

VECTOR V1: Development of a Long-Range UAV with Three-Engine Thrust Vectoring for VTOL

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1. Project overview

The project developed an electric unmanned aerial vehicle (UAV) combining vertical take-off and landing (VTOL) with fixed-wing forward flight. Two motors are mounted on the wings and a third on the tail. Servo-operated mechanisms rotate the motor–propeller assemblies from vertical lift to forward thrust. A blended-wing-body airframe supports wing-borne flight, allowing the same three propulsion units to serve both operating modes.



2. Comparison with a conventional drone



Feature	Conventional multirotor drone	Developed tri-rotor VTOL UAV
Propulsion layout	Typically four or more fixed-axis rotors	Three tilting motor–propeller assemblies
Lift in forward flight	Rotors continuously provide the lift required to remain airborne	Fixed wing progressively supports lift after transition
Forward movement	Aircraft tilts to direct rotor thrust horizontally	Motors tilt forward; wing and control surfaces support cruise
Mission suitability	Hovering and local inspection tasks	Vertical access combined with extended forward-flight missions
Design trade-off	Simpler fixed motor mounts; continuous rotor-lift demand	Potential cruise-energy benefit; added tilt mechanisms and transition control

3. Background and objectives

The project aimed to develop a lightweight aircraft combining runway-independent operation with efficient forward flight. Development covered motor tilting, aerodynamic and dynamic analysis, prototype fabrication, and experimental demonstration of vertical lift and transition.

4. Innovation and technical contribution

The design integrates tilting propulsion, a lightweight printed airframe, avionics and configurable flight control into a functioning aircraft. The Falcon V2 airframe configuration was adapted through the integration of motor mounts, tilting mechanisms and onboard systems. The engineering contribution encompasses mechanical design, additive manufacturing, electrical integration, aerodynamic and dynamic modelling, controller tuning and experimental demonstration.

Design, Fabrication and Control

One propulsion system for vertical lift and forward travel

5. Prototype configuration

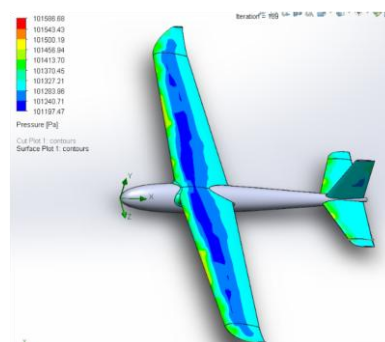
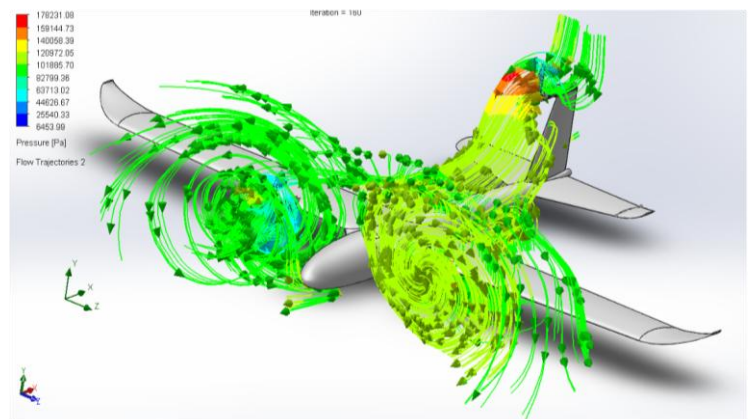
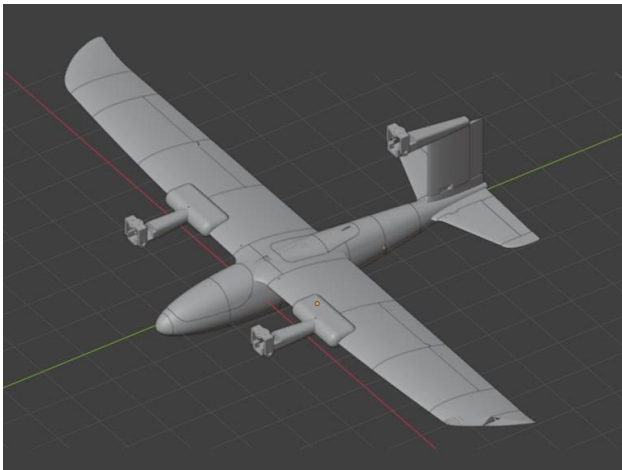
Mass	2.75 kg, Payload – 1kg
Propulsion	Three Hobbywing XRotor 2812, 1100 KV motors; Mamba F65 ESC
Power system	6S LiPo battery; nominal voltage: 22.2 V
Control and navigation	Matek H743-WING; ArduPilot; ELRS receiver and GPS
Actuation	Emax ES3054 tilt servos; ES08MAII control-surface servos
Airframe construction	LW-PLA, PLA+ and PETG; carbon-fibre/aluminium reinforcement
Max Cruise-speed	200 km/h
Endurance target	90–120 minutes; depends on the battery and wind condition

6. Development method

Concept selection and mechanical design. Three candidate concepts were compared using a weighted matrix covering mass, processing capability, power-to-weight ratio, mechanical reliability, energy storage and manufacturing ease. The selected concept scored 8.65/10. CAD work in Fusion 360 and SolidWorks supported the airframe adaptation, rear motor mount and tilting mechanisms.

Fabrication and integration. The airframe was produced using FDM 3D printing on a Creality K1 Max. Lightweight PLA formed the main aerodynamic surfaces, with PLA+ and PETG used for functional or more demanding parts. Internal carbon-fibre and aluminium rods reinforced the printed sections. Propulsion, servos, flight controller, receiver and GPS were then integrated into the aircraft.

Analysis and flight control. SolidWorks Flow Simulation examined airframe pressure and airflow, rotor downwash and forward-flight propeller wakes. XFLR5 aerodynamic data supported MATLAB state-space models of hover and cruise. The 12-state model indicated a need for active hover stabilisation and greater aerodynamic damping in cruise. The prototype used ArduPilot's flight-control framework and PID tuning through Mission Planner; adaptive control and engine-failure recovery remain development objectives.



Experimental Results and Project Significance

Flight testing, practical applications and further development

7. Testing and demonstrated results

Testing progressed from ground levelling checks to VTOL hover and horizontal-flight trials. The first hover trial showed attitude oscillations, delayed yaw response and poor altitude holding. The first horizontal-flight trial also exposed substantial attitude disturbances during transition. These observations informed controller tuning, compass calibration, centre-of-gravity adjustment and investigation of rear-motor heating.

Following control-system refinement, the second VTOL test demonstrated reduced roll and pitch oscillations and improved yaw tracking. The second horizontal-flight test showed closer agreement between commanded and measured roll angles, indicating improved lateral stability. The aircraft successfully transitioned from vertical lift to wing-borne forward flight. These results demonstrate the functionality of the propulsion-tilting mechanism and integrated control system, with flight-log analysis confirming improved attitude tracking following tuning.



8. Practical value and further development

Potential applications include **military drones, search and rescue, aerial inspection, environmental monitoring and lightweight delivery to locations with restricted access**. Local additive manufacturing allows components to be revised and reproduced during development, while commercially available electronics and an open-source autopilot support further experimentation. Payload capability and operational suitability require mission-specific testing.

Further development will focus on repeated transition and landing trials, endurance and energy-use measurement, payload evaluation, adaptive control and emergency recovery. Dedicated testing will establish long-range mission performance and assess single-engine-failure recovery.

9. Conclusion

The project delivered a fabricated and flight-tested tri-rotor VTOL UAV, demonstrating vertical lift and transition to fixed-wing forward flight. Its integration of a shared tilting propulsion system, lightweight construction and configurable flight control provides a practical foundation for developing an aerial platform capable of runway-independent operation and extended forward-flight missions.

