5 min. flight window • Successful landing	• Cruise speed must be high enough to complete the laps
M2	$1+\frac{NetIncome_{\text{Team}}}{NetIncome_{\text{Max}}}$	• Carry a minimum of three passengers and one cargo • Passengers must be in the same horizontal plane, accessed by a unique hatch, in a single compartment separated from the cargo and electronics, and be fully restrained during flight	• There must be a reliable and secure latch and hinge to access the passenger compartment • The plane must be able to carry the added load of the passengers and cargo and must not dramatically affect the center of gravity
M3	$2+\frac{(\frac{Laps\times BannerLength}{0.05\times WingSpan+0.75})_{\text{Team}}}{(\frac{Laps\times BannerLength}{0.05\times WingSpan+0.75})_{\text{Max}}}$	• Banner must be a minimum of 10 inches long with a maximum aspect ratio of 5 • Banner must be stowed externally during take-off • Banner must not interfere with flight performance • Banner must fly vertically when deployed • Banner must be deployed and released midflight • Banner must not be damaged during flight	• Plane must be stable enough to handle the change in drag and center of gravity after banner deployment • Plane must have enough power to maintain airspeed with increased drag after banner deployment • Banner must be weighted or held to ensure it flies vertically • Banner must be made out of a durable material to ensure it down not tear during the mission
GM	$\frac{MissionTime_{\text{Min}}}{MissionTime_{\text{Team}}}$	• Load and unload passengers and cargo as fast as possible • Load, deploy and release the banner as fast as possible	• Passenger and cargo hatches must be easily accessible and the restraining device for the passengers must be easy to activate to reduce loading time • The banner deployment mechanism must be easy to load and release mechanism must work under the force of gravity with the plane facing up

Table 3: Mission Scoring and Requirements

3.2 Sensitivity Analysis

A sensitivity analysis of several design parameters and mission objectives was conducted in Python. All variables were correlated through physics calculations to simulate the real tradeoffs these parameters induce on each other. The output indicated that several design parameters have non-linear relationships with the score, primarily because variations in these parameters can change the number of completable laps, resulting in abrupt fluctuations in the results. Figure 3 shows how varying each design parameter by a certain amount while holding the others at a reasonable median value effects the score. Only some of the key variables in the sensitivity analysis were included in the figure for readability. A key takeaway the team made from this analysis is that the wingspan does not have a strong correlation with the score since increasing the wingspan improves flight efficiency at almost an equal rate to the cost penalty in M2. Additionally, the analysis shows that wing area should be minimized, however this is not necessarily ideal because the plane needs enough lift to hold the weight. Finally, the battery capacity has an optimal value around the median. This is because increasing battery capacity allows the plane to fly faster for more laps until a certain point where it becomes inefficient to increase capacity.

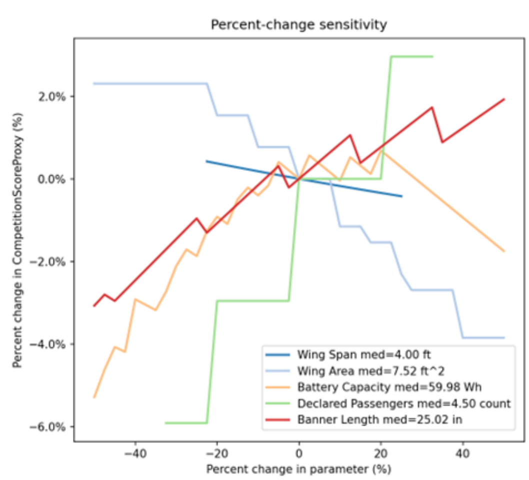

Figure 3: Sensitivity Analysis Plot

3.3 Trade Studies

Trade studies were conducted prior to design optimization to choose a suitable propulsion, landing gear, tail, and wing configuration. Choices were made based on the comparisons shown in Table 4 and Table 5. The comparisons are based on the chosen figures of merit, including the manufacturability, stability, maneuverability, flight speed, and ease of payload loading.

		Wing Type			Wing Shape		Wing Placement		
Figures of Merit	**Factor**	**Biplane**	**Monoplane**	**Flying Wing**	**Taper**	**Rectangular**	**High-Wing**	**Mid-Wing**	**Low-Wing**
Manufacturability	0.3	0	1	0	0.9	1	0.5	0.9	0.2
Stability	0.3	0.7	1	0.3	0.9	1	0.9	0.7	0.3
Maneuverability	0.1	0.8	1	0.8	1	0.7	0.7	0.8	0.9
Flight Speed	0.2	0.5	1	0.4	1	0.8	1	1	1
Payload Loading Speed	0.1	0	0.8	0.5	1	1	0.7	0.6	0.7
TOTAL		0.39	**0.98**	0.3	**0.94**	0.93	0.76	**0.82**	0.51

Table 4: Comparison of Wing Configurations.

		Propulsion Configuration			Landing Gear Configuration		Tail Configuration		
Figures of Merit	**Factor**	**Tractor**	**Pusher**	**Twin**	**Tricycle**	**Taildragger**	**T-Tail**	**Conventional Tail**	**V-Tail**
Stability	0.1	1	1	1	1	0.8	0.5	0.9	1
Weight	0.3	1	1	0.8	1	1	0.8	1	0.9
Component / Payload Compatibility	0.5	0.9	0	1	1	0.5	1	1	0.9
Thrust	0.1	0.7	0.6	1	–	–	1	0.9	0.9
TOTAL		0.92	0.46	**0.94**	**0.9**	0.63	0.74	**0.95**	0.94

Table 5: Comparison of Propulsion / Landing Gear / Tail Configurations.

3.4 Optimization Code

Queen's Aircraft Performance Optimization Tool (QAPOT) is an in-house Python optimization script called built on the aerosandbox library which optimizes, and sizes airframe parameters given an objective to minimize or maximize. A preliminary design is made in OpenVSP for an estimate of parasitic drag for major aircraft components. Given these drag coefficients, and M2 parameters to maximize the score, QAPOT is able to calculate desired cruise speed, center of gravity, angle of incidence, wingspan, tail sizing, and many other parameters.

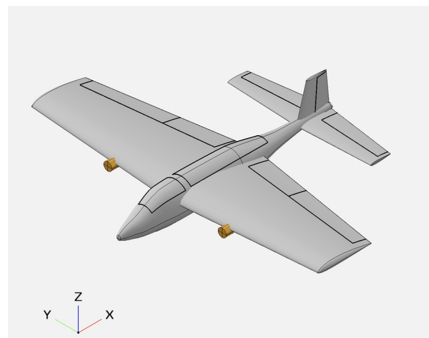

Figure 4: Airframe Isometric View

3.5 Preliminary Design

3.5.1 Preliminary Airframe Design

The preliminary design of the aircraft is shown in Figure 4. Using QAPOT, the input was optimizing the M2 parameter, and sizing results were the output. Notably, the wingspan uses all 5ft and has a large planform area. The minimum empty weight is expected to be 2.90kg as it will be constructed with carbon fiber. The preliminary airfoil choice is an N10 for the wing due to its high lift and relatively low drag. Further preliminary sizing is shown in Table 6. Although twin propellors are used, they are powered by a single battery. The current planned layout for internal components and payload is shown in Figure 5.

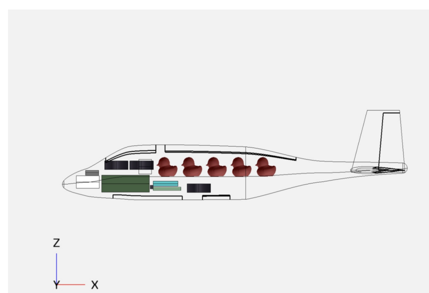

Figure 5: Aircraft Internal Layout

Propulsion		**Wing**		**Tail**		**Fuselage**	
Motor	580 Kv	Wingspan	1.5 m	Tail Span	0.8 m	Fuselage Length	1.1 m
Propeller	11×6 – EW	Mean Chord	0.38 m	Tail Chord	0.14 m	Fuselage Width	0.15 m
Battery	3.3 Ah 6S	Aspect Ratio	3.98	Tail Area	0.11 m²	Empty Weight	2.9 kg
Max Thrust	5028 g	Planform Area	0.56 m²	Vertical Tail Area	0.05 m²	Drag at Cruise	3.8 N
Endurance	21.76 min	Airfoil	N10	Airfoil	NACA0012	Neutral Point	0.15 m behind LE

Table 6: Summary of Key Aircraft Parameters.

3.5.2 Preliminary Banner Mechanism Design

The banner will be deployed and subsequently released using a single integrated mechanism. Multiple unique banner mechanisms have been proposed and are being designed for testing. One potential design, pictured on the left in Figure 6 has two arms, each matching the skin's shape and pivoting on the same side, pinch the banner against the plane with a rubber grip. The banner's strings are internally routed through the tail of the plane and looped to a pin. When the pin is actuated, the banner will be released.

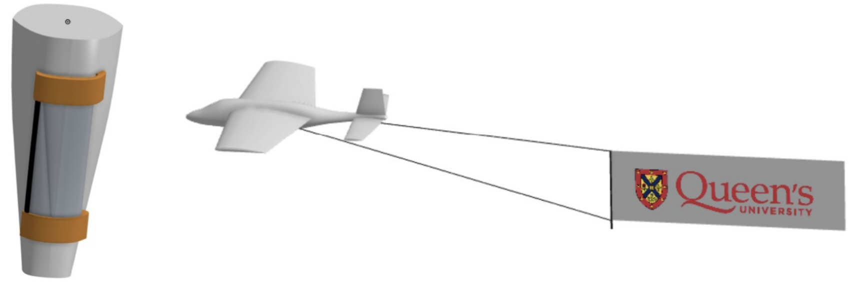

Figure 6: Preliminary Design of Banner Release Mechanism

3.6 Mission Target

M1		M2		M3	
Minimum Speed	8.1 m/s	Ducks	9	Banner Length	1.5m
Lap Number	3	Pucks	3	Total Weight	3.21kg
Cruise Speed	25.1m/s	Total Weight	3.59kg	Cruise Speed with Banner	14 m/s
Time/Lap	30.0s	Cruise Speed	25.1 m/s	Lap Number	5
Total Time	110s	Lap Number	9		
CoG from Leading Edge	0.024m in front	Time/Lap	30.0s		

Table 7: Summary of Test Parameters

The course is modelled as a 500ft upwind leg, followed by a 180-degree turn, then a 1000ft downwind leg with an orbit, another 180-degree turn, and a 500ft final leg. Excluding the turns, the distance is 2000ft/lap. Turn distance is modeled using the cornering radius and calculating the distance for two circles. The total effective distance is 754m per lap. The initial ground roll is estimated at 10s, and an additional 10s is allocated to the upwind climb out of the first lap to account for a slower ground speed. This leaves an airtime of 280s to fulfil all laps, and 93s/lap for three laps. This correlates to a minimum cruise speed of approximately 8.1m/s.

M2 is informed by QAPOT score optimization. Ducks and pucks are the most important parameter, however the aircraft cannot fit more than 9 ducks reasonably due to wingspan limitations. The desired cruise speed will also be used in M1 to verify functionality.

4. Manufacturing Plan

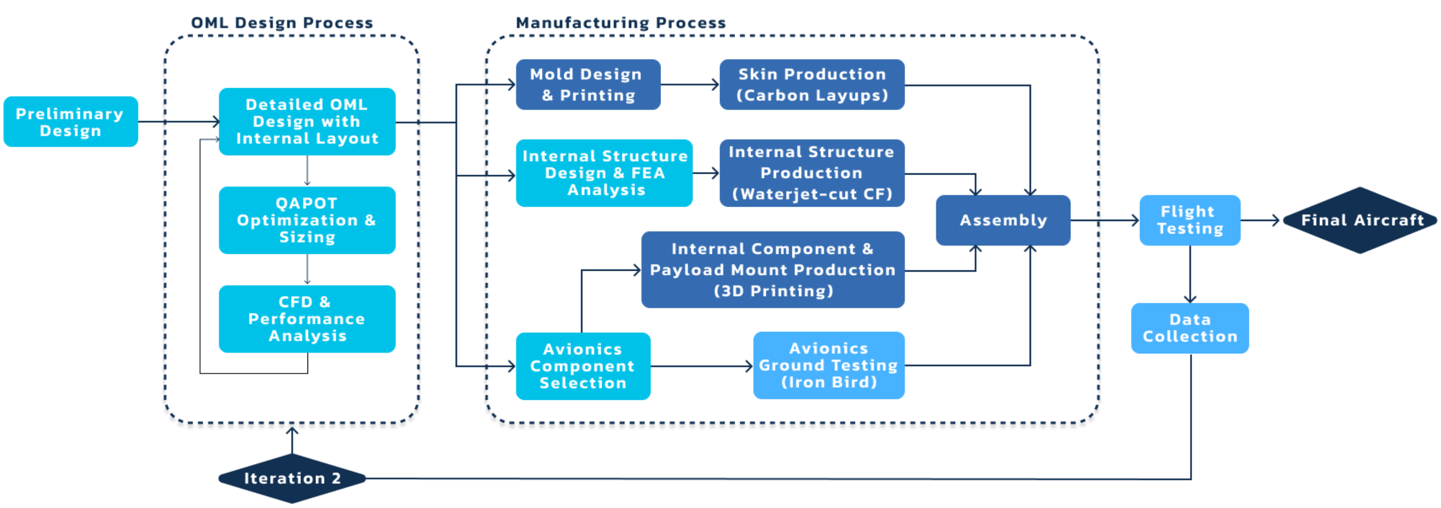

Figure 7: Design and Manufacturing Process Chart

The overall manufacturing plan for the aircraft will be divided into two phases, as we plan to construct two iterations of the drone. The first iteration will have a manufacturing plan which is meant to be time and budget efficient, whereas the second will be refined for better quality. The manufacturing flow can be seen in Figure 7.

The first iteration will be manufactured with a two-layer, wet carbon fiber layup on 3D-printed molds. The skin will have a top and bottom half which will be adhered together with epoxy. Since 3D-printed molds have layer lines, there will be a textured exterior to the skin which will likely induce extra parasitic drag. Usually to counteract this, the team would sand down the molds to a smooth finish before performing the layups however, as both an experiment to see how much mold sanding improves performance, and a time saving measure, the molds will not be sanded for iteration one. The internal structure will be CNC cut from plywood and epoxied together and to the skin. It will consist of spars and ribs contacting the skin of the aircraft and horizontal plates in the fuselage. There will be two carbon fiber rods running the length of the wing.

For the second iteration, the team will start by evaluating the quality of the structure and skin from the previous design and make any necessary changes. The key change will be the internal structure will be fully manufactured from water jet cut carbon fiber plates. This change will reduce weight and increase stiffness.

5. Test Planning

In preparation and after the construction of the first prototype, the tests shown in Table 8 will be performed. Aerodynamic, structural, and electrical simulations have been done to predict the performance of the prototype. Ground and flight test will also be performed with an experienced RC pilot to identify and solve potential issues. A full run-through of the competition task with time constraints enforced will be done to verify that the team and prototype meet mission requirements. All flight testing will be conducted under AMA rules with an experienced RC pilot to ensure safety compliance.

A custom data-logging unit will be built from open-source hardware to collect flight data during testing and validation. This module will collect and store relevant flight data but will be unable to relay this data to the ground station during flight. It will be used to diagnose and solve any issues that arise while completing competition tasks, and provide flight performance data of iteration one, to aid in the design of iteration two.

Test Type	Sub-team	Objective	Method
Simulation			
Plane configuration	Aerodynamics	Analyze airflow around plane	Use Ansys to simulate fluid flow
Stability analysis		Observe how plane responds to disturbances in equilibrium	Use XFLR5 to conduct Stabliity Analysis
Finite element analysis	Structures	Analyze different structural components under stress	Use Ansys to simulate stress on object
Circuit Simulation	Systems Integration	Analyze circuit behaviour of PDB	Use LTSpice to simulate circuit
Ground Tests			
Control Surfaces	Aerodynamics	Ensure full control surface range of motion & Servo motor operation	Deflect control surfaces using Tx and observe range of motion
Center of Gravity		Ensure correct CG location under different load conditions	Lift aircraft by wings and observe balance
Wing Tip Loading	Structures	Ensure structural integretity of wings under high G loading conditions	Lift plane vertically by wingtips under max takeoff load conditions
Strength		Ensure banner drop support structure strength	Drop plane from intermediate height multiple times
Banner Release		Verify proper function of banner release mechanism	Use Tx to trigger banner release
Rate Gyro	Systems Integration	Verify proper function of on board flight stablization module	Lift aircraft and rotate on pitch, roll and yaw axis and observe control surface deflections
Radio Range		Verify radio connection range	Bind Rx and Tx and walk away from drone until connection is lost
Carbon Sheilding		Test radio connectivity within carbon fiber structure	Bind Rx and Tx, set Rx in custom carbon fiber test appratus and test radio connectivity
Capacity		Verify time to drain battery at max current draw	Mount propulsion system ro a test and run motor at full throlttle with proppler on
Iron Bird		Test compeition battery load scenario to verify battery suitability	Layout all components, connect power and evaluate battery and PDB behaviour
Flight Tests			
Plane configuration	Aerodynamics	Test plane configuration	Collect flight data (Airspeed, Acceleromoter, etc.) using data collection module
Take Off Distance		Find out takeoff distance for different takeoff weights	Takeoff with different loads and measure takeoff distance
Banner flight		Observe pitch tendencies, change in speed and attitude	Apply same throttle and collect flight data using data collection module
Turning Test		Find out turning radius and turning time	Perform 360 degree turns and collect flight data using data collection module
Release and Fly	Structures	Verify banner drop mechanism and see if banner flys horizontal	Deploy banner mid air using test plane
Task Viability	Systems Integration	Verify plane configuration and systems are appropriate for competition tasks	Simulate competition tasks at airfield

Table 8: Testing Objectives and Methods