VTOL Ducted-engine drone

Carolina SkyLab

Week 1 Concept Lock and Safety Baseline

By the end of Week 1, all of the following conditions must be satisfied.

- Vehicle configuration is frozen including thrust vector layout and stabilization concept.
- Primary flight mode is defined as stabilized attitude with pilot commanded throttle.
- Control authority is defined as thrust magnitude plus gimbal pitch and yaw only.
- Mass budget spreadsheet exists with target all up mass and contingency margin.
- Safety rules are written covering arming, disarming, battery handling, and test conduct.
- Kill switch behavior is defined and hardware is selected.
- Test progression is frozen as bench testing, static thrust, tethered hover, then free hover.
- A single technical authority is assigned final go or no go decision power.

Week 2 System Architecture and Procurement Freeze

By the end of Week 2, all of the following conditions must be satisfied.

- Flight controller model is selected and ordered.
- Radio control system is selected and ordered.
- EDF units, ESCs, batteries, and chargers are selected and ordered.
- Gimbal actuator type is selected and ordered.
- Power architecture is finalized including voltage, current limits, and protection.
- Signal architecture is finalized including PWM, digital motor control, and serial buses.
- Complete wiring diagram exists including kill switch integration.
- Initial CAD layout exists showing thrust lines, avionics placement, and center of mass target.

Week 3 Mechanical Design Lock

By the end of Week 3, all of the following conditions must be satisfied.

- Gimbal geometry is finalized with defined axes of rotation.
- Mechanical hard stops are designed into the gimbal.
- Duct mounting and structural load paths are finalized.
- Avionics mounting structure is designed.
- Landing gear concept is finalized.
- Structural components are fabricated or queued for fabrication.
- Target center of mass location is defined relative to thrust vector intersection.

Week 4 Electronics Bench Validation

By the end of Week 4, all of the following conditions must be satisfied.

- Flight controller powers reliably from the final power system.
- IMU orientation and sensor readings are verified.
- Radio control link is functional with correct channel mapping.
- Failsafe behavior is verified on the bench.
- ESCs arm and spin motors safely with guards or ducts removed.
- Current draw is measured at low and medium throttle.
- Kill switch reliably cuts motor power.
- No wiring exhibits overheating under expected loads.

Week 5 Airframe Assembly Complete

By the end of Week 5, all of the following conditions must be satisfied.

- Airframe is fully assembled.
- EDF units are rigidly mounted and aligned.
- Gimbal assemblies are installed on the airframe.
- Landing gear supports the vehicle upright.
- Wiring is routed, strain relieved, and secured.
- Battery mounting allows center of mass adjustment.
- Vehicle can be safely powered on and off without disassembly.

Week 6 Gimbal Actuation Verification

By the end of Week 6, all of the following conditions must be satisfied.

- Gimbal actuators move smoothly through full range.
- Neutral gimbal position is mechanically centered.
- Direction conventions are verified for all axes.
- Software enforces gimbal angle limits.
- Gimbal response is stable with no idle oscillation.
- Manual gimbal control via radio is functional.
- Failsafe returns gimbal to neutral or safe position.

Week 7 Control Allocation and Stabilization

By the end of Week 7, all of the following conditions must be satisfied.

- Control mixing from pilot input to thrust and gimbal commands is implemented.
- Attitude stabilization loop is active and correctly signed.
- Output saturation and rate limits are enforced.
- Throttle ramping and soft start behavior are configured.
- Vehicle responds correctly when manually tilted at idle thrust.
- No runaway behavior occurs during sensor disturbance.
- Logged IMU data shows acceptable vibration levels.

Week 8 Static Thrust and Thermal Qualification

By the end of Week 8, all of the following conditions must be satisfied.

- Static thrust testing is completed.
- Maximum continuous thrust is measured.
- Peak current draw is within component limits.
- Motor and ESC temperatures remain within safe bounds.
- Vibration issues are mitigated or documented.
- Cooling airflow paths are confirmed.
- Throttle limits are adjusted based on thermal results.

Week 9 Tethered Hover Achievement

By the end of Week 9, all of the following conditions must be satisfied.

- Tether system is built and structurally verified.
- Vehicle lifts its own weight while tethered.
- Attitude remains stable in hover.
- Small pitch and yaw commands are controllable and recoverable.
- No sustained oscillations occur.
- Failsafe motor cutoff works under thrust.
- Battery voltage sag during hover is acceptable.

Week 10 Hover Refinement and Balance

By the end of Week 10, all of the following conditions must be satisfied.

- Center of mass is tuned for neutral hover.
- Hover throttle percentage is recorded.
- Attitude gains produce smooth response.
- Gimbal motion remains within limits during hover.
- Landing gear does not interfere with thrust or gimbal motion.
- Startup and shutdown procedures are repeatable.
- Target hover duration is achieved tethered without overheating.

Week 11 Free Hover Readiness

By the end of Week 11, all of the following conditions must be satisfied.

- All safety checks pass consistently.
- Conservative throttle and tilt limits are enforced.
- Spotter roles and emergency procedures are defined.
- Short untethered hops are successful.
- Vehicle lifts off, hovers briefly, and lands under control.
- Post flight logs show stable behavior.
- No structural or electrical degradation is observed.

Week 12 Free Hover Demonstration

By the end of Week 12, all of the following conditions must be satisfied.

- Vehicle performs repeatable free hover flights.
- Hover remains stable for tens of seconds.
- Yaw control is smooth and controllable.
- Vehicle lands safely without tipping.
- Multiple batteries can be flown without rework.
- Final mass, hover time, current, and temperatures are documented.
- A prioritized version two improvement list is completed.