Airframe and Structural Design

Atılım UAV Team · Atılım University — Airframe Subteam Technical Documentation · SUAS 2026

ABSTRACT

The Atılım UAV airframe is a foldable quadcopter structure developed for the 2026 Student Unmanned Aerial Systems (SUAS) competition. Its primary load path combines carbon-fiber tubes, G10 composite plates, and aluminum foldable joints and motor mounts. G10 provides high in-plane stiffness, electrical insulation, and radio-frequency transparency, allowing communication antennas and receivers to remain inside the airframe without significant signal attenuation. The carbon-fiber arms, telescopic landing gear, and hook-and-loop battery mounting support tool-free deployment and rapid field servicing. In transport configuration, the aircraft folds to 13 x 13 x 7.1 inches; in flight configuration, it measures 21.2 x 21.2 x 11 inches. The foldable arm and motor mounts were analyzed in ANSYS under maximum thrust loading, confirming a safety factor of 1.5 against yield.

1 DESIGN CHOICES

The aircraft is a folding multirotor built around two profiled G10 composite plates separated by spacers. Carbon-fiber arms extend from the central structure, and each arm carries an aluminum motor mount and a telescopic landing leg on a foldable joint. Figure 1 shows the aircraft in its deployed flight configuration. Six requirements shaped the structure:

- Low structural mass and clear internal wire routing.
- Radio-frequency transparency around the internal telemetry, RC, and Global Navigation Satellite System (GNSS) components.
- A stiff primary load path from the motor mounts to the main plates.
- Tool-free deployment and rapid field servicing.
- Foldable landing gear that remains stable in both deployed and folded positions.
- A transport envelope that fits the 18 x 14 x 8 inch Personal Item sizing tier.

The selected architecture addresses these requirements through G10 plates, carbon-fiber arms, foldable joints, spring-assisted telescopic landing gear, and a battery secured with hook-and-loop fasteners. The modular arrangement allows damaged arms, landing-gear components, and other critical parts to be replaced without dismantling the complete airframe.

Figure 1. The airframe in its deployed flight configuration, from the CAD model. The carbon-fiber arms and telescopic landing gear are fully extended for flight.

2 CENTRAL FUSELAGE

The central fuselage is formed by top and bottom G10 composite plates held apart by spacers. The plates house the avionics and communication components, while the lower side carries the battery pack and payload module. Thrust loads are transferred from the motor mounts through the carbon-fiber arms and foldable joints to these main plates.

2.1 Plate Geometry and Mass Reduction

Strategic cutouts in both plates reduce mass and simplify internal wire routing. The openings allow power and signal harnesses to pass through the structure instead of being routed around the plate edges. Figure 2 shows the two plate profiles.

2.2 Why G10

G10 was selected for the plates because it provides high in-plane stiffness, excellent electrical insulation, and RF transparency. Unlike metallic materials, G10 has minimal impact on radio-frequency signals, allowing GNSS, telemetry, and RC communication signals to pass through the structure with negligible attenuation. This makes it particularly suitable for mounting antennas and wireless communication components inside the airframe while maintaining reliable signal quality.

2.3 Spacer Columns and Structural Rigidity

Spacers installed between the main plates increase the bending stiffness of the UAV body and help the two plates act as one structural assembly. Figure 3 shows the assembled plate stack and the wiring space created between the plates.

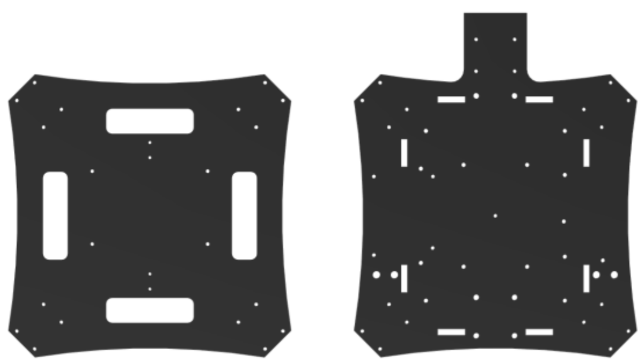

Figure 2. The top and bottom chassis plate profiles. The cutout pattern reduces plate mass and provides routes for internal wiring.

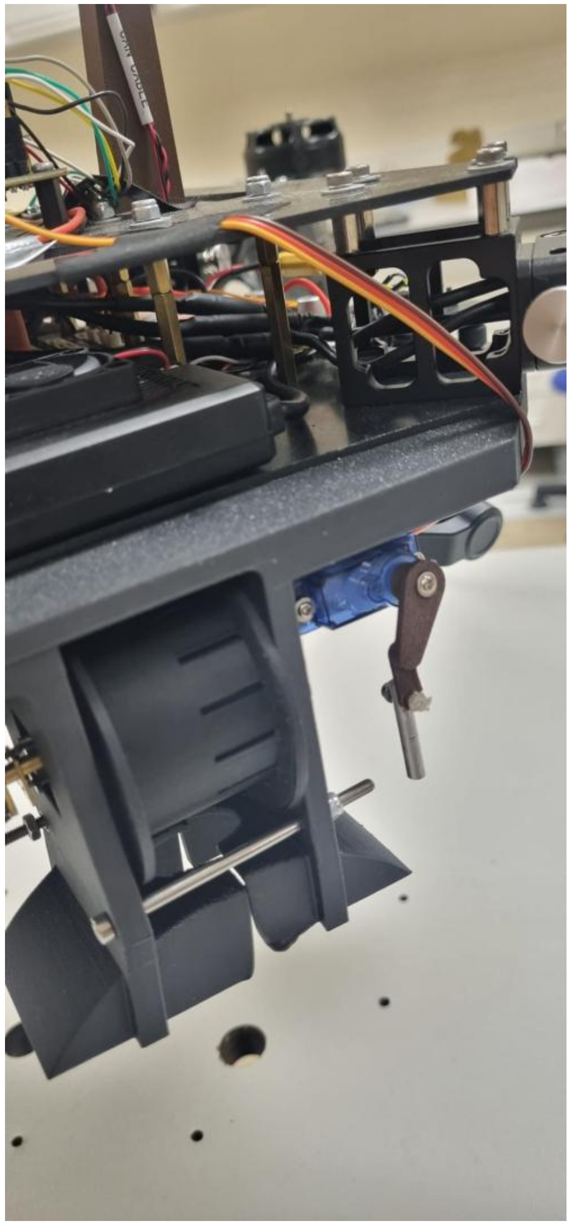

Figure 3. The assembled plate stack. The spacers connect the main plates and create an internal volume for wiring and subsystem installation.

3 FOLDING ARCHITECTURE AND TOOL-FREE ASSEMBLY

The carbon-fiber arms attach to the main structure through foldable joints that lock securely in the flight position and fold inward for transport. The landing gear is inspired by a folding motorcycle side stand. Each telescopic leg is mounted on a pivot near the motor mount, and a spring-assisted mechanism helps maintain the gear in either the deployed or folded position.
The battery pack is secured with hook-and-loop fasteners instead of permanent fixtures. This allows rapid battery replacement while keeping the pack fixed during flight. Together, the folding arms, landing gear, and removable battery mounting allow the aircraft to be deployed and serviced using hands only.

4 MANUFACTURING AND MOTOR MOUNTS

The motor mounts are critical load-transfer components manufactured in house from wrought 6061-T6 aluminum. They are designed for the selected propulsion system and fit the 20 mm carbon-fiber tubes, transferring motor thrust and torque into the primary structure.

Figure 4. The in-house motor mount CAD model. The circular face carries the motor bolt pattern, while the cylindrical interface connects the mount to the 20 mm carbon-fiber tube.

Table 1. Airframe materials and the main reason for each selection.

Item	Material or mechanism	Selection basis
Main plates	G10 composite laminate	High in-plane stiffness, electrical insulation, and RF transparency
Inter-plate spacers	Structural spacers	Increase plate-stack stiffness and maintain internal separation
Main arms	20 mm carbon-fiber tubes	Low-mass primary load path
Arm joints	Foldable locking joints	Tool-free deployment and individual arm replacement
Motor mounts	Wrought 6061-T6 aluminum	Transfer motor thrust and torque into the carbon-fiber arms
Landing gear	Telescopic, pivoted, spring-assisted mechanism	Stable deployed and folded positions
Battery mounting	Hook-and-loop fasteners	Rapid replacement without permanent fixtures

5 STRUCTURAL SIMULATION AND FATIGUE ASSESSMENT

To validate the structural integrity of the foldable arm and motor mounts under operating loads, the components were analyzed in ANSYS under the thrust loading generated during flight. Static analysis confirmed that the foldable arm and motor mounts maintain a safety factor of 1.5 against yield under maximum thrust load. The repeated stress introduced by motor operation and the folding and unfolding cycles was also considered to assess durability over repeated competition use.

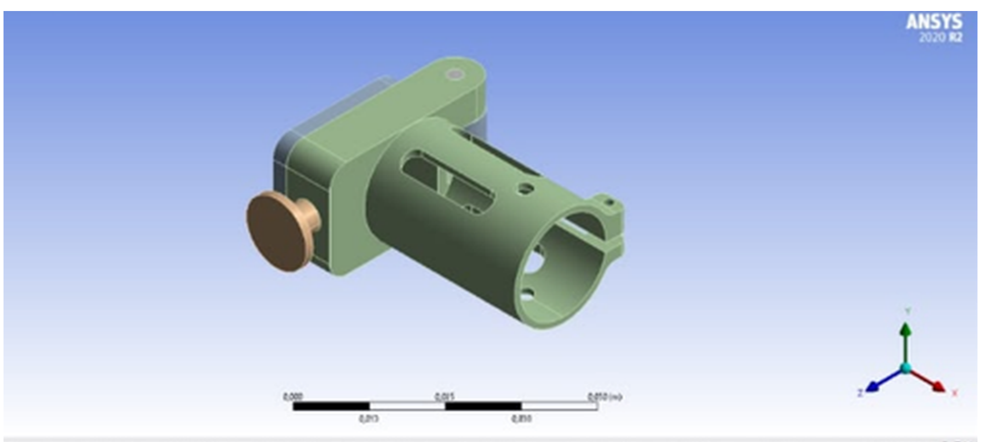

Figure 5. Foldable arm and motor mount assembly as modeled in ANSYS, using wrought 6061-T6 aluminum.

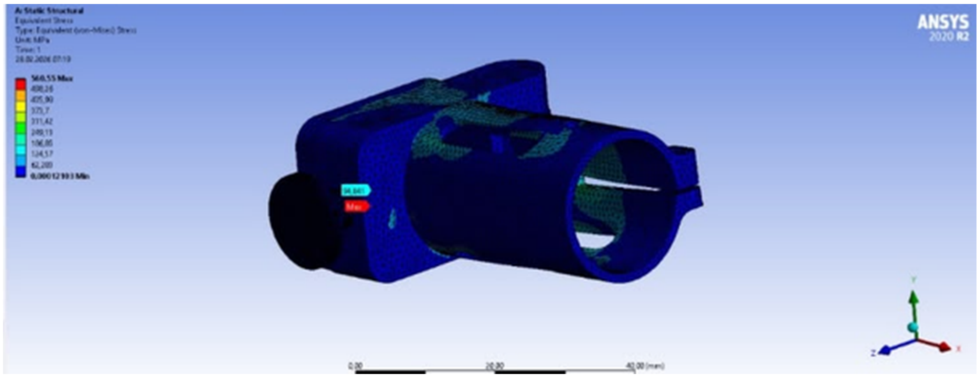

Figure 6. Equivalent von Mises stress on the foldable arm and motor mount assembly under maximum thrust load.

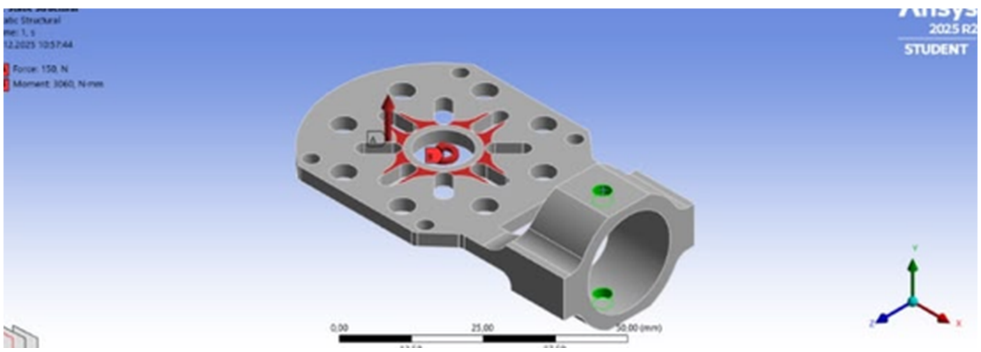

Figure 7. Motor mount plate load case: a 150 N thrust force and the accompanying 3060 N mm moment.

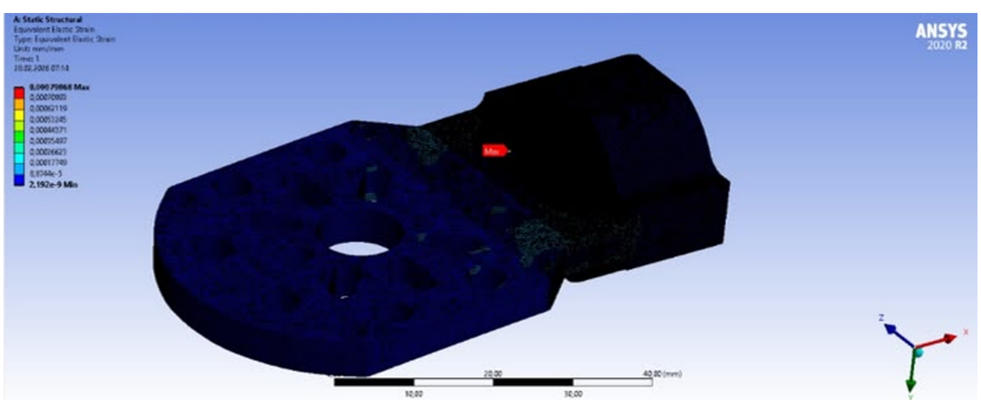

Figure 8. Equivalent elastic strain on the motor mount plate under the same load case.

6 TRANSPORT CONFIGURATION AND VEHICLE ENVELOPE

In flight configuration, the aircraft measures 21.2 x 21.2 x 11 inches. For transport, the arms and landing gear fold inward, reducing the envelope to 13 x 13 x 7.1 inches. This fits within the 18 x 14 x 8 inch Personal Item sizing tier. The aircraft can be unpacked from this state and prepared for flight in approximately three minutes using hands only.

Figure 9. The aircraft folded for transport. The carbon-fiber arms and telescopic landing gear are retracted to produce the 13 x 13 x 7.1 inch transport configuration.

The structural and modularity choices were made against the fixed mass budget summarized in Table 2. The 5.9 kg dry mass and 6.7 kg operational mass remain below the 11 kg maximum takeoff weight, leaving capacity for both payloads and the required battery system.

Table 2. Vehicle mass and performance summary.

Parameter	Value
Dry weight (no payload)	5.9 kg
Operational weight (both payloads)	6.7 kg
Maximum takeoff weight	11 kg
Maximum horizontal speed	18 m/s
Maximum vertical speed	5 m/s
Flight endurance (operational weight)	~30 min
Maximum flight range	32 km