

Universidad de Castilla-La Mancha

Escuela de Ingeniería Industrial y Aeroespacial de Toledo

Technical Report

Air Cargo Challenge 2026



#Team 26
DIANA UCLM

Toledo, May 1, 2026

Contents

1	Introduction	2	5.3	3D components	19
1.1	Air Cargo Challenge 2026	2	6	Electronics of the Aircraft	20
1.2	DIANA UCLM	2	6.1	Propulsion system design	20
1.3	Previous competitions	2	6.1.1	Experimental setup and instrumentation	20
2	Project Management	3	6.1.2	Electronic current-limiting and “oversizing” strategy	20
2.1	Human resources	3	6.1.3	Comparative results and selection	21
2.2	Planning	4	6.2	Power system and energy management	22
2.3	Sponsors of the project	5	6.2.1	ESC unit selection	22
2.4	Budget and costs	7	6.2.2	Battery sizing and selection	22
3	Aerodynamic Design	8	6.2.3	Wiring and connectors	23
3.1	Main wing airfoil	8	6.3	Control and communication system	23
3.2	Main wing geometry	9	6.3.1	Flight controller	23
3.3	Empennage	10	6.3.2	Servos	24
3.4	Control surfaces	10	6.3.3	Avionics battery	24
3.5	Wingtip devices	11	6.3.4	Transmitter and receiver	25
3.6	Stability	12	6.4	Electronic architecture	25
3.6.1	Static stability and control effectiveness	12	7	Performance and Payload Prediction	26
4	Structural Design	13	7.1	Performance	26
4.1	Wing-skin layup optimization & FEM simulations	13	7.2	Payload prediction	26
4.2	Wing structure	14	8	Outlook	28
4.3	Fuselage	15	9	Drawings	29
4.4	Empennage	17	A	Detailed Aircraft Cost	34
4.5	Fuselage-wing coupling	17			
5	Manufacturing	18			
5.1	Casts	18			
5.2	Infusion process and hand-laminating	18			

1. Introduction

1.1 Air Cargo Challenge 2026

The Air Cargo Challenge is a biennial worldwide university engineering competition, with the 2026 edition being hosted in Stuttgart. The main objective of the event encompasses the complete design, manufacturing, and flight operations of a radio-controlled Unmanned Aerial System (UAS). As the regulations are revised for every edition, the aircraft's design has been optimized to comply with the stringent constraints of the 2026 participation handbook. Consequently, this technical report details the final specifications of the aircraft, alongside a comprehensive overview of the engineering design and manufacturing methodologies employed.

1.2 DIANA UCLM

DIANA UCLM is a student-led engineering association affiliated with the University of Castilla-La Mancha, Spain, headquartered at the historic Fábrica de Armas campus in Toledo. Founded in 2022 by a core group of Aerospace Engineering students, the organization was established to close the gap between the daily theoretical subjects and practical aircraft design and manufacturing. Since its creation, the association has experienced substantial growth and integration within the university community. Today, the team comprises a multidisciplinary roster of over 20 active members and is strongly supported by a robust network of local and national sponsors. Beyond the purely technical pursuit of aircraft design and manufacturing, DIANA UCLM places a big emphasis on cultivating soft skills, fostering cross-functional teamwork, and building a collaborative professional network among future engineers.

1.3 Previous competitions

DIANA UCLM's 2026 design is built upon the knowledge obtained during the 2024 and 2025 Xtrachallenge competitions, where we created from scratch cargo aircraft for both solid and dynamic liquid payloads. After validating our aerodynamic capabilities by securing the 'Maximum Payload' award in 2024, the team wanted to take a step forward in the manufacturing area. Consequently, in 2025, we transitioned from a heavy, 95% 3D-printed PLA aircraft to a highly optimized hybrid structure. By utilizing aeronautical wood and heat-shrinkable film for the lifting surfaces, and reserving PLA exclusively for complex forms.

The 2026 development cycle has focused on mastering advanced manufacturing techniques using composite materials, specifically carbon and glass fibers. Integrating these high-performance composites with our established expertise in balsa wood and PLA provides the engineering team with the necessary flexibility to select the optimal material for each specific component. This hybrid material strategy allows for a precise balance between structural rigidity and weight reduction, ultimately maximizing the aircraft's overall performance and payload capacity.

2. Project Management

2.1 Human resources

DIANA UCLM is composed of a total of 23 aerospace engineering students 2.1 from various parts of Spain and Andorra, all brought together under the Escuela de Ingeniería Industrial y Aeroespacial de Toledo (EIIA), which belongs to the Universidad de Castilla-La Mancha (UCLM). The following structure is the one chosen by the team to distribute its members and direct its efforts towards the different tasks and challenges faced by DIANA.

1. Operations and Logistics Department

Mainly responsible for three areas: seeking funding through events, establishing contacts, negotiating collaborations with companies, and managing advertising and social media.

2. Aerodynamics and Design Department

Applying theoretical concepts of Aerodynamics and aircraft morphology to optimally design the aircraft.

3. Propulsion and Electronics Department

Designing and assembling the onboard electronics system in the prototype for the correct operation of control surfaces and integrating the propulsion system into it.

4. Structures and Manufacturing Department

Building the physical and final model, designing the internal structure, simulating dynamic loads, and performing static tests.

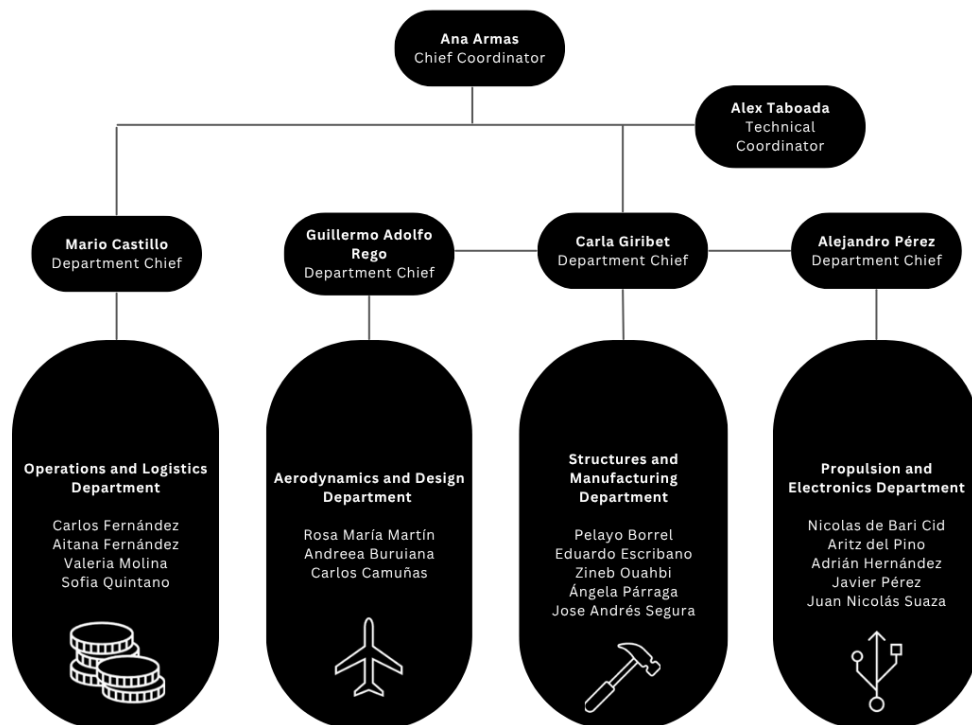


Figure 2.1: DIANA UCLM Team

2.2 Planning

To ensure the proper coordination of the various technical areas and compliance with the deadlines established for the competition, the DIANA team has developed a comprehensive roadmap. Figure 2.2 details the project's schedule, broken down by departments and key phases, spanning from the initial conception in July 2025 to the completion of the final report in May 2026.

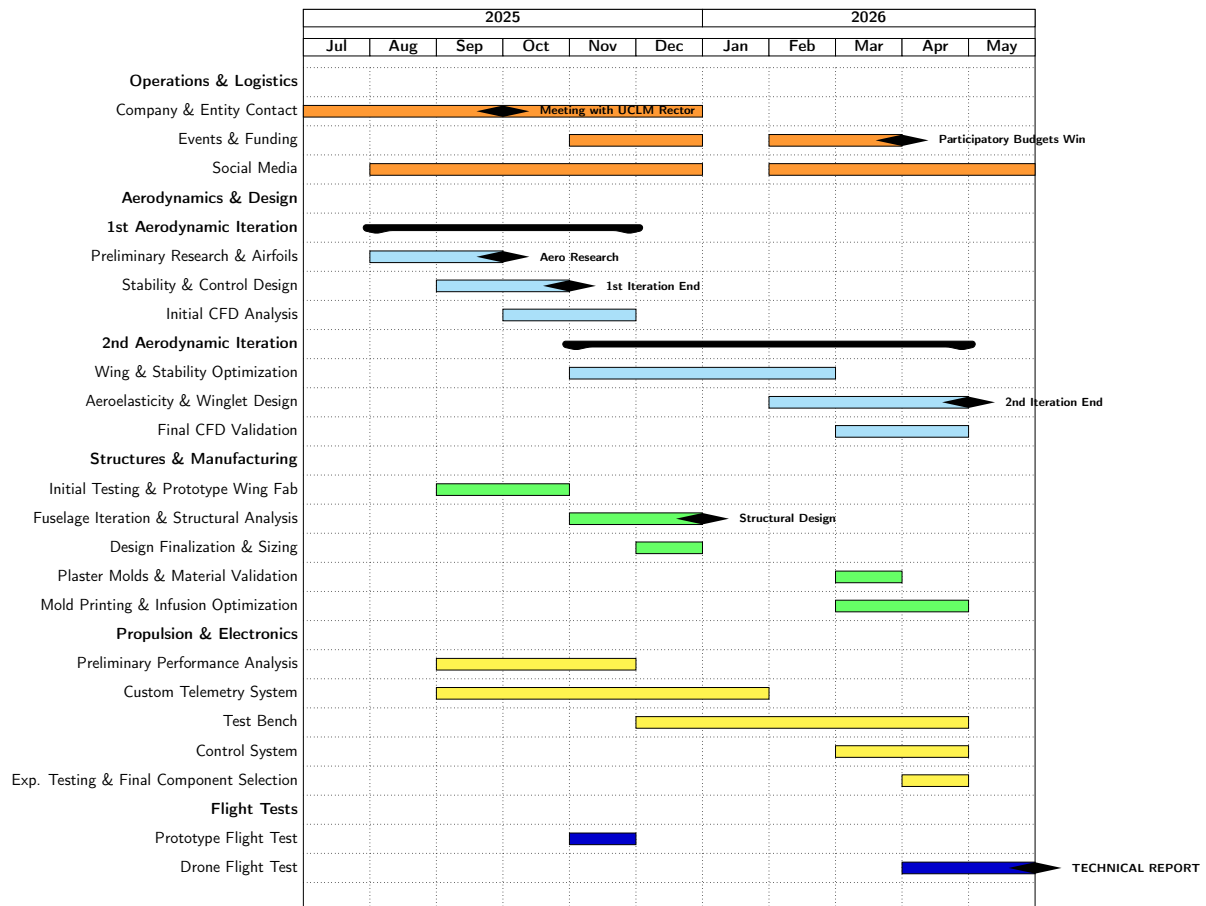


Figure 2.2: Detailed Project Schedule - DIANA UCLM

2.3 Sponsors of the project

Main Sponsor

University of Castilla-La Mancha (UCLM): Universidad de Castilla-La Mancha is a leading Spanish institution in technology and engineering education. For the DIANA team, the university provides the essential facilities and environment to apply our theoretical knowledge to the design of real drones through a "learning by doing" approach. This critical support is made possible through direct funding from the UCLM Social Council and the Participatory Budgets program. Their financial backing, amounting to around €12,000 allowed us to acquire the advanced materials, electronics, and logistical support needed to compete internationally.



Gold Sponsors

Ferreterías Julián: Ferretería Julián is a local hardware supplier and a cornerstone of the DIANA project, being the very first sponsor to ever support our team. Their trust was instrumental during our initial phase, providing a €1,000 credit line at the beginning of the year and donating specialized workshop materials valued at €150. As our founding sponsor, their early commitment to our vision remains a fundamental part of our team's history and success.



Escuela de Ingeniería Industrial y Aeroespacial de Toledo (EIIA): The EIIA-To is a key institutional partner and a fundamental pillar of the DIANA project. Their commitment to our team has been demonstrated through the full financing of our competition registrations (€1,050) and the provision of specialized workspaces and facilities within the campus. Furthermore, we receive constant technical and academic guidance through our faculty advisor, Sergio Horta, whose mentorship and coordination have been essential in bridging the gap between theoretical education and high-level aerospace engineering.



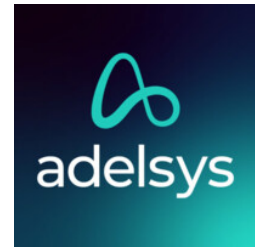
Club de Aeromodelismo Alcotán: The Alcotán Aeromodelling Club is a key collaborator for the DIANA team. They provide the essential flying facilities where we conduct all our prototype flight tests. Additionally, their experienced members offer expert instruction and training for our pilots, ensuring safe and successful flight operations.



Silver Sponsors



Adelsys: This company is a valued sponsor of the DIANA project. Their financial contribution of €400 has provided our team with essential funding used for necessary materials and components.



DANIMA COMPOSITES: thanks to the mentorship and donations of company manager and collaborator David Barrios, the DIANA team learnt how to properly use the infusion technique for composite materials such as carbon fibre.



GlobalCaja: The GlobalCaja bank provided financial support of €1,050 for DIANA's team transportation to the ACC premises.



Bronze Sponsors



ICSA - Aernnova: ICSA has supported our team by donating €300 worth of specialized materials, which greatly enhance our manufacturing capabilities.



SmartMaterials: SmartMaterials has supported our team by donating €140 worth of 3D printing filament spools. These high-quality materials are essential for the rapid prototyping and manufacturing of our custom components.



2.4 Budget and costs

A detailed summary of departmental expenditures during the academic year is provided in Table 2.1. This table also highlights the proportion of expenses funded by the sponsors referenced in the previous section.

Item	Amount	Description
Project Costs		
Manufacturing Materials	€2,300	Carbon fiber, balsa wood, 3D printing filaments, epoxy resin
Electronics & Propulsion	€950	Brushless motors, ESC, high-performance LiPo batteries, telemetry
Logistics & Transport	€2,500	Competition registration and travel expenses for the team
Miscellaneous	€1,400	Tools, hardware, 3D printers, vacuum chamber
Merchandising & Events	€1,000	T-Shirts, lanyards, notebooks, polo shirts
Logistics	€3,200	Transport to the competition for the team and the aircraft
Total Costs	€11,350	
Sponsors & Funding		
UCLM (Main Sponsor)	€12,000	Direct funding (Social Council & Participatory Budgets)
Ferretería Julián	€1,150	€1,000 credit line + 150 € in specialized workshop materials
EIIA (Gold Sponsor)	€1,050	Full financing of the competition registrations (ACC)
Globalcaja	€1,050	Financial aid for team transportation to the ACC premises
National Lottery sales	€1,040	Fundraising initiative through the sale of national lottery tickets
Miscellaneous Income	€1,357.77	Funds gathered from diverse events (Warhammer Fair, Family Science, Christmas basket), donations (Micro Patronage Web), and local sponsorships (e.g., Pizzería La Esquina Del Norte)
Adelsys	€400	Financial contribution
ICSA	€300	Specialized materials donation
SmartMaterials	€140	3D printing filament spools
Total Budget	€18,487.77	

Table 2.1: Detailed Cost and Funding Breakdown for DIANA UCLM Project.

3. Aerodynamic Design

3.1 Main wing airfoil

The wing design process began with the selection of an airfoil. This task was driven by the need to balance two objectives: maximizing lift to carry payload and achieving sufficient speed, which typically involves thinner, high-speed profiles.

After evaluating the performance of several candidates, such as the Clark Y, E216, S23021 and SD7037 as shown in Figure 3.1, the Clark Y airfoil was chosen due to its compromise between lift capability and flight speed.

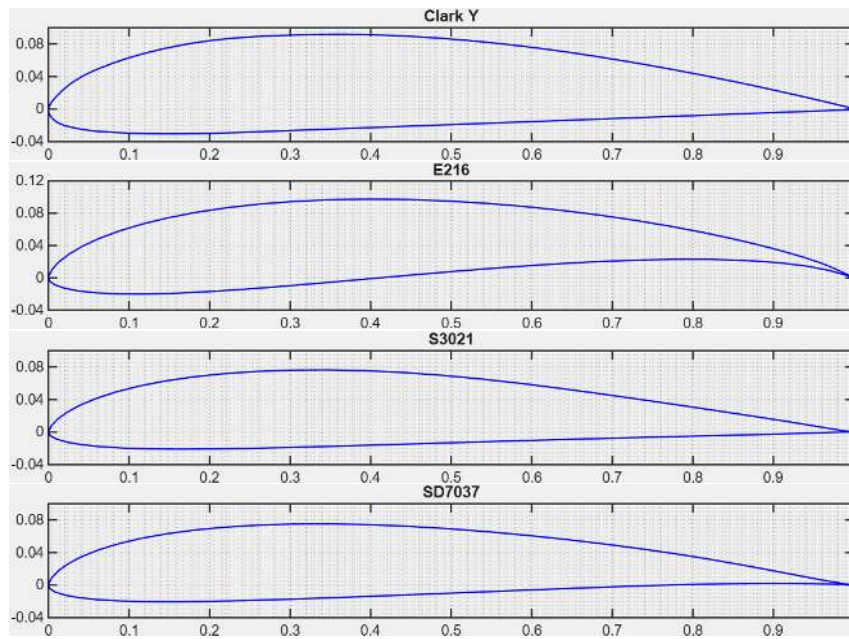
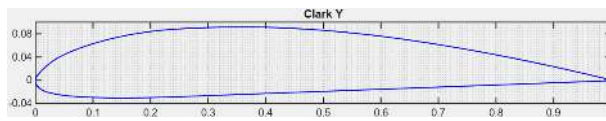
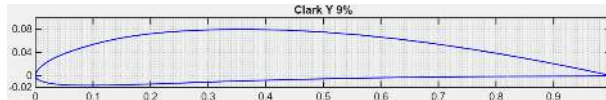


Figure 3.1: Airfoils considered in the initial stage

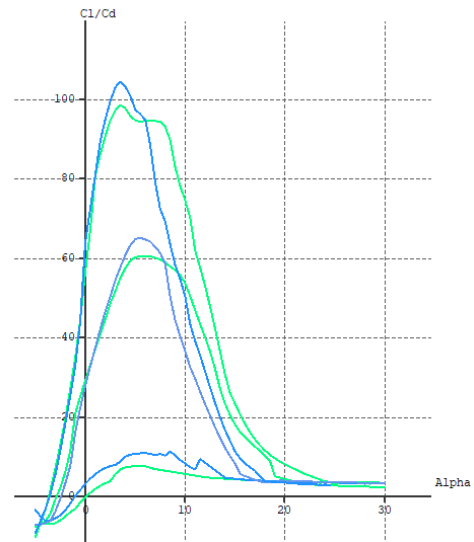
After the selection of the Clark Y airfoil, two thinner versions were created from it by reducing its maximum thickness with the intention of achieving a higher aerodynamic efficiency. The original Clark Y airfoil has a maximum thickness of 11.7% of its chord. Modified versions with reduced thicknesses of 11%, 10% and 9% of its chord were examined in order to evaluate their aerodynamic performance. Figure 3.2 shows the comparison between the original Clark Y and the modified Clark Y 9%. Figure 3.2c presents the aerodynamic efficiencies of both airfoils at three different Reynolds numbers, with the Clark Y 9% being the most efficient and therefore selected for the aircraft.



(a) Standard Clark Y airfoil



(b) Clark Y 9% airfoil



(c) Aerodynamic efficiency comparison at three different Re numbers. In green, the standard Clark Y airfoil. In blue, the thinner Clark Y 9% airfoil.

Figure 3.2: Comparison between the two Clark Y airfoils

3.2 Main wing geometry

The wing mounted on the aeroplane is semi-elliptical as shown in Figure 3.4, featuring a flat leading edge and an elliptical trailing edge, as an elliptical lift distribution helps reduce induced drag generated by the wing. The aim was getting a good manoeuvrability at the cost of some stability, therefore the aircraft presents some neutral-stability features, namely a mid wing with no cantilever. The geometry and specifications of the main wing—without the fuselage—are as follows:

- **Wingspan:** 3 m without WD¹, 3.146 m with WD
- **Root chord:** 0.25 m
- **Wing area:** 0.635 m²
- **Aspect ratio:** 14.17
- **Angle of incidence:** 1 degree
- **Other:** *Cantilever, no dihedral, no twist, mid wing*

The wing with can be seen in Figure 3.4, while its polar and efficiency curves are displayed in Figure 3.3.

¹Wingtip Devices.

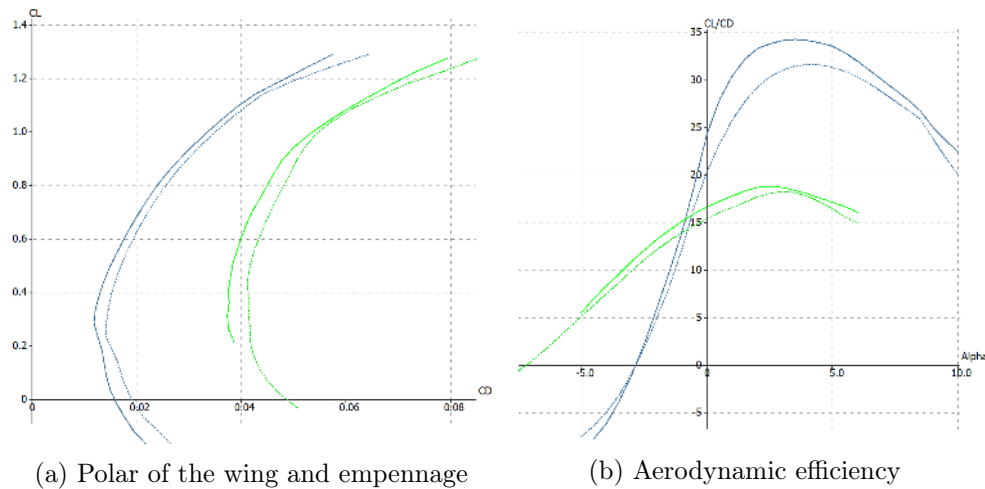


Figure 3.3: Aerodynamic curves of the wing and empennage assembly in clean configuration (blue) and with flaps 15° (green). Solid lines represent the analysis at 25 m/s, while dotted lines represent the analysis at 15 m/s.

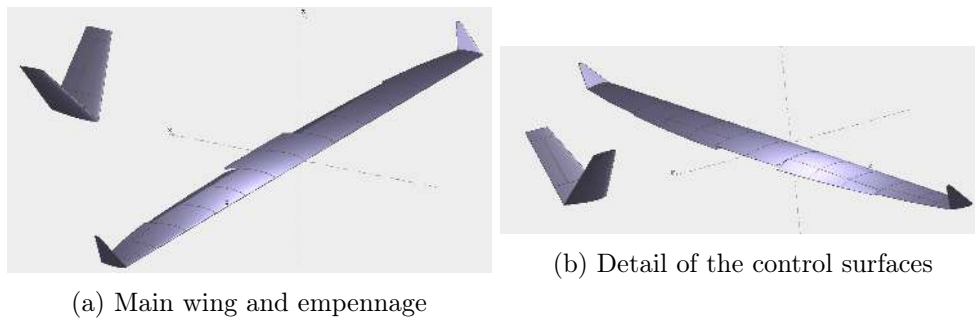


Figure 3.4: Wing and empennage

3.3 Empennage

The empennage follows a V-shaped configuration with a 45-degree dihedral. This option was the most optimal considering the reduction of tail weight by the elimination of the vertical stabilizer. This configuration had also been used for previous aircraft models submitted for other competitions, so the team had some experience with it.

The airfoil used in the empennage is the NACA 0008, chosen chiefly due to its thinness and, therefore, lower drag, while still being able to fit a servomotor inside.

3.4 Control surfaces

The first aircraft design iterations started out with flaperons as the only control surfaces on the main wing. In later iterations, they were replaced by a set of flaps and a set of ailerons so more wing area is fixed and available to produce lift throughout the flight. The layout of the control surfaces can be seen in Figure 3.4b, and their effectiveness is discussed in Section 3.6.1.

Flap deflection was analysed, and two configurations of 15° and 30° were compared. The results showed the obvious greater lift increase of the 30° setting, making it the chosen deflection had it not been for the pitching moment generated. This moment required near-full deflection of the elevator to maintain pitch attitude, leaving little elevator margin for control inputs. The

only solution was then to modify the empennage incidence angle, which would reduce the efficiency of the aircraft during the critical cruise and manoeuvring phase. This idea was discarded immediately, and the flap configuration was finally set to 15° .

3.5 Wingtip devices

Wings with elliptical shapes tend to minimize the effects of wingtip vortices, or at least significantly reduce their intensity. However, from a manufacturing standpoint—considering that the wings will be fabricated from carbon-fibre composites—elliptical geometries induce more complexity and a higher cost. Moreover, in order to increase the wingspan and the aspect ratio to improve aerodynamic efficiency, a wing configuration with straight tips was selected. In order to compensate for the loss of efficiency resulting from steering away from purely elliptical shapes, it was determined that winglets would be used.

After conducting a preliminary investigation, three primary wingtip configurations were selected for analysis: straight, straight (smaller) and blended—or upswept—tips. The models were evaluated using CFD, varying key parameters for both options, such as the sweep angle, curvature radius and height. Different configurations of angles of attack were studied, and based on the results, the blended winglet demonstrated slightly superior performance, including improved behaviour in cruise conditions and a higher overall aerodynamic efficiency. Consequently, this configuration was selected as the final design. Table 3.1 summarizes the aerodynamic efficiencies obtained by the CFD analysis of each winglet option.

Angle of attack	Straight	Straight (smaller)	Blended
0°	18.329	18.231	18.875
2°	12.822	12.799	12.862
4°	9.771	9.770	9.587

Table 3.1: Aerodynamic efficiencies obtained for each of the three winglet options

A symmetrical aerodynamic profile for the winglet was chosen to avoid generating additional momentum. Moreover, this winglet was the easiest to manufacture, thus being advantageous from a structural and manufacturing standpoint as well.

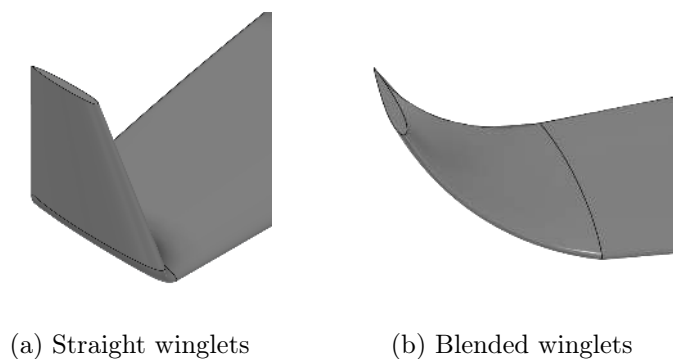


Figure 3.5: Winglet designs analysed

3.6 Stability

3.6.1 Static stability and control effectiveness

The neutral point of the aircraft is at 12.1 cm from the main-wing leading edge. In order to attain the desired stability, the goal static margin (SM) was set to 20%, which places the desired centre of gravity at 7.8 cm from the wing leading edge according to the definition of static margin:

$$SM = \frac{x_{NP} - x_{CG}}{MAC} \iff x_{CG} = x_{NP} - SM \cdot MAC, \quad (3.1)$$

where MAC stands for the Mean Aerodynamic Chord, and is equal to 0.215 m. Furthermore, the limits imposed were a static margin no less than 10% nor greater than 30%, as this would translate into an aircraft too difficult to manoeuvre.

After performing some stability analyses in XFLR5, the stability derivatives for the aircraft were found within the ranges recommended by the bibliography consulted. These obtained values can be seen on the left side of Table 3.2. All three derivatives provide the aircraft with a positive static stability, albeit both directional derivatives fall close to the lower limit of the recommended range—meaning the aircraft is not as stable as it could be. However, this was an already expected side effect of the V-shaped empennage or, rather, of the lack of a purely vertical stabilizer.

Moreover, in order to check the manoeuvrability of the aircraft, the control effectiveness was also analysed in XFLR5, obtaining the control-effectiveness coefficients presented on the right side of Table 3.2.

Parameter	Value	Parameter	Value	Parameter	Value
$C_{m\alpha}$	-1.410	$C_{m\delta_e}$	-1.513	-	-
$C_{l\beta}$	0.083	$C_{l\delta_a}$	-0.073	$C_{n\delta_a}$	0.0012
$C_{n\beta}$	-0.043	$C_{n\delta_r}$	0.282	$C_{l\delta_r}$	0.0184

Table 3.2: Stability derivatives (left), control-effectiveness coefficients (middle) and control-induced-moment (right) coefficients given by the static-stability and control analyses.

4. Structural Design

In order to build a plane with the needed characteristics, it is necessary to use a light weight material that can withstand all of the forces that the aircraft is going to experiment in flight. To achieve that, carbon fiber is selected for the skin because of its strength-to-weight ratio.

4.1 Wing-skin layup optimization & FEM simulations

To determine the most efficient wing skin configuration, four layup iterations are simulated in Abaqus learning edition, provided by the UCLM, under a static aerodynamic load corresponding to MTOM with a load factor of 2 (2G). The structures are evaluated based on maximum deflection, Hashin damage failure criteria, elastic instability and total structural mass.

Hashin damage analysis confirms that material failure is negligible across all designs, with the maximum stress never exceeding 1.5% of the material's total capacity. Consequently, structural buckling of the upper skin under compression is the primary limiting factor for this design.

Analyzed configurations

- **1 carbon-fiber layer:** Being the lightest option, it supports the 2G load ($\delta_{max} = 19.91$ mm) and offers a low buckling safety margin ($\lambda_{crit} = 2.61$).
- **2 carbon-fiber layers:** Provides massive buckling resistance ($\lambda_{crit} = 16.36$) and high stiffness ($\delta_{max} = 12.31$ mm). However, it is over-engineered, increasing the weight significantly.
- **1 carbon-fiber layer with carbon reinforcement:** A targeted approach using a double carbon layer only at the high-stress root and leading edge areas.
- **1 carbon-fiber layer with 1 fiberglass layer:** Achieves a strong buckling factor ($\lambda_{crit} = 6.75$). Nevertheless, the low structural efficiency of the fiberglass increases the weight remarkably.

Conclusion & final selection

The targeted partial reinforcement is selected as the optimal design. By concentrating the extra carbon fiber strictly in critical zones, the structure efficiently manages load distribution. This configuration maintains excellent aerodynamic stability with a maximum deflection of $\delta_{max} = 16.12$ mm and ensures a safe buckling margin of $\lambda_{crit} = 3.44$. This strategic layup multiplies the buckling resistance by 1.32 compared to the single-layer design, while only adding a few grams.

4.2 Wing structure

The final internal structure of the wing represents an optimized balance between torsional rigidity, bending strength, and minimal structure mass. The structure is designed to withstand a load factor of 2 at MTOW while strictly preventing geometric instability, such as local skin buckling.

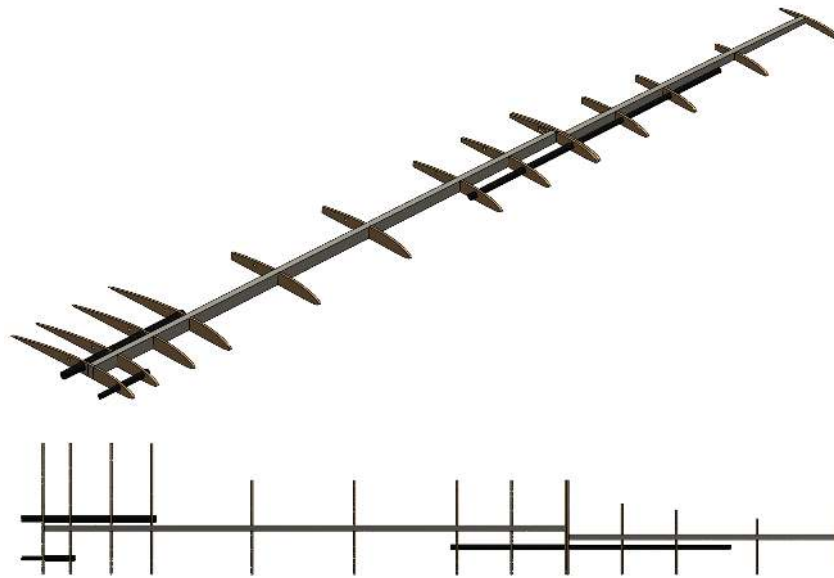


Figure 4.1: Isometric (upper) and top (bottom) view of the internal structure

The main skin of the wing is made with a carbon fiber layup, using a double reinforcement in the leading edge, that absorbs most of the twisting forces and distribute the general aerodynamic pressures into local, internal parts, which are:

Main spar (Rohacell-Roving): The main spar is the critical component for absorbing bending moments, resisting tension on the lower surface and compression on the upper surface, while its web handles shear stresses. It is placed at the maximum thickness point (34% of the chord) to maximize the moment of inertia. Two material configurations were evaluated:

- **Balsa-wood I-Beam:** Ideal for resisting shear stresses in simple bending. This option provides excellent strength-to-weight ratio, ease of assembly, low cost, and orthotropic resistance.
- **Rohacell Core with Roving 12k:** A polymethacrylimide foam core that acts as a continuous skin stabilizer, preventing local buckling of the thin carbon fiber under aerodynamic loads. The caps feature unidirectional carbon fiber (Roving 12k), eliminating woven crimp to ensure 100% of the carbon's tensile strength works along the span.

The Rohacell-Roving model was finally selected based on two crucial factors:

- **High global stiffness:** Reducing the maximum deflection by nearly 4 mm improves the aeroelastic response.
- **Buckling prevention:** Critical failure in these structures arises, normally, from geometric instability under compression, not from exceeding the elastic limit. The continuous Rohacell core stabilizes the thin carbon upper skins, preventing local buckling at high load factors.

The results for the Rohacell-Roving spar are:

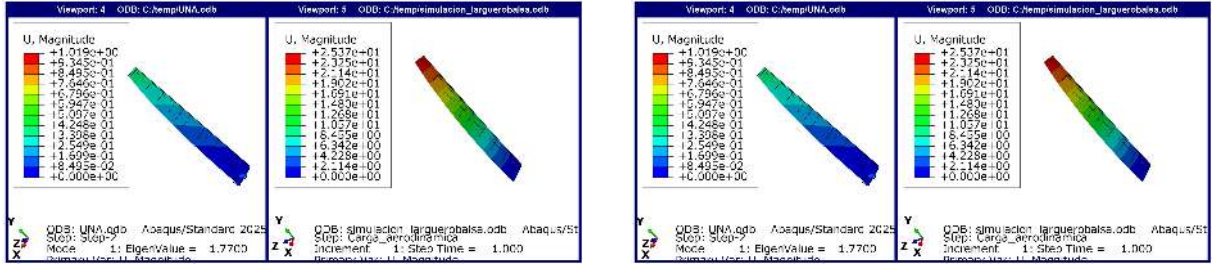


Figure 4.2: Wing with Rohacell spar: Displacement (left) and Von Mises stress (right)

Evaluating the wing as a cantilever beam, the maximum deflection relative to the total semi-span (1500 mm) is defined as:

$$\text{Relative Deflection} = \frac{21.51}{1500} \cdot 100 = 1.43\%$$

A limit load displacement below 1.5% indicates a highly rigid, hyperstatic design, which prevents structural failure during flight and maintains the effective angle of attack throughout the span. Carbon fiber laminates with epoxy resin typically exhibit the ultimate strengths exceeding 600 Mpa (often reaching over 1500 MPa). Assuming a conservative limit of 500 MPa, the safety factor under a 2g limit load is:

$$\text{Safety Factor (SF)} = \frac{\sigma_{\text{ultimate}}}{\sigma_{\text{max}}} \approx \frac{500 \text{ MPa}}{40.23 \text{ MPa}} > 12$$

An SF greater than 12 confirms the material operates strictly within the elastic regime, safely removed from yielding or rupture.

Due to the long span, the wing also needed to be segmented to fit in the transport box; this is why this main spar is divided into two. Additionally, it is displaced towards the front in the second segment to make space for the ailerons' electronics.

Transverse ribs: Fourteen balsa wood ribs are distributed across each 1.5 meter semi-span. Chosen for their exceptional stiffness-to-weight ratio and orthotropic shear resistance, the balsa acts as a load-transfer bridge between the skin and the spar. By distributing these ribs across the wing, the critical buckling stress increases, ensuring that the airfoil maintains its geometry under high loads.

Bayonets: The connection to the fuselage is secured by two carbon fiber bayonets per semi-span. These act as sub-spars by also helping with the distribution of load within the structure, and by matching the material of the spar with the skin's stress concentrations are avoided and sudden jumps in flexibility that could induce fatigue cracking at the wing root are prevented.

4.3 Fuselage

The fuselage is designed to contain a maximum payload of 8 cans while also being able to carry different placements of payload, distributing it around the wings to even the weight lengthwise.

The main structure is based on balsa wood and finish birch frames which not only shape the fuselage and transfer concentrated loads, but also creates the loading bay.

The silhouette is designed to keep only the necessary space between the cans and the main skin, made of two layers of carbon fiber, leaving no room to place stringers or longerons. This is solved by reinforcing concrete areas of the skin with 20 layers of 12k roving in the longitudinal direction to transmit the axial loads to the frames. Also, five carbon fiber rods pierce the frames, avoiding the cans to touch one-another and reinforcing the main structure.

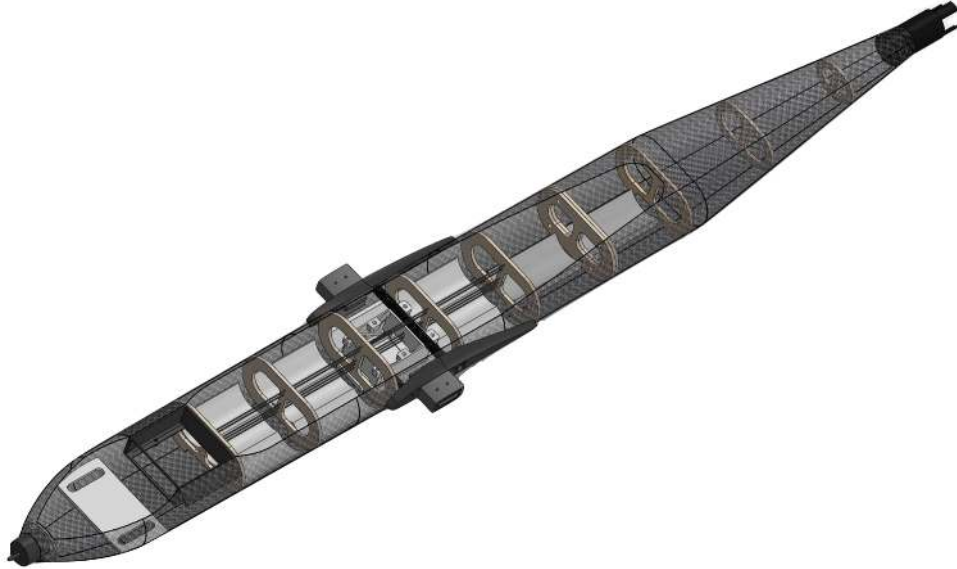


Figure 4.3: Fuselage's internal structure

As mentioned, different configurations of payload are possible. The challenge is to place different amount of cans while still being on a stable range for the center of gravity.

Based on the requirements produced by the Department of Aerodynamics (Section 3.6.1), the plane is going to be stable as long as the center of gravity stays between 50 and 100 mm (blue area) from the leading edge. This restriction is only satisfied in the 6 following configurations:

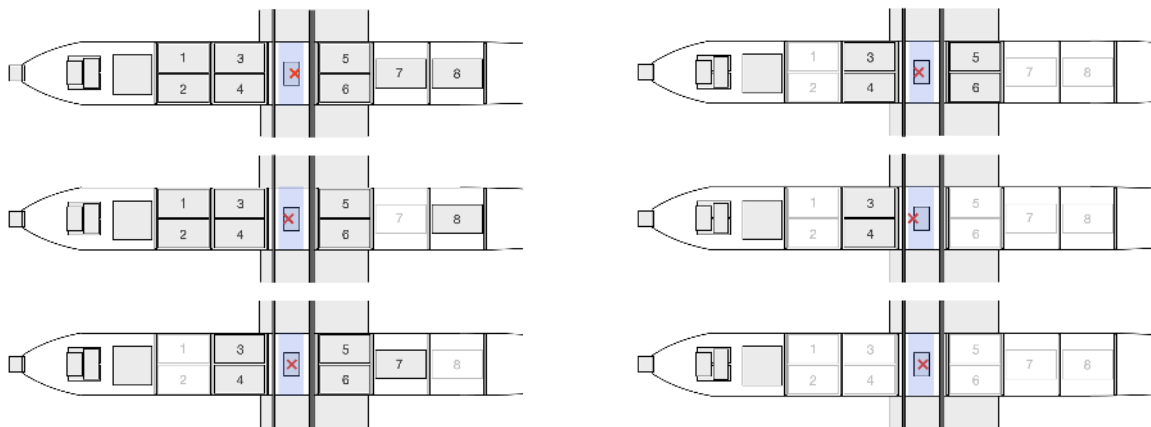


Figure 4.4: Position of center of gravity according to the payload carried

According to this configurations, the most optimal payload is with 8 cans, followed by 5 cans and an empty cargo bay.

4.4 Empennage

Regarding the empennage, one main carbon fiber skin composes the aerodynamic profile, while its internal structure uses the same approach as before—five balsa ribs hold in place the airfoil’s geometry, and a rohacell spar connects them together. Additionally, two bayonets help stabilize rotation and flexion from the root.

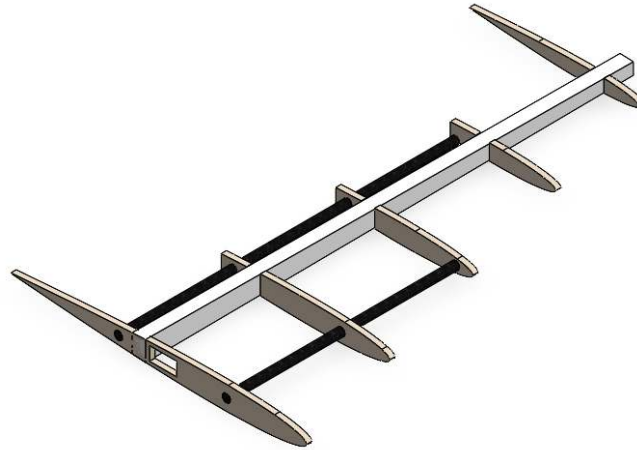


Figure 4.5: Isometric view of the empennage’s internals

4.5 Fuselage-wing coupling

To enable the wings and the fuselage to interact as an only body, the bayonets have to be well placed and secured inside the fuselage. To achieve it, a 3D printed piece is designed and located inside the fuselage, being able not only to hold the bayonets in place but also to contain the controller inside.

The lower piece is directly glued to the main skin, while the one above is secured using screws.

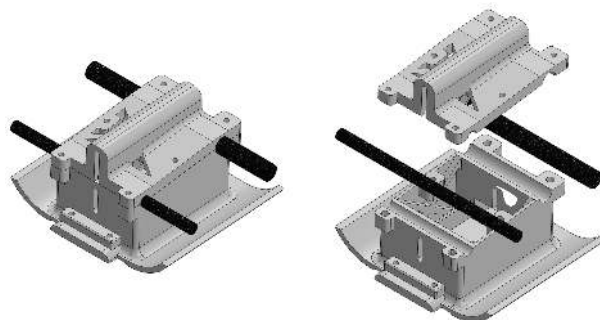


Figure 4.6: Joint between the wing and the fuselage

5. Manufacturing

In order to achieve the plane's best performance, it was decided to work with carbon fibre because of its exceptional strength-to-weight ratio. A **200g 2x2 twill 3K** was used to manufacture the skin and other materials such as balsa wood, finish birch and 3D printing filament were used to create the inner structure.

5.1 Casts

Two iterations took place during the manufacturing process; plaster molds and 3D printed molds. This techniques were selected for being accessible, simple and trustworthy. After some samples it was proven that 3D printing was the most reliable option.

Method	Strong points	Weak points
3D printing	Reliable	Slow
	Precise	Sanding is necessary
	Simple	
Plaster	Easy to work with	Fragile
	Cheap	Time-consuming

Table 5.1: Comparative of techniques for cast manufacturing

5.2 Infusion process and hand-laminating

To shape the carbon fiber, an infusion technique is chosen in most of the pieces to get an even coat of resin. More complex geometries are manufactured using hand laminating techniques.

In all the pieces, carbon fiber is placed to $\pm 45^\circ$ to handle torsional twisting loads and sheer forces. In addition, **12K roving** is positioned in the longitudinal direction to improve structural stability.

In order to get a good coupling between the skin and the roving, both materials are infused together.

On the following table, a summary of how pieces have been manufactured is shown:

Part	Technique	Layers	Structural reinforcement
Wing	Infusion	1 layer, leading edge reinforced	20 threads of 12k roving
Fuselage	Infusion	2 layers	20 threads of 12k roving
Empennage	Infusion	1 layer	None
Landing gear	Hand laminating	2 layers	None

Table 5.2: Comparative of techniques for cast manufacturing

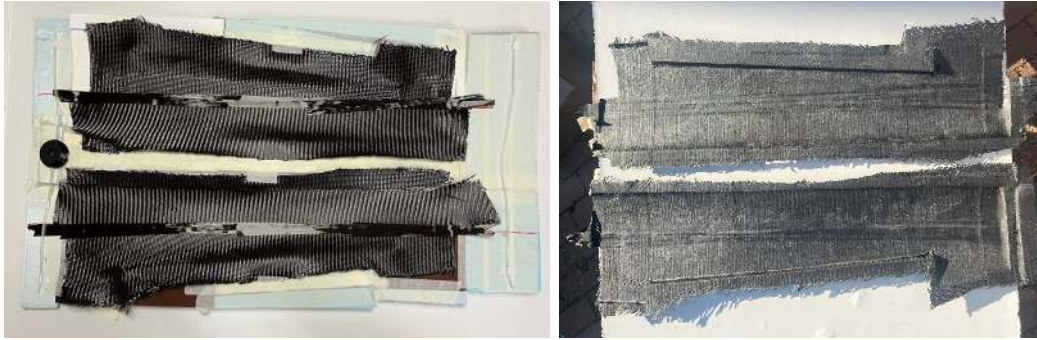


Figure 5.1: Final part of the wing before (left) and after (right) the infusion process (inner face)

5.3 3D components

To fit the plane in the transport box it is mandatory to slice the aircraft in different pieces, being necessary to devise joints. Also, electronics have to be placed properly. To solve this problem, 3D pieces are designed and printed.

Depending on the purpose of the piece, a different material is selected, finding the balance between weight, functionality and resistance. The following criteria is used to designate the filament.

- **Joints:** Polyamide Carbon Fiber (PACF); provides stiffness, strength and withstands heat flow.
- **Dividers and fixtures:** Light Weight PLA, to obtain lighter pieces.
- **Control surfaces:** Light weight PLA
- **Wheels:** Thermoplastic Polyurethane (TPU); offering high elasticity and excellent abrasion resistance.



Figure 5.2: 3D printed joints and fixtures

6. Electronics of the Aircraft

6.1 Propulsion system design

The propulsion system is a cornerstone of the aircraft’s performance, tasked with providing maximum static thrust for takeoff while operating under a strict **30 A current limit**. Our design integrates the mandatory **T-MOTOR AT2814 900 KV** motor with an optimized propeller selection and a custom electronic control strategy.

6.1.1 Experimental setup and instrumentation

To move beyond theoretical simulations, a custom **twin-engine test bench** was developed over a five-month period. The bench supports simultaneous dual-motor testing, enabling configuration-level comparisons under identical electrical and mechanical conditions, as shown in Fig. 6.1 and Fig. 6.2.

The instrumentation suite includes:

- **Thrust measurement:** A 20 kg load cell calibrated to measure static force.
- **Rotational speed:** An **IR TCRT5000** reflective sensor for precise RPM tracking.
- **Power monitoring:** A **Matek Hall Effect** sensor to log instantaneous Current (A) and Voltage (V).

Data is sampled via an Arduino-based system, stored in **.csv** format on a microSD card, and subsequently processed using MATLAB for comparative analysis.



Figure 6.1: Propeller-mounted reflective target and IR sensor alignment for real-time rotational speed measurement.



Figure 6.2: Twin-engine configuration demonstrating the bench’s dual-motor simultaneous measurement capability.

6.1.2 Electronic current-limiting and “oversizing” strategy

Our design employs an **electronic current-limiting** strategy. We tested both manufacturer-recommended propellers (12×6, 13×6.5) and oversized candidates suggested by the Department of Aerodynamics (11×8, 12×8, 13×8) to maximize mission score.

By utilizing a larger propeller and clamping the current at 30 A through ESC firmware or throttle mapping, we achieve a dual advantage:

1. **Static phase:** During takeoff, the motor is held at the maximum legal 30 A, extracting the highest possible static thrust from the oversized propeller.
2. **Dynamic phase:** As the aircraft accelerates, the aerodynamic “unloading” effect reduces the torque required by the propeller. This allows the current limiter to permit higher RPMs, resulting in a higher cruise speed compared to a naturally limited propeller.

6.1.3 Comparative results and selection

The processed data from the experimental trials provided the four critical performance metrics illustrated in Fig. 6.3.

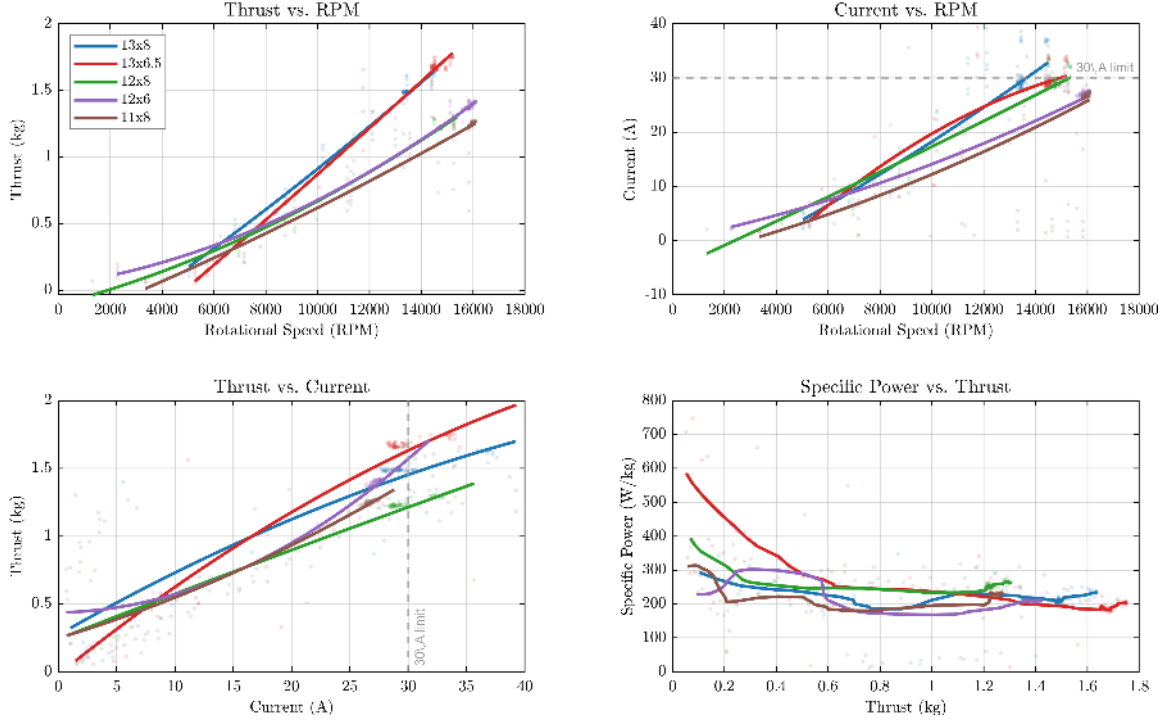


Figure 6.3: Propulsion analysis across all tested propeller configurations. *Top-left:* Thrust vs. RPM. *Top-right:* Current vs. RPM, with the 30 A competition limit indicated. *Bottom-left:* Thrust vs. Current — primary selection criterion at the 30 A boundary. *Bottom-right:* Specific Thrust (g/W) vs. Thrust — efficiency mapping for cruise optimisation.

The **Thrust vs. Current** curve is the primary selection tool, identifying which propeller yields the highest thrust at the 30 A threshold. Additionally, the **Specific Thrust (g/W)** analysis ensures that the chosen setup remains efficient during the cruise phase, optimizing battery endurance and thermal management.

Experimental results show that the **13×8** and **13×6.5** propellers perform similarly at the 30 A boundary. However, by integrating aerodynamic performance predictions—which account for the propeller unloading effect and cruise efficiency—the **APC 13×8E (Thin Electric)** propeller is selected as the definitive configuration.

This specific model was chosen for its optimized airfoil designed for high-RPM electric flight, providing the necessary pitch-to-diameter ratio to maintain high airspeed during the cruise phase while operating within the 30 A limit. The high-rigidity composite construction of the APC series minimizes blade deformation under load, ensuring consistent thrust delivery. Furthermore, every unit will undergo static balancing to eliminate parasitic vibrations, protecting the onboard telemetry and ensuring the structural integrity of the motor mount throughout the mission.

6.2 Power system and energy management

6.2.1 ESC unit selection

ESC selection was based on the maximum current draw verified during custom test bench trials. Under the established competition limits, the T-Motor AT2814 900KV motor draws a peak of 30A.

The T-Motor AT 40A ESC was selected to provide a 25% safety margin, ensuring high reliability during the 120s full-power cruise phase. To comply with competition requirements for electrical isolation, the integrated 3A@5V BEC will be manually disabled (by disconnecting the positive lead of the signal cable). This ensures complete separation between the high-current power circuit and the control electronics, preventing potential EMI/RFI interference. Furthermore, choosing a model from the same manufacturer's ecosystem ensures optimal timing synchronization and superior thermal stability under the expected ambient conditions.

6.2.2 Battery sizing and selection

Capacity requirement

The battery sizing process begins from a worst-case energy consumption model. Each flight phase is assigned a duration and the system is assumed to draw the maximum permitted current of 30 A throughout, providing a conservative upper bound on capacity. The flight profile considered is:

Phase	Description	Duration (s)
Takeoff	Full-throttle static thrust	20
Climb	Ascent to mission altitude	60
Cruise	Maximum-distance cruise task	120
Approach	Maneuvering and landing margin	120
Total		320

Table 6.1: Flight phase breakdown used for battery sizing

The required capacity is computed from the fundamental charge equation:

$$C_{\text{req}} = I_{\text{max}} \cdot t_{\text{total}} \quad (6.1)$$

where $I_{\text{max}} = 30 \text{ A}$ is the maximum operating current and $t_{\text{total}} = 320 \text{ s} = 0.08 \text{ h}$ is the total mission duration. Applying a safety factor $k_s = 1.2$ to account for current peaks, sensor loads, and component aging:

$$C_{\text{design}} = k_s \cdot I_{\text{max}} \cdot t_{\text{total}} = 1.2 \times 30 \text{ A} \times \frac{320}{3600} \text{ h} \approx \mathbf{3\,200\,mAh} \quad (6.2)$$

Voltage and chemistry constraints

The competition regulations impose a maximum cell count of **3S**, fixing the nominal pack voltage at $3 \times 3.7 = 11.1 \text{ V}$ and a fully charged voltage of 12.6 V . The maximum continuous power available to the propulsion system is therefore:

$$P_{\text{max}} = V_{\text{nominal}} \cdot I_{\text{max}} = 11.1 \text{ V} \times 30 \text{ A} = 333 \text{ W} \quad (6.3)$$

Single pack vs. parallel configuration

A dual-pack parallel arrangement (two 3S packs in parallel) was evaluated as an alternative to a single high-capacity cell. While a parallel configuration reduces effective internal resistance and distributes thermal load between cells, it introduces additional complexity: two balance connectors must be managed, the total connector and wire mass increases, and charge balancing between packs requires matched state-of-charge before flight. For a capacity requirement as moderate as 3200 mAh, a single equivalent pack is lighter, simpler, and presents lower failure risk. The parallel option was therefore discarded.

Selected battery

Based on the capacity requirement from Eq. (6.2) and the 3S voltage constraint, the **Zeee 3S 3300 mAh LiPo** was selected. It satisfies the sizing criterion with a 3% margin, and its discharge rating of 50C yields a maximum continuous current of:

$$I_{\text{cell,max}} = C_{\text{rate}} \cdot C_{\text{nominal}} = 50 \times 3.3 \text{ Ah} = 165 \text{ A} \quad (6.4)$$

This result satisfies the requirement for a minimum maximum discharge rate of 40 A. Furthermore, being 5.5 times the 30 A operating point, it ensures that the cells are never thermally stressed, preserving cycle life throughout the competition weekend.

6.2.3 Wiring and connectors

Regarding the physical interfaces, XT60 connectors were selected for the primary power path to ensure full compatibility with the competition's mandatory telemetry system, which must be connected in series between the battery and the ESC. To complement this, 12 AWG silicone wire was chosen, as it is the maximum gauge compatible with the XT60 terminal housing. This combination was specifically engineered to achieve the lowest possible electrical resistance and thermal accumulation, ensuring that the 30 A continuous current does not cause significant voltage sags or connector degradation during the mission.

6.3 Control and communication system

6.3.1 Flight controller

The selected flight controller is the **Matek H743-Wing V3**. This is the first time the team has integrated a dedicated flight controller into the aircraft design. The decision was driven by the demanding flight envelope of the platform: given the large wingspan and high cruise speed, passive stability alone is insufficient to guarantee safe and precise handling throughout the mission.

Although the competition regulations prohibit autonomous operation, the use of **Fly-By-Wire A (FBWA)** mode is permitted and constitutes the primary motivation for adopting this system. In FBWA mode, the pilot retains full manual authority over direction and throttle while the controller continuously corrects attitude deviations, effectively preventing inadvertent stalls or excessive bank angles that could compromise the aircraft or the mission score.

Beyond attitude stabilisation, the **Matek H743-Wing V3** enables two additional safety-critical functions programmed for this competition:

- **Electronic current limiting at 30 A**, implemented in combination with the **Matek HSES Hall Effect** current and voltage sensor. The sensor provides real-time current feedback to the controller, which adjusts the throttle output to prevent the motor from

exceeding the competition-mandated 30 A limit. The same sensor monitors battery voltage and triggers a configurable low-voltage alert, providing the pilot with timely warning before entering a critical discharge state.

- **Roll-angle limiter at 35°**, providing a 5° safety margin below the 40° regulatory ceiling. This soft limit is enforced by the controller in FBWA mode and prevents structural overload on the wing during aggressive maneuvering.

The controller provides a regulated 5–7.2 V output, integrates an IMU, and is built around an STM32H7 microcontroller, enabling flexible peripheral assignment and PWM compatibility with all onboard actuators. **Mission Planner** was selected as the primary ground control and configuration interface.

6.3.2 Servos

The selected servo model is the **Hacker / Jeti DITEX EL0315M MG Digital**. These servos were chosen due to their compact size, low weight (approximately 15 g), and a torque of approximately 3.8 kgf/cm at 6 V. Based on the requirements presented in Table 6.2, this model is used for all control surfaces.

Control surface	Required torque (kgf/cm)
Ailerons	1.8
Flaps	3.0
Ruddervators	1.0

Table 6.2: Minimum torque requirements for each control surface

6.3.3 Avionics battery

The avionics bus — comprising the flight controller, receiver, servos, and telemetry module — is powered by a dedicated battery, independent of the propulsion pack. Its capacity is sized from the estimated current consumption of each subsystem, summarised in Table 6.3.

Subsystem	Avg. current (mA)	Peak current (mA)
Matek H743-Wing V3 (FC)	500	800
Servos $\times 6$ (active flight)	1,800	6,000
RadioMaster XR1 Nano (RX)	100	100
Matek HSES sensor	20	20
Total	2,620	7,120

Table 6.3: Estimated avionics current consumption

Applying the same energy sizing methodology used for the propulsion pack (Eq. 6.1), with the average consumption $I_{\text{avg}} = 2.62$ A, the total mission time $t = 320$ s, and a safety factor $k_s = 1.3$ to cover servo activity peaks:

$$C_{\text{avionics}} = k_s \cdot I_{\text{avg}} \cdot t = 1.3 \times 2.62 \text{ A} \times \frac{320}{3600} \text{ h} \approx 303 \text{ mAh} \quad (6.5)$$

A 3S pack is selected, with a nominal voltage of 11.1 V falling well within the 6.5–30 V direct input range of the **Matek H743-Wing V3**. The board’s internal BEC, configurable

between 5–7.2V via solder pads, steps this voltage down to supply the servos and receiver at the appropriate level. The calculated requirement of 234mAh is well below the 1000mAh packs currently available to the team, providing a comfortable margin of $\times 4$ and justifying their use without further oversizing. A **3S 1000mAh LiPo** is therefore selected as the avionics battery, offering adequate autonomy, low weight, and full compatibility with all connected subsystems.

6.3.4 Transmitter and receiver

The selected receiver is the **RadioMaster ExpressLRS XR1 Nano 2.4 GHz**, fully compatible with the chosen transmission system and suitable for the communication range required by the mission profile.

The selected transmitter is the **RadioMaster TX16S MKII MAX Hall V4.0 (ExpressLRS)**. This model was chosen for its modern architecture and high channel count (up to 16 channels), its native **ExpressLRS** internal module, and its Hall effect gimbals, which deliver significantly smoother and more precise stick inputs compared to traditional potentiometer-based systems. An additional advantage is the ability to display live telemetry data directly on the built-in screen, allowing the pilot to monitor battery voltage and current in real time during flight.

6.4 Electronic architecture

Figure 6.4 presents the onboard electronic layout, showing the physical placement of all subsystems and the separation between the propulsion and avionics power buses.

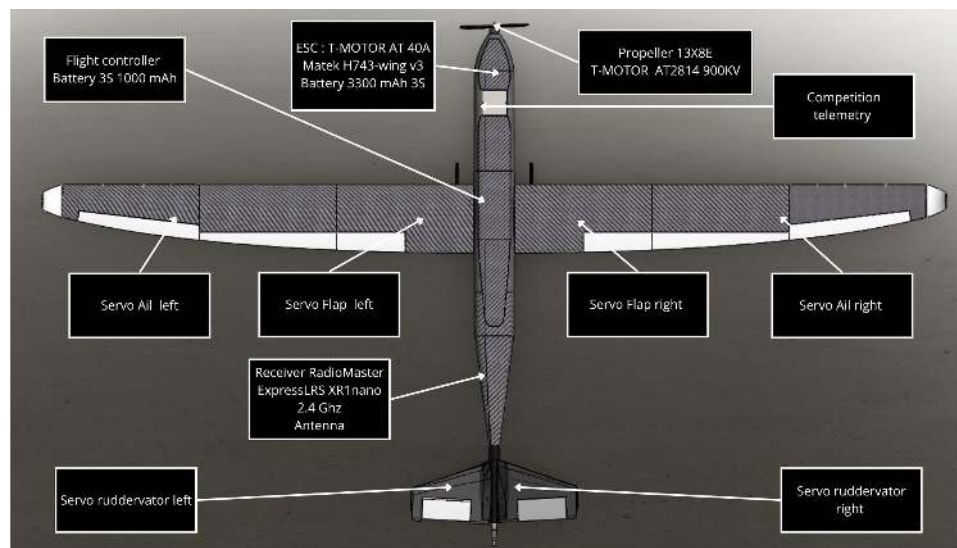


Figure 6.4: Electronic architecture of the aircraft, showing component placement and power distribution across the propulsion and avionics buses.

7. Performance and Payload Prediction

7.1 Performance

With the selected 13x8 propeller and the aerodynamic coefficients given both by XFLR5 and CFD analysis, the performance curves obtained are presented in Figure 7.1 as function of the payload transported.

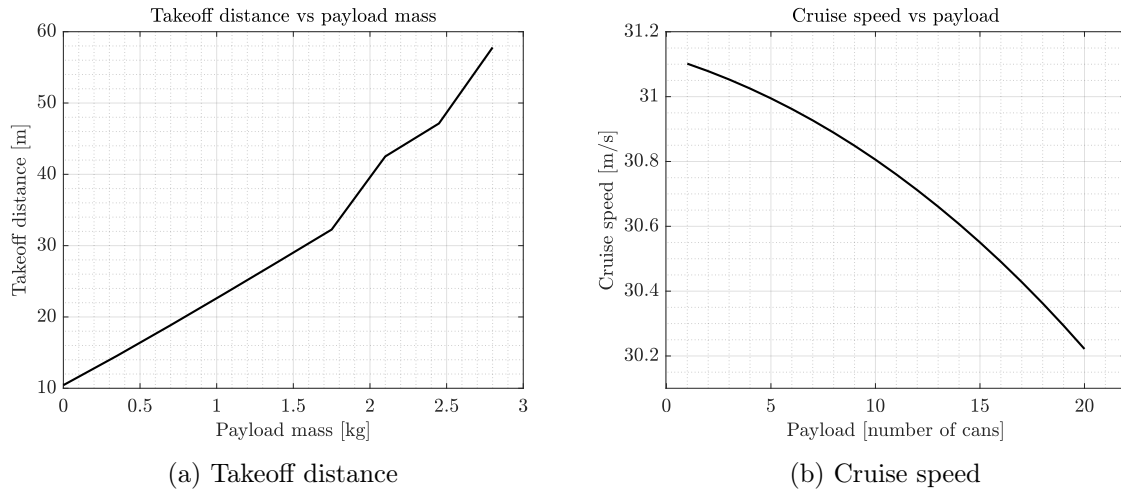


Figure 7.1: Performance curves as a function of the payload transported

7.2 Payload prediction

For calculating the estimated payload, a performance script was written in MATLAB. This script was at first created as a means of simulating a take-off phase using propulsion data from several propellers, and produced a propeller recommendation in terms of payload lifted and speed attained during cruise, as shown in Figure 7.2. The results obtained showed a maximum payload of 8 cans—the payload was discrete and measured in cans—with a Basic Empty Mass of 3 kg. For the calculations, the conditions input were the average historic atmospheric conditions observed in Stuttgart during summer. Any deviation in density on the day of the competition will affect the payload carried as shown in Figure 7.3.

A payload distribution within the fuselage was determined which will allow for different payload configurations without displacing the centre of gravity out of range—this was further discussed in Section 4.3. The centre of gravity is at 6.3 cm from the main-wing leading edge for an empty aircraft and at 7.4 cm for full payload—well within the desired range presented in Section 3.6.1.

Ranking	Prop	Cans	Payload [kg]	Takeoff distance [m]	Cruise speed [m/s]
1	{'p12x8' }	8	2.8	56.62	31.134
2	{'p13x8' }	8	2.8	57.793	30.889
3	{'p12x6' }	8	2.8	56.673	30.024
4	{'p13x65E'}	8	2.8	52.028	29.575
5	{'p10x8' }	7	2.45	55.117	31.447
6	{'p11x8' }	7	2.45	50.873	31.365
7	{'p10x6' }	7	2.45	55.658	30.837
8	{'p11x6' }	7	2.45	51.132	30.523
9	{'p10x5' }	7	2.45	55.659	30.202
10	{'p11x5' }	7	2.45	51.001	29.807
11	{'p12x5' }	7	2.45	51.789	29.345

Figure 7.2: Ranking of propellers obtained with the performance script

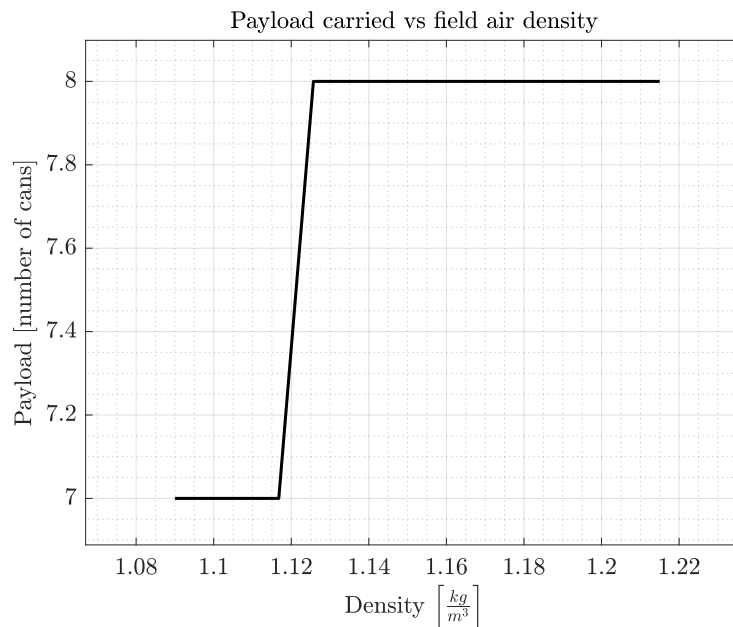


Figure 7.3: Payload carried as a function of air density on the day of the competition

8. Outlook

As we finished the design phase of the 2026 aircraft, the team is now focusing on the final manufacturing and assembly stages. Combining carbon fiber with aeronautical wood and PLA demands a meticulous assembly process. The upcoming weeks are dedicated to finalizing the airframe, installing all the electronic components, and ensuring we build the aircraft exactly according to our CAD models.

Once the aircraft is fully assembled, it will undergo hard ground testing designed to validate the data obtained via CFD and FEA. This testing phase includes static load testing for the main wing and all the joints to verify the structural integrity under maximum payloads. At the same time, we will put the propulsion system under an extensive bench test. By analyzing all the tests and comparing them with the data recorded previously, we will confirm that we match the demanding requirements dictated by the ACC ruleset.

The final part of the timeline is the flight test program. First flights will prioritize the verification of handling qualities, static and dynamic stability, and stall characteristics without payload. Then, when we complete those tests, we will progressively increment the payload to confirm that we can fly with those weights. Also, we will check the reliability of our electronic components during the flights.

Once all these tests are finished and we can confirm that we have a reliable aircraft, the hard development work will be done. The only remaining step will be traveling to the Air Cargo Challenge in Stuttgart to demonstrate our platform and see the final results.

In parallel to these technical milestones, the team aims to further cultivate the symbiotic relationships established with our sponsors. Additionally, the logistical procedures for transporting both the aircraft and the team to the competition will be thoroughly detailed.

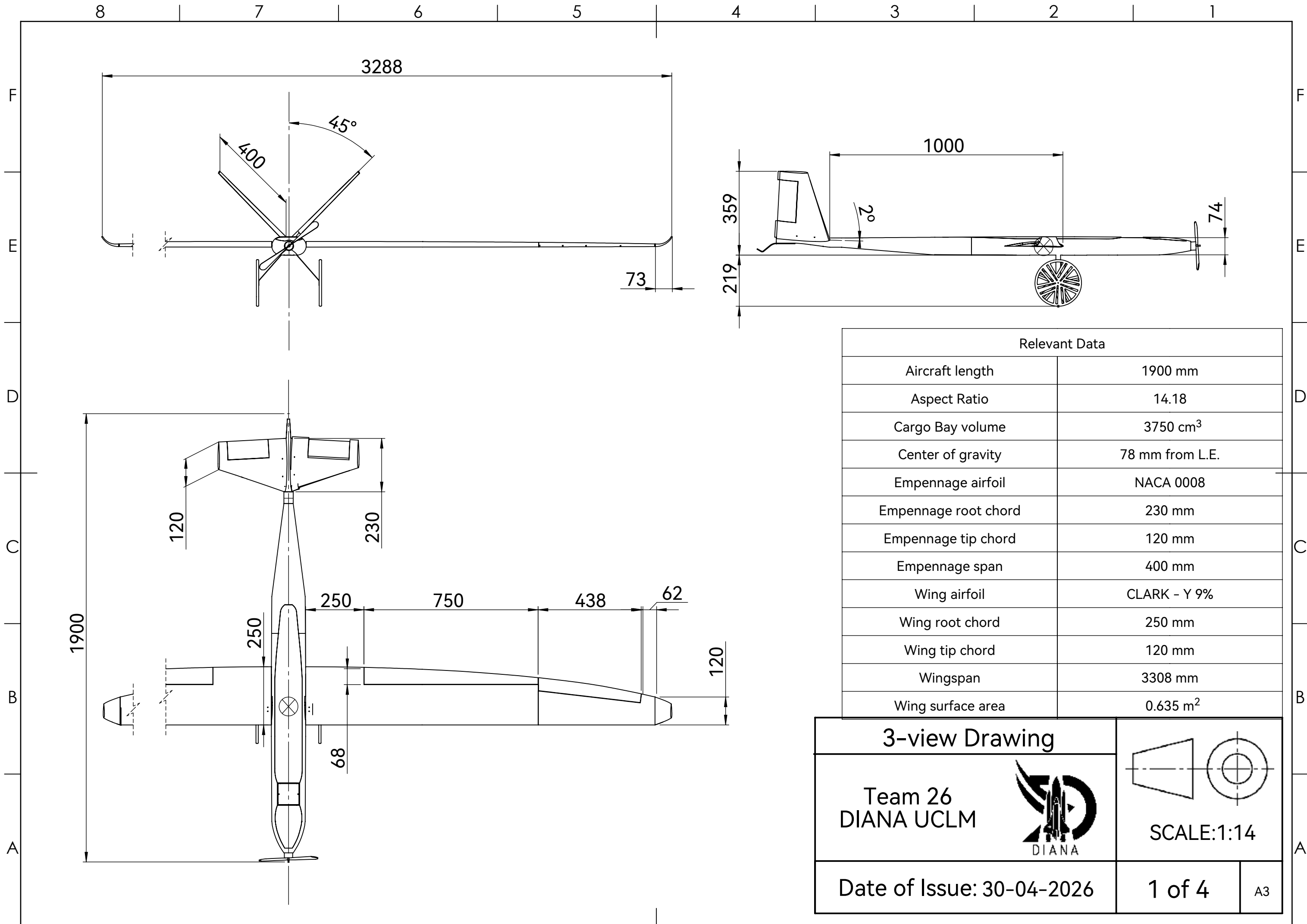


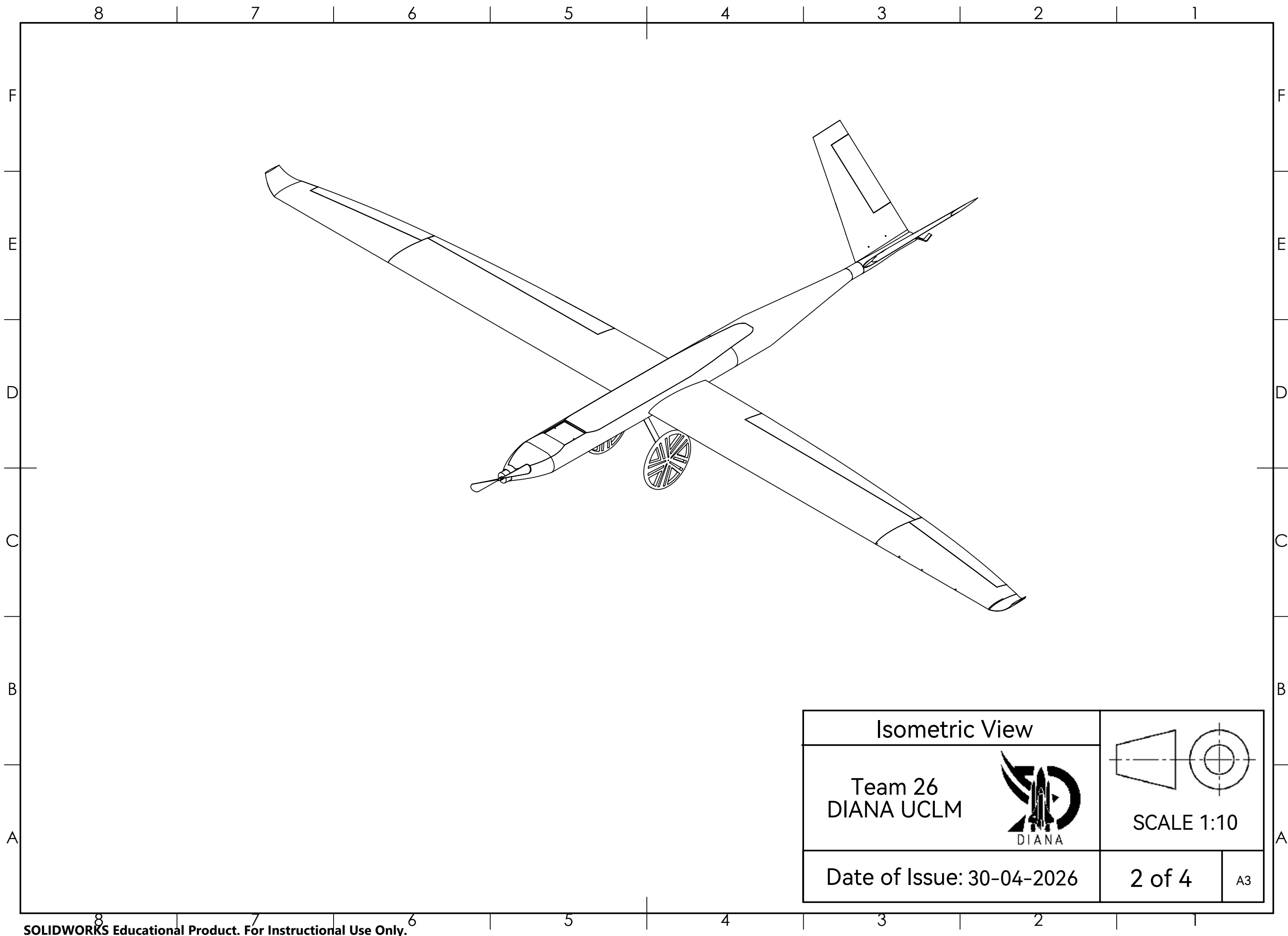
Figure 8.1: DIANA's Aircraft

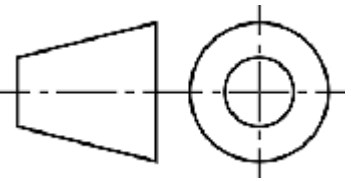
9. Drawings

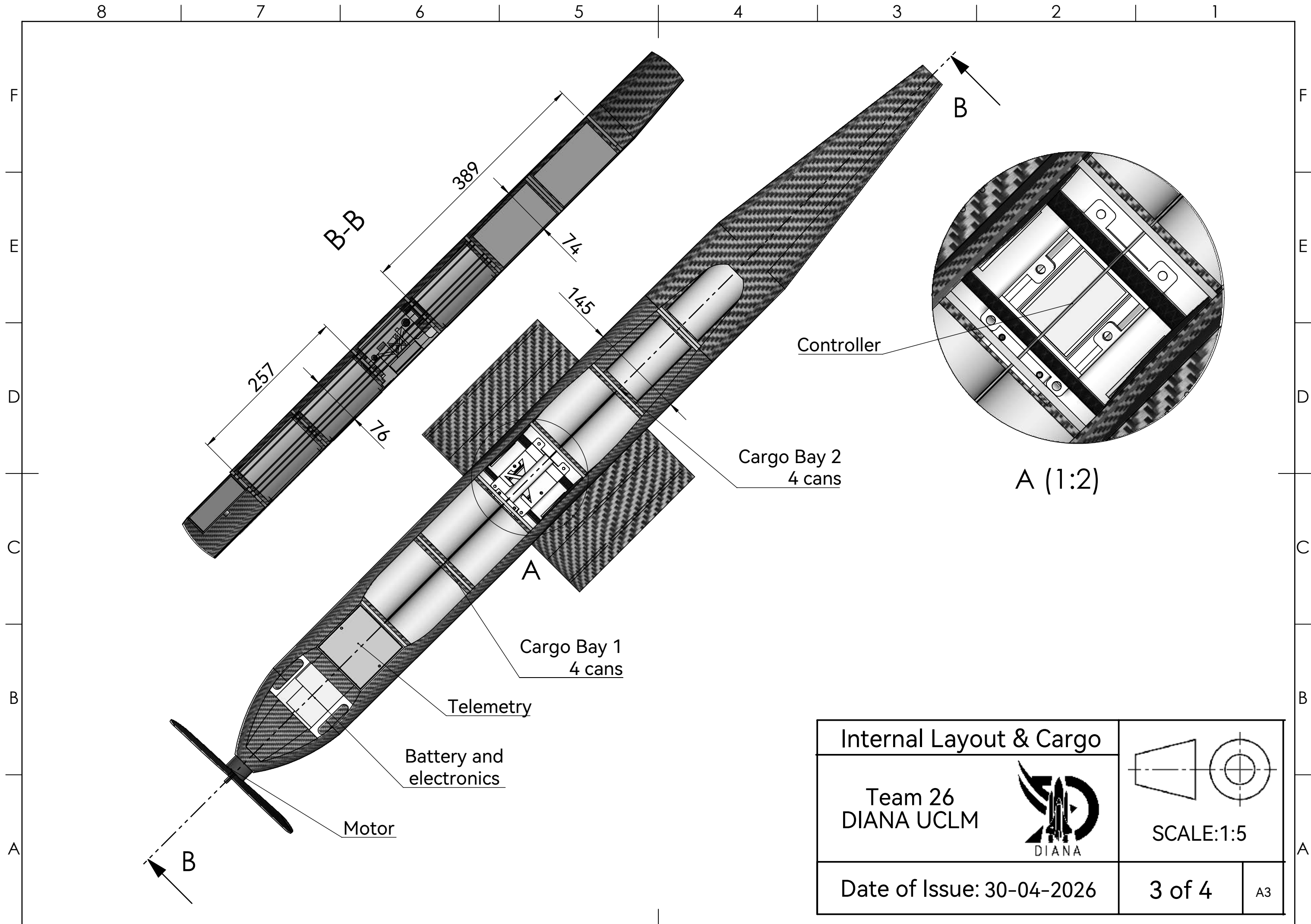
This final section contains the technical drawings of the DIANA UCLM aircraft.

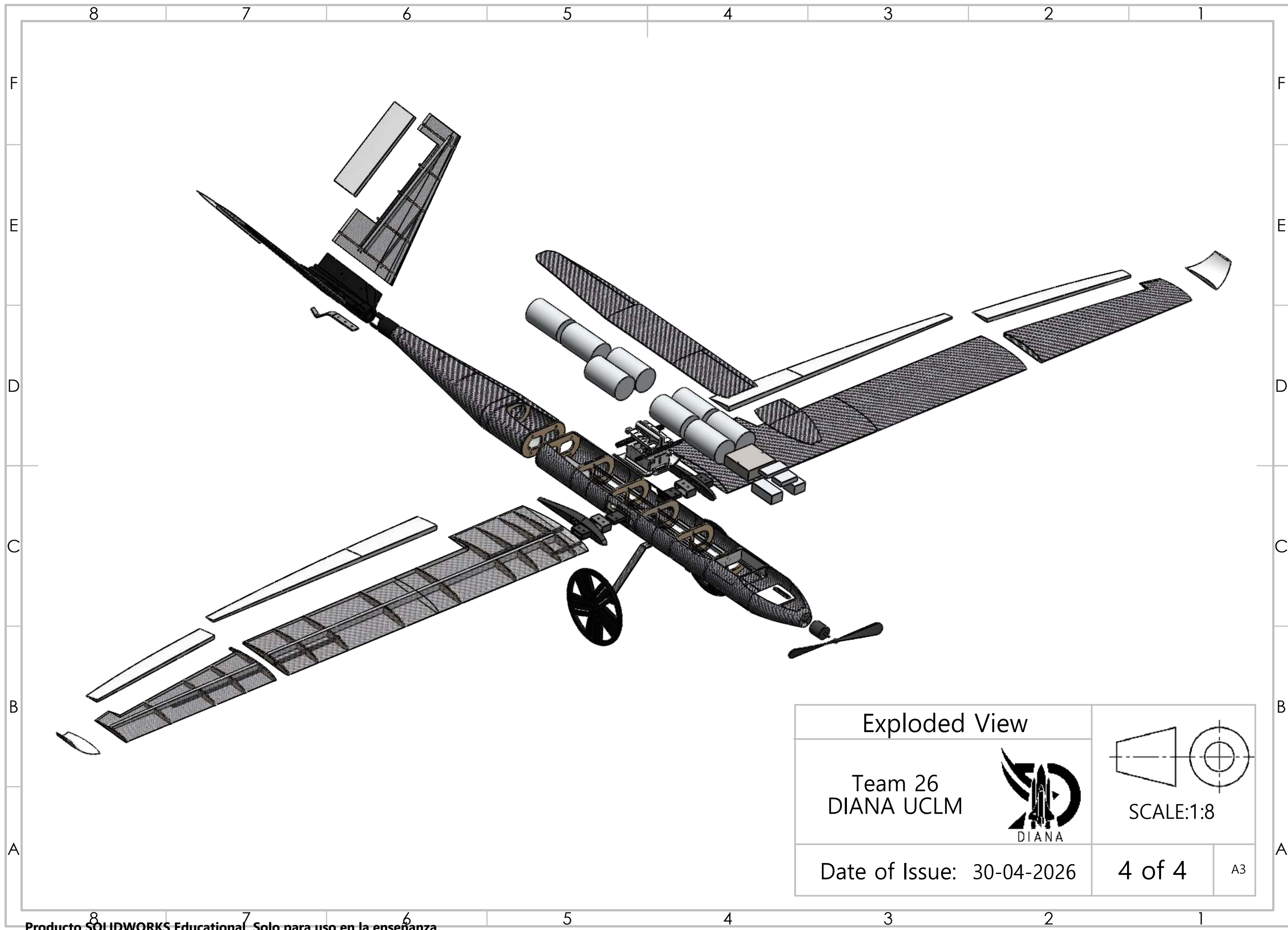
1. 3-view drawing
2. Isometric view
3. Internal layout & cargo
4. Exploded view





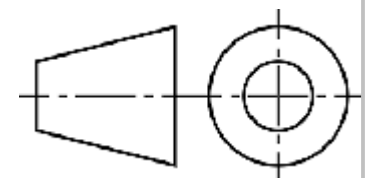
Isometric View			
Team 26 DIANA UCLM		 SCALE 1:10	
Date of Issue: 30-04-2026		2 of 4	A3





Exploded View

Team 26
DIANA UCLM



SCALE:1:8

Date of Issue: 30-04-2026

4 of 4

A3

A. Detailed Aircraft Cost

Table A.1: Manufacturing materials and cost breakdown

Subassembly	Material	Quantity	Unit price (€)	Total (€)
Wings	Carbon Fiber 200g 3k	1.91 m ²	16.89	32.13
	Rohacell 31 IG-F PMI foam core	0.000791 m ³	161.33	32.68
	Carbon Tube 10x8	1 pc.	14.50	14.50
	Carbon Tube 14x12	1 pc.	19.51	19.51
	Carbon Tube 12x10	1 pc.	17.00	17.00
	Carbon Tube 8x6	1 pc.	13.50	13.50
	Balsa Wood 4mm	0.1 m ²	4.20	4.20
	Carbon Roving 12k	120 m	11.05	26.52
	Hinges	10 pc.	0.48	4.77
	LW-PLA	70 g	18.55	1.73
	Aeronautical Wood	0.0225 m ²	2.30	2.30
Empennage	Carbon Fiber 200g 3k	0.274 m ²	16.89	4.63
	Balsa Wood 4mm	0.1 m ²	4.20	4.20
	Carbon Tube 6x5	1 pc.	8.85	8.85
	LW-PLA	40 g	18.55	0.98
	Hinges	4 pc.	0.48	1.91
	Rohacell 31 IG-F PMI foam core	0.042 m ³	161.33	1.74
	Tailskid	3 g	0.18	0.18
Tail-fuselage joint	PACF	250 g	15.25	15.25
Fuselage	Carbon Fiber 200g 3k	1.94 m ²	16.89	32.81
	Aeronautical Wood	0.04 m ²	4.13	4.13
	PACF - LWPLA	400 g	21.55	21.55
Landing gear	Sky-Fly Carbon Fiber	1 pc.	12.33	12.33
	TPU (Wheels)	154 g	2.40	2.40
Other components	Hardware (Screws, Inserts, Washers)	1 set	-	5.00
	Carbon Steel	122 g	0.36	0.36
Resins & sealants	Epoxy Resin IN2	5 kg	96.83	96.83
	Epoxy Glue ET5428 (Twin Tube)	1 pc.	76.00	76.00
	Epoxy Glue ET500 (Twin Tube)	1 pc.	94.50	94.50
TOTAL MANUFACTURING COST				€ 552.49

Table A.2: Electronics and propulsion system cost breakdown

Component	Quantity	Unit price (€)	Total (€)
Servos Hacker/Jeti DITEX EL0315M	6 ud	22.91	137.46
Power Battery ZEE 3S LiPo 330mAh	1 ud	29.00	29.00
Control Battery	1 ud	8.35	8.35
Electronic Speed Controller (ESC)	1 ud	15.90	15.90
Flight Controller Matek H743 wing V3	1 ud	107.00	107.00
Receiver RadioMaster EXPRESS LRSXR1 Nano 2,4GHz	1 ud	13.50	13.50
Radio Transmitter RadioMaster TX16s MKII MAX	1 ud	250.00	250.00
T-Motor AT2814 900KV	1 ud	49.99	49.99
Propeller 13x8	1 ud	6.30	6.30
Servo Linkages (Piano Wire)	6 ud	0.57	3.39
Wiring (Red/Black)	1 ud	5.37	5.37
TOTAL ELECTRONICS COST			€626.26

Table A.3: Total aircraft cost

Category	Subtotal cost (€)
Manufacturing and structures (Table A.1)	552.49
Electronics and propulsion system (Table A.2)	626.26
TOTAL AIRCRAFT BUDGET	€1,178.75