

## Motivation & Purpose

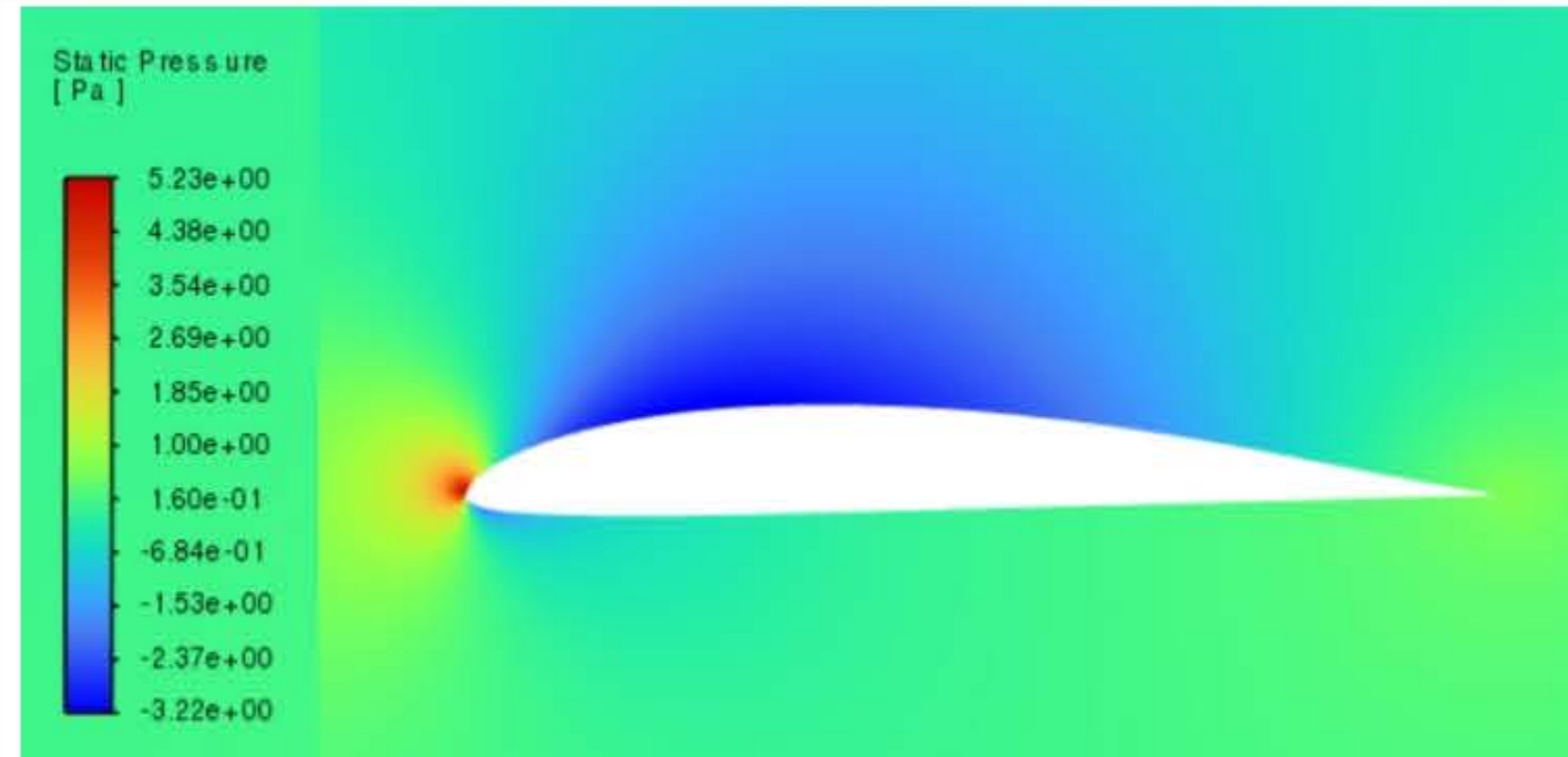
The performance of fixed-wing Vertical Takeoff and Landing (VTOL) Unmanned Aerial Vehicles (UAVs) is influenced by the ability to transition between hover and forward flight, where lift shifts from the rotors to the wings and the system becomes more sensitive to control and power demands. The goal of this project is to understand how the system performs during this transition phase and how it affects overall efficiency and endurance. Designed for search- and-rescue missions, it excels in multiple flight modes. In horizontal flight, the drone can travel long distances quickly while efficiently scanning large areas. In hover mode, it can loiter over specific locations, conduct detailed searches, and maneuver into hard-to reach areas with precision. This adaptability significantly enhances search- and-rescue operations, reducing response time, conserving resources, and ultimately helping save lives. The versatility also makes it suitable for applications such as area mapping, infrastructure inspection, and post-disaster assessment, where both endurance and maneuverability are critical.

## Design



The UAV body was modeled after a NACA 2415 airfoil to reduce fuselage drag and provide additional aerodynamic lift during forward flight. This is useful for us because we transition from hover to cruise, where streamlined geometry improves efficiency and stability. The 15% airfoil thickness also provides internal volume for electronics and structure while maintaining a smooth aerodynamic profile. This system is built around a F405 flight controller running INAV, which handles stabilization and control. For propulsion, we are using ECO II 3115 brushless motors driven by a 70 amp 4-in-1 ESC. The system is powered by a 6S 6000 mAh LiPo battery. We also use a high torque servo for the tilt control mechanisms. Most of the airframe is 3D printed using PLA. We kept prints light by using two walls with about 5% gyroid infill. To make up for the low infill, we added carbon fiber spars, which provide the main structural strength and stiffness for the wings and tail. For assembly, CA glue and epoxy was used, where epoxy was used for attaching the tail section to the fuselage. We also designed built in channels for wiring, which helps keep everything organized, protected, and more aerodynamic.

## Computational Simulation



This figure shows a computational fluid dynamics (CFD) simulation of the S7055 airfoil performed in ANSYS. The contour represents static pressure distribution around the airfoil. As airflow approaches the leading edge, a high-pressure region forms, where the flow stagnates. Over the top surface, the flow accelerates, creating a low-pressure region that generates lift. The pressure gradually recovers toward the trailing edge. The S7055 airfoil was selected due to its strong performance at low Reynolds numbers, making it well suited for UAV applications. Its geometry promotes stable lift generation and good efficiency during forward flight.

## Results & Future Work

From the initial design phase, the predicted takeoff mass of the UAV was approximately 2.2 kg; however, due to design changes and material additions, the final mass increased to about 6.3 kg. This increase in weight, without changes to the propulsion system, reduced the thrust-to-weight ratio below 1, preventing vertical takeoff. As a result, the system was unable to generate sufficient lift to overcome its own weight during testing. Although takeoff was not achieved, ground testing confirmed stable yaw behavior and proper rotor tilting, indicating that the control system and mechanical design performed as expected under powered conditions. The propulsion system also showed consistent motor response during spool-up, with no major instabilities observed. Additionally, the estimated center of gravity was located near the wing quarter-chord, which is consistent with a stable aircraft configuration and supports the validity of the aerodynamic design. These observations suggest that the primary limitation of the system was not due to instability or poor aerodynamic performance, but rather the imbalance between system mass and available thrust. Overall, the results demonstrate that the design approach is viable, and future work will focus on reducing structural mass and improving propulsion efficiency.

## Experimental Setup



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## References

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