

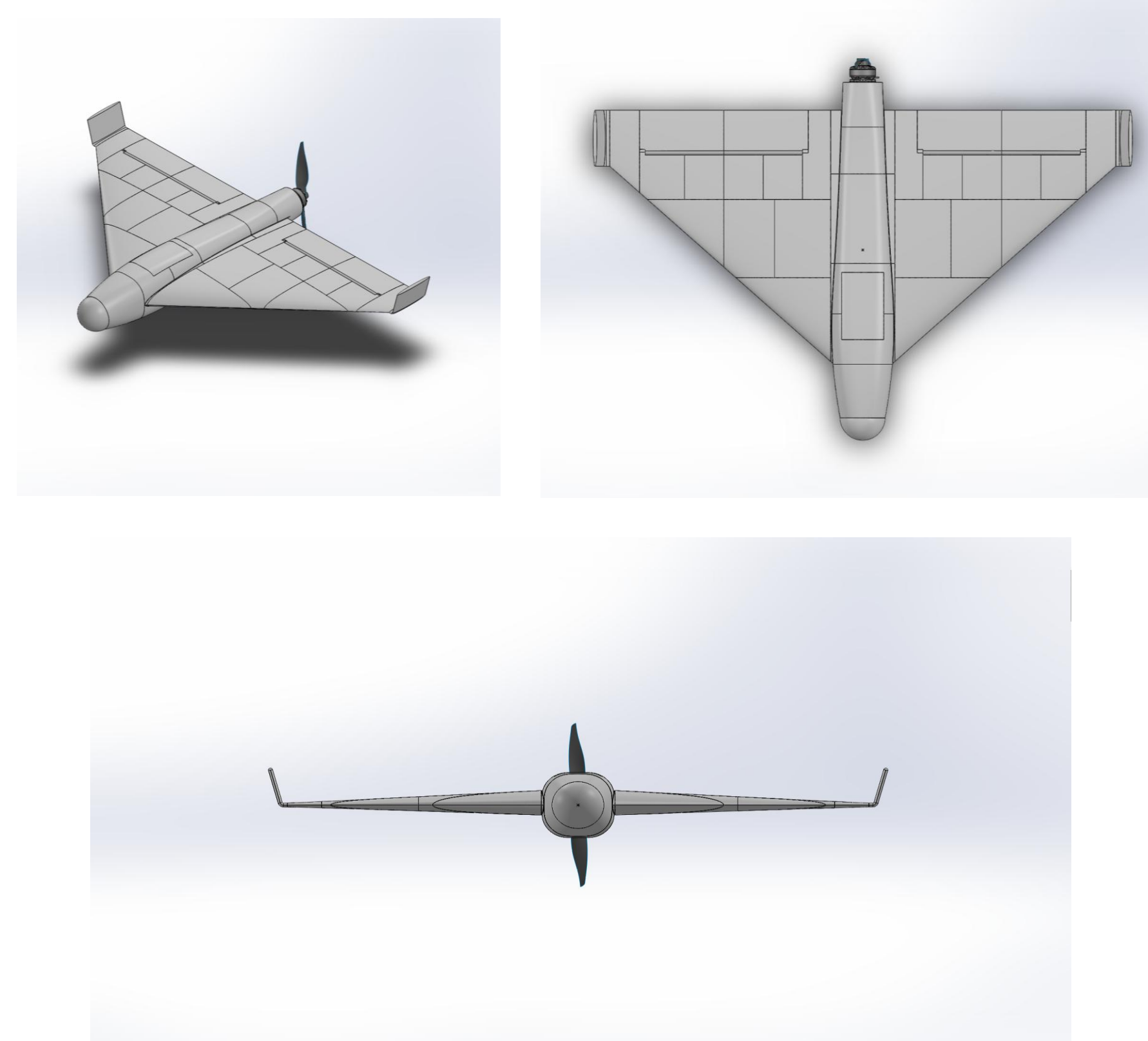
## Abstract

This project presents the design and evaluation of an unmanned aerial vehicle intended for extended-endurance flight while carrying a medical payload. The goal was to create a lightweight, efficient, and manufacturable fixed-wing platform that integrates aerodynamic performance, structural integrity, and reliable onboard systems. Multiple concepts were evaluated before selecting a final compact configuration with an estimated takeoff weight of 1.65 kg, a 0.96 m wingspan, and a thrust-to-weight ratio of approximately 1.21. Aerodynamic tools were used to study airfoil behavior and guide the wing design, while additive manufacturing studies were performed to improve tolerances, reduce mass, and assess material suitability. Electronics integration included the flight controller, servos, GPS-related hardware, and supporting wiring. In addition, material characterization and ASTM-based testing methods were incorporated to support future structural validation. The result is a feasible UAV prototype and a design process that supports future endurance and medical-delivery testing.

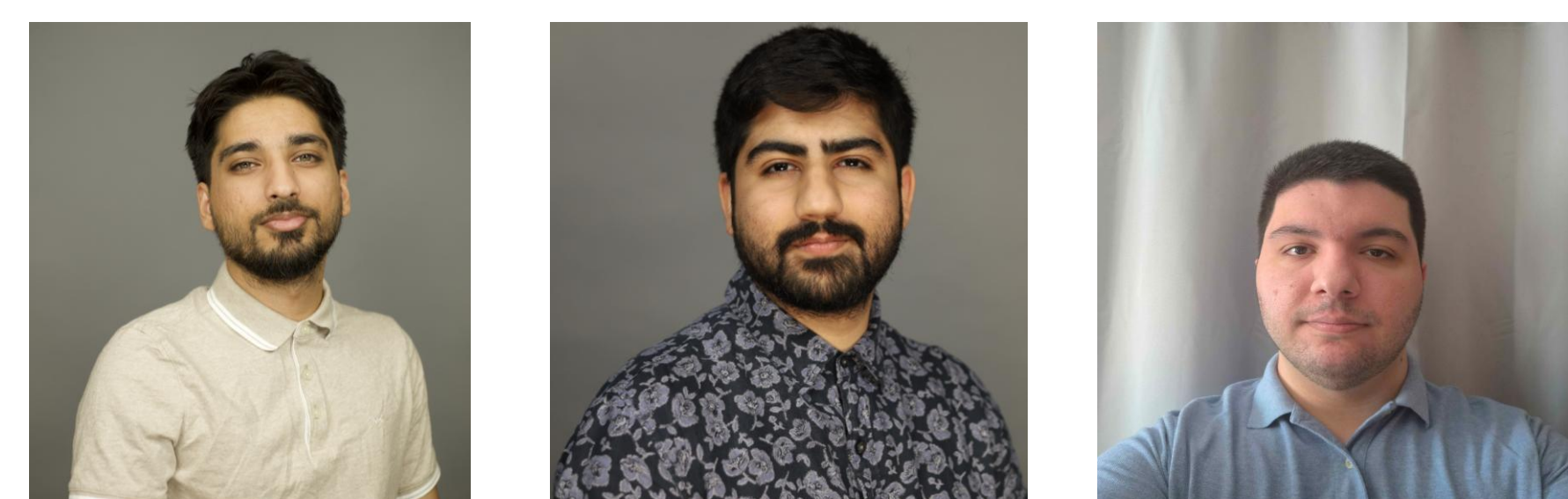
## Mission Objectives

- ❖ Develop an efficient fixed-wing UAV for extended endurance
- ❖ Safely transport a medical payload
- ❖ Reduce weight and power demand through optimized design
- ❖ Integrate key onboard systems for stable operation
- ❖ Evaluate performance using analysis and experimental testing

## Design



## Our Team



**Mujib Sarwari**  
Manufacturing Lead  
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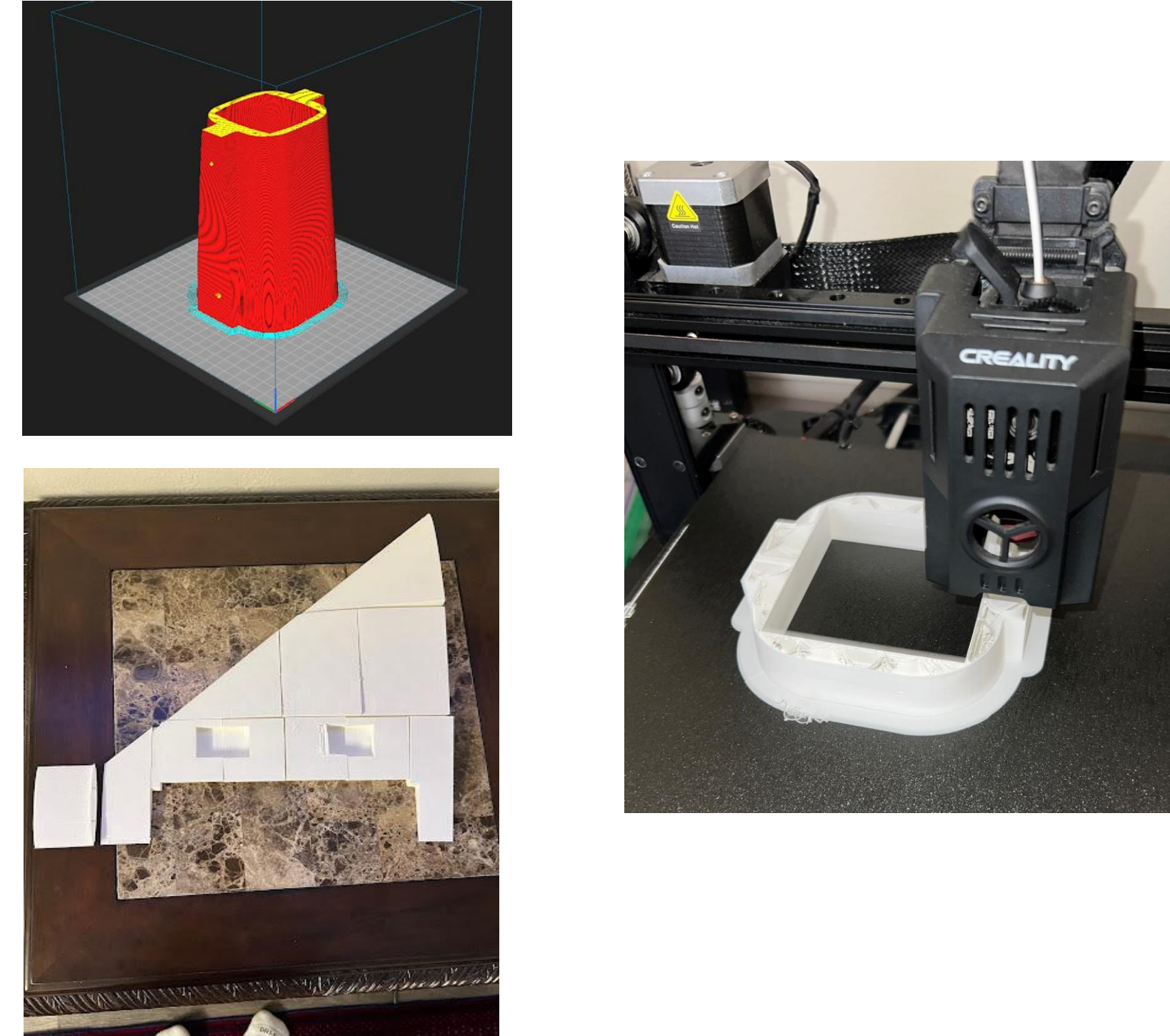
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Manufacturing Lead  
Materials Scientist

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CAD Designer

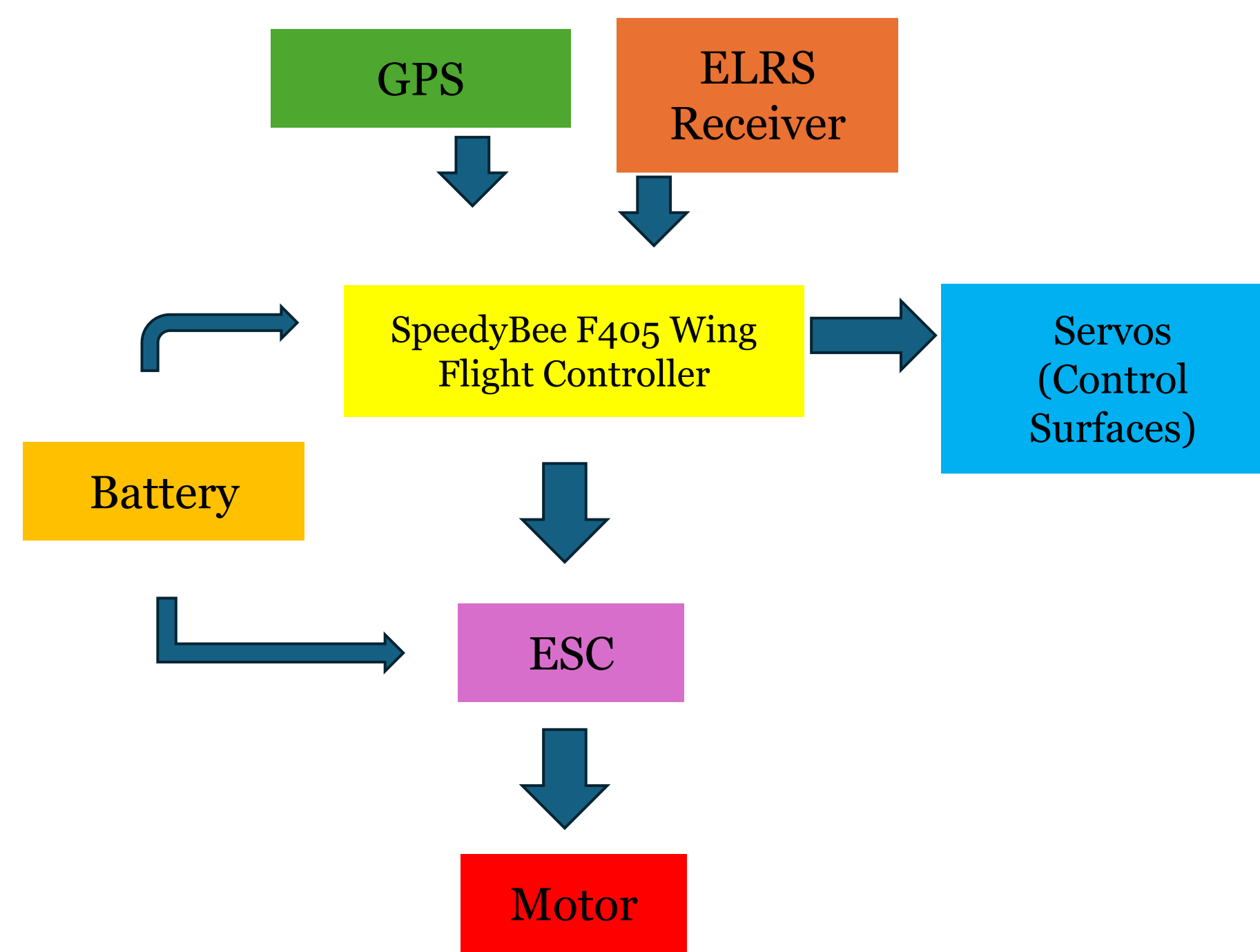
## Manufacturing and Assembly

The fuselage and wing sections were printed separately and assembled into the final aircraft configuration, allowing the team to move from CAD development to a physical prototype. The manufacturing phase focused on producing a lightweight structure while maintaining enough geometric consistency for successful fit-up and integration. After the main airframe was assembled, key onboard hardware was incorporated, including the flight controller, receiver, GPS module, servos, wiring, and connector hardware. Pushrods were also added to link the control surfaces to the servo system and enable actuation for later testing.

On average, print time was reduced by approximately **6.6%**, with a maximum reduction of nearly **30%** observed for specific geometries.



## Block Diagram



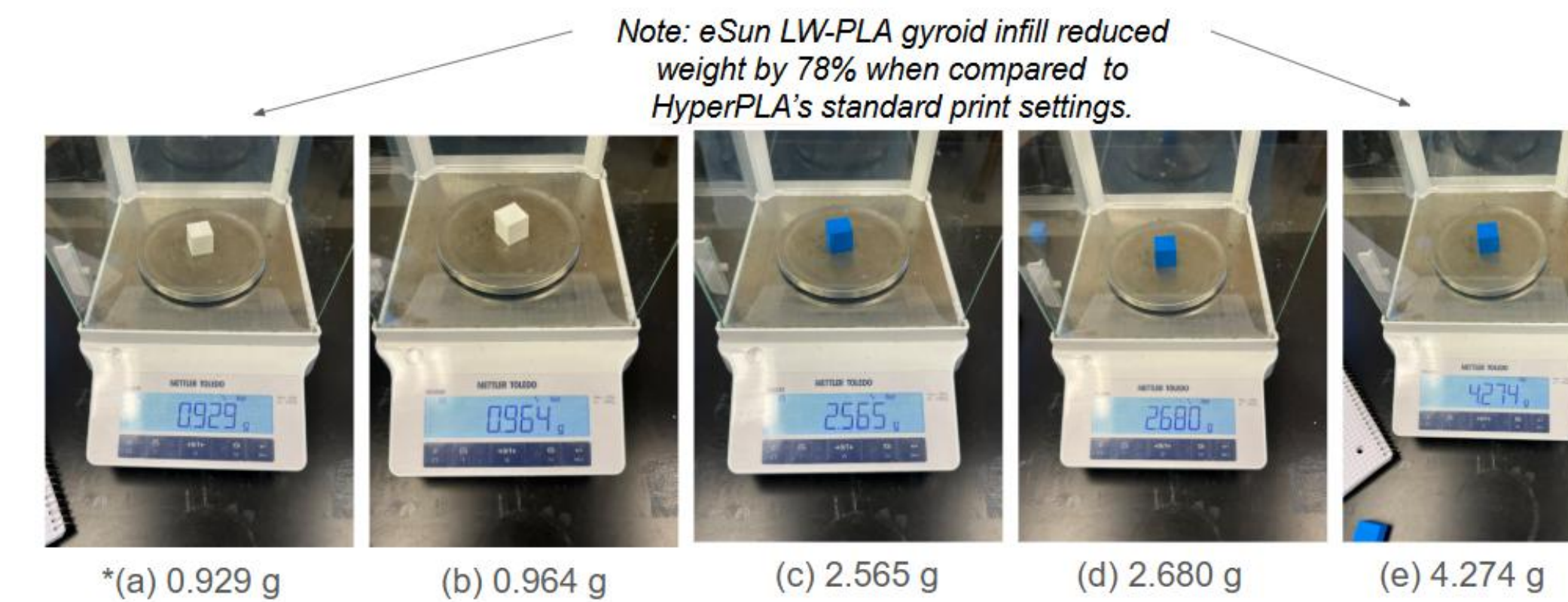
## Acknowledgements

The authors would like to express their sincere gratitude to **Professor Roni Goldshmid** of the SDSU Department of Aerospace Engineering for her guidance and support throughout this project. We also thank **Dr. Margherita Capriotti** from the Non-Destructive Evaluation (NDE) Research Clinic for granting access to ultrasonic testing equipment, and **Nilay Kanova Dogan**, Teaching Assistant in the Department of Chemistry & Biochemistry, for providing access to the Mettler Toledo Precision Balance ME303E for precise mass measurements. Special thanks to **Dr. Samuel Kassegne**, Principal Investigator of the **NanoFab.SDSU** lab, for access to the **Instron 5543A (1 kN capacity) testing machine with Advanced Video Extensometer (AVE)**. We also acknowledge **Dr. Hamid Nourollahi**, **Mr. Greg Morris**, and teaching assistants **Carson Sutton** and **Mohamed Ibn Bayasi** for their support and access to the **Instron 3385H 250 kN Dual Column Universal Testing Machine** with clamp-on strain measurement capabilities. Finally, we thank **Dr. Khaled Morsi**, Principal Investigator of the **Advanced Materials Processing Lab (SDSU AMPL)**, for his guidance on applying the **ASTM D638 standard** for tensile testing of plastics.

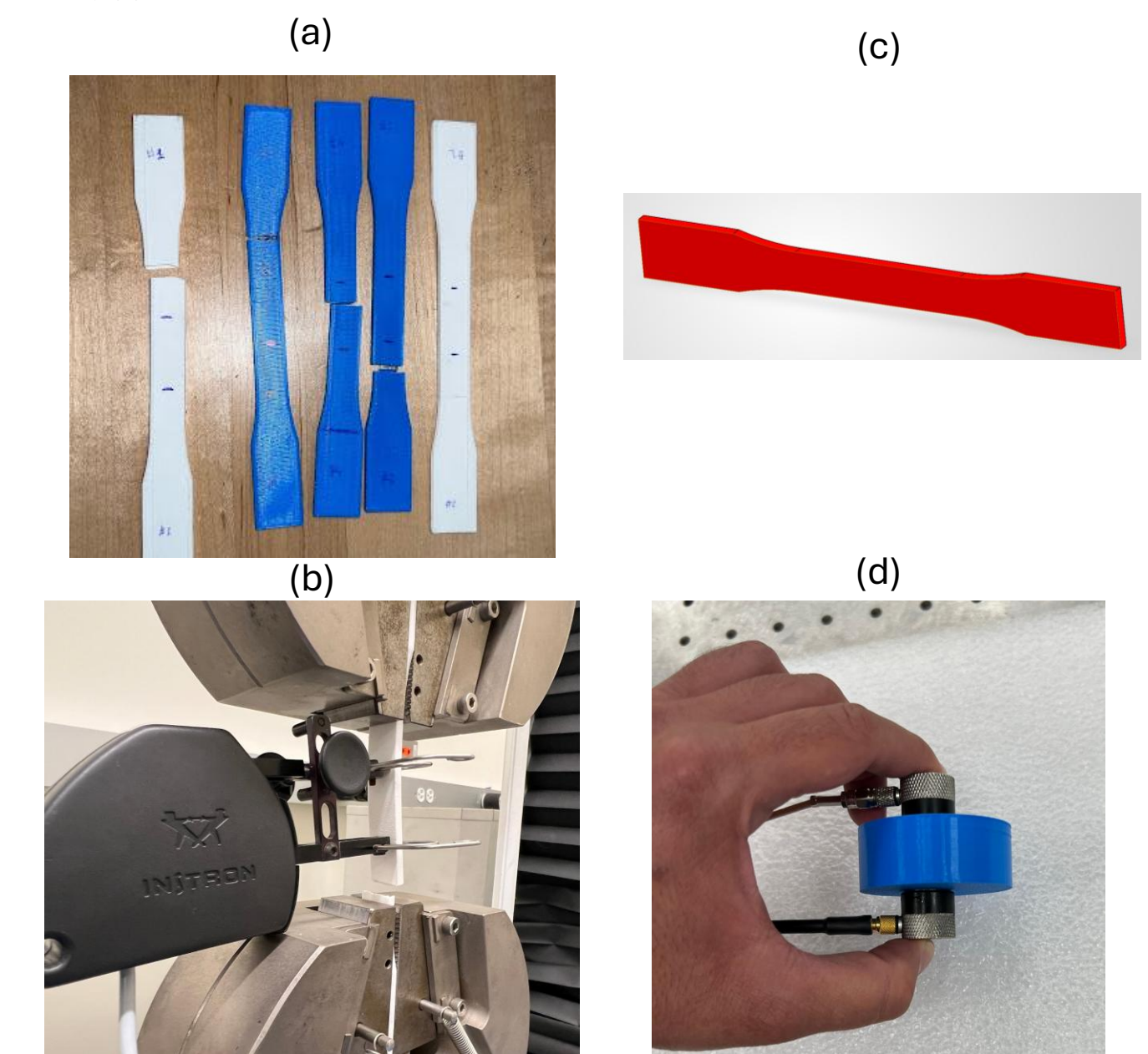
## Materials Characterization

Material characterization was performed to evaluate the suitability of 3D-printed materials for lightweight UAV structures. ASTM D638 tensile testing was used to measure tensile strength, modulus, and strain at failure, while ultrasonic non-destructive evaluation (NDE) was used to assess internal quality and consistency. The results supported material selection by balancing structural performance, manufacturability, and low mass.

## Materials Characterization (Density)

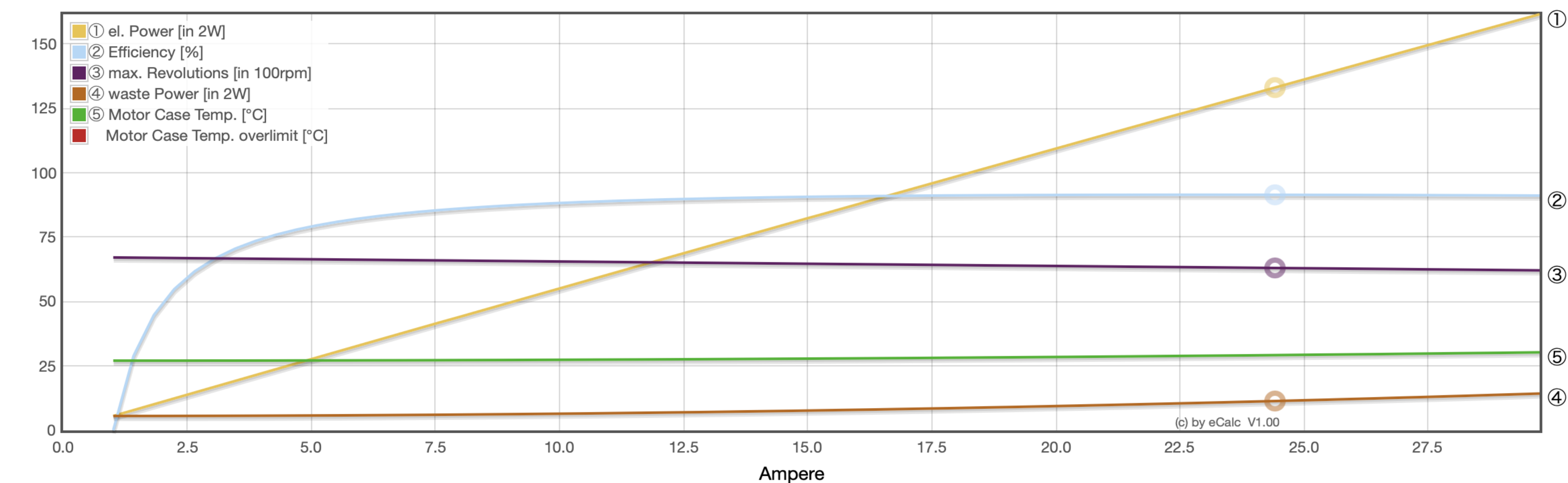


**Fig 1 (a) \*LW-PLA gyroid 3% infill. (b) LW-PLA cubic subdivision 3% infill. (c) Creality Hyper PLA gyroid 3% infill. (d) Cubic Subdivision 3% infill (e) Cubic 20% infill (standard settings).**

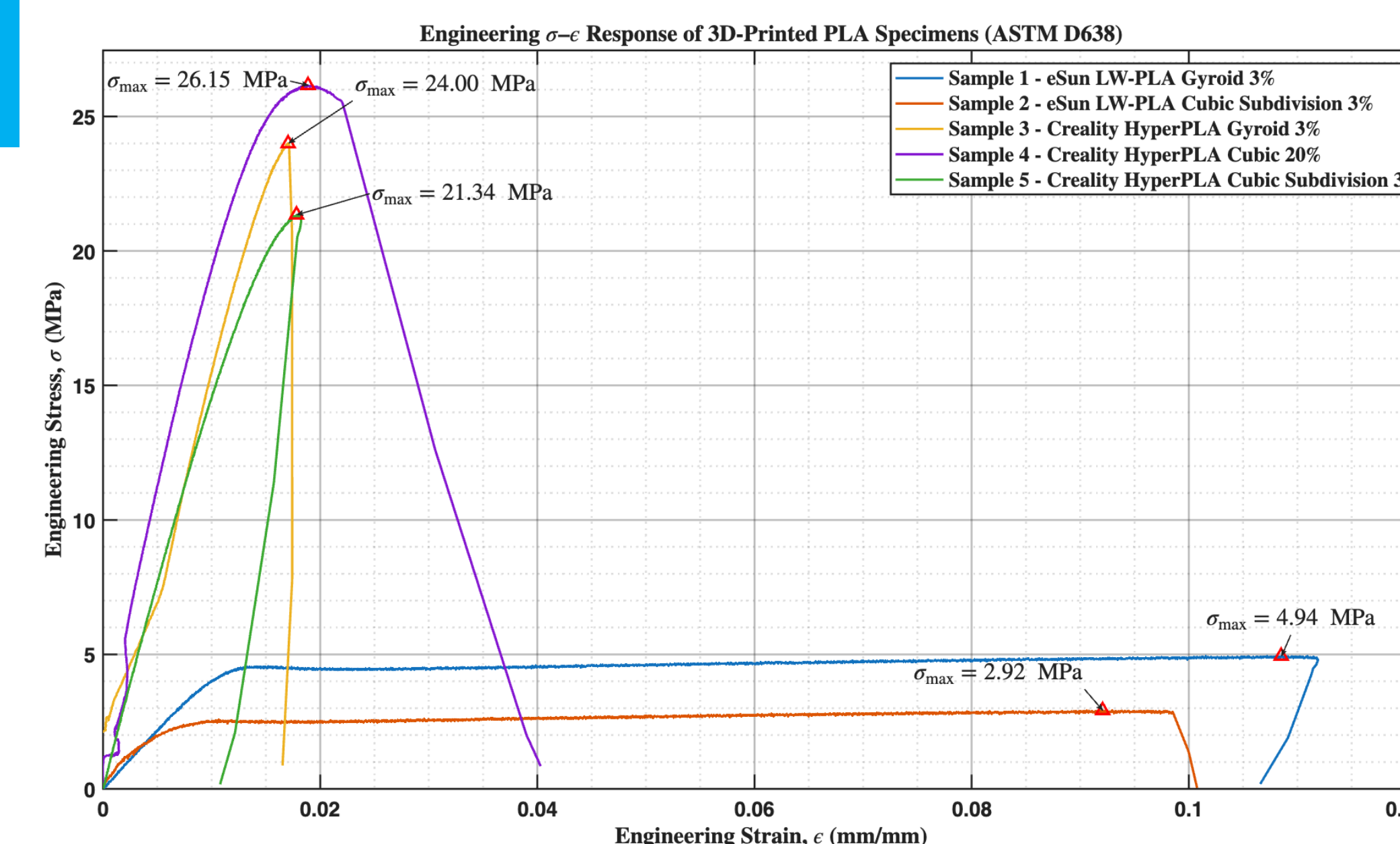


**Fig. 2 (a) Post-experimentation (tensile testing). (b) Instron 3385H tensile experimentation. (c) ASTM D638 Type I dog bone specimen. (d) NDE testing with ultrasonic transducers.**

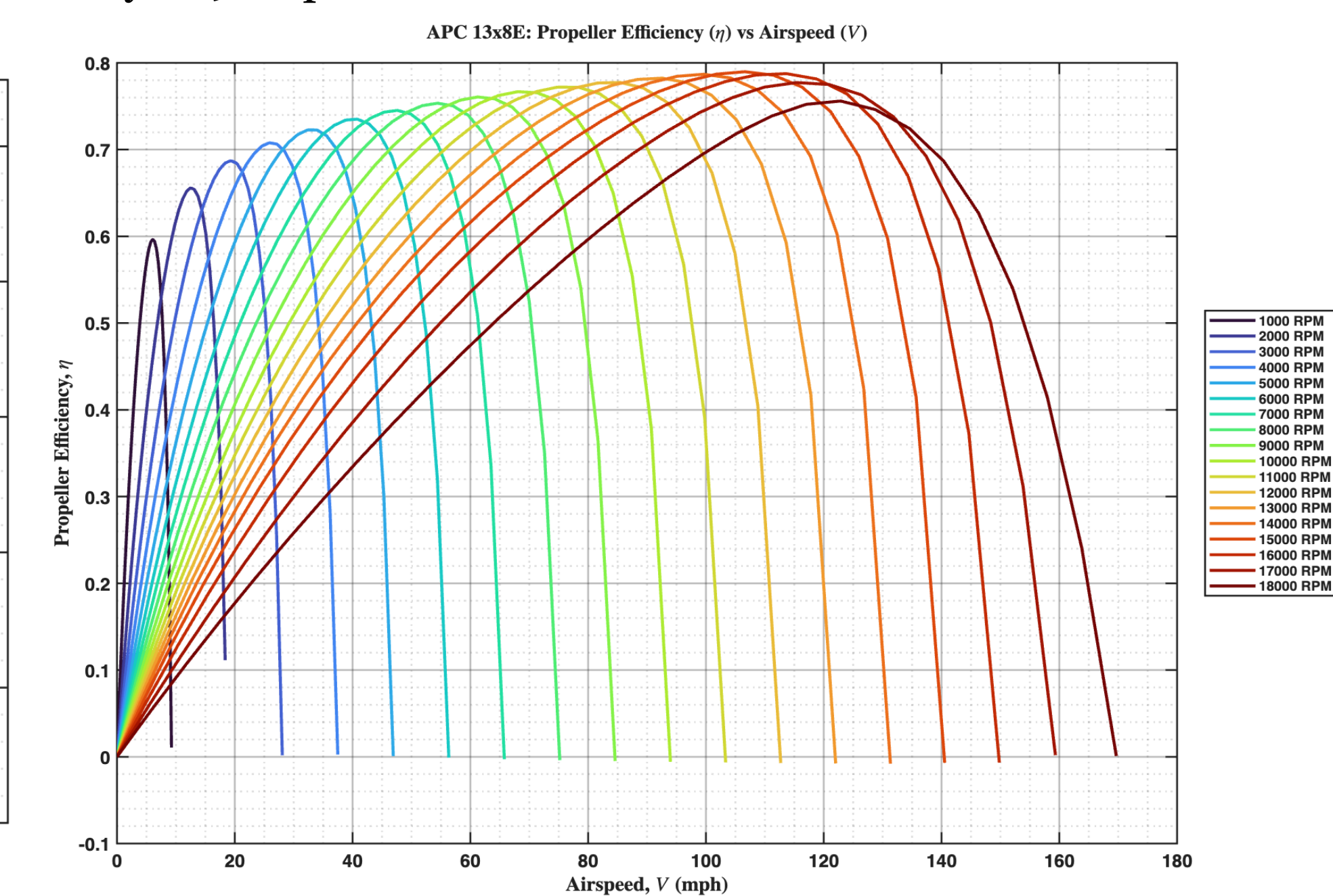
## Results



**Fig. 3** At peak performance, the motor reached about 6298 RPM, drew 24.6 amps, used about 270 watts of power, and operated at about 10.94 volts with an efficiency of 91.8 percent.



**Fig. 4** Engineering stress-strain response of 3D-printed PLA specimens according to ASTM D638 standards.



**Fig. 5** APC 13x8E Propeller efficiency vs airspeed graph at varying RPMs.

In **Figure 4**, LW-PLA and HyperPLA with 3% gyroid infill show similar initial behavior, but HyperPLA fails in a brittle manner while LW-PLA exhibits greater ductility and sustained deformation. The gyroid infill sustained higher stresses while allowing greater strain compared to cubic subdivision patterns in both materials. Therefore, LW-PLA with 3% gyroid infill was selected for its lightweight structure and superior performance among the low-density specimens.

In **Figure 5**, The efficiency curves show that propeller efficiency increases with airspeed to a peak before decreasing at higher velocities for each RPM. Increasing RPM shifts the peak efficiency to higher airspeeds while maintaining similar maximum efficiencies (~0.75–0.78). Compared to the 12×10E, the 13×8E provides improved low-speed efficiency and thrust due to its larger diameter and lower pitch, making it better suited for lower power consumption and higher lift generation.