AIRFRAME ARCHITECTURE AND DESIGN OF THE SWIFT-UAV: AN OPEN-SOURCE 20 KG-CLASS 3D-PRINTED FIXED-WING RESEARCH PLATFORM

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STATE OF THE MARKET

- Rapidly growing demand for UAVs in science, surveying, infrastructure, agriculture, and defense
- Industry largely dominated by multi-rotor systems
- However, Fixed-wing UAVs frequently provide longer endurance, range, and larger payload capacity
- Capable platforms do exist
  - However, most high-performance systems are closed-source and expensive

[1] https://www.grandviewresearch.com/industry-analysis/global-commercial-drones-market
[2] https://drone-works.com/dji-matrice-350-rtk-h30t-pro-utilities-inspection-combo-by-drone-works/
[3] https://botsanddrones.co/drone-hardware-components/f/edge-autonomy-penguin-b-drone---america-commercial-drone-guide

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MISSION STATEMENT

- Existing fixed wing UAVs effectively meet payload range and endurance requirements
- However, high-performance platforms are typically:
  - Proprietary
  - Expensive
  - Arduous to modify
- In-house solutions burn man-hours and typically require specialized and expensive manufacturing (ex composite wings)
- No widely accessible platform combines:
  - heavy payloads (5-10lbs)
  - high endurance (1hr +)
  - open-source design
  - low-cost manufacturing (< $2000, minimal tooling)

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SCIENTIFIC WORKHORSE FOR INFLIGHT TESTING (SWIFT-UAV)

- Open-source, fixed-wing research UAV designed for accessible aerial science and flight testing
  - 5 kg nominal payload
  - Target ~1 hour endurance and 25 m/s cruise speed
- Built primarily from 3D-printed components and standardized T-slot aluminum extrusion
  - All parts fit on a standard 256mm print bed
- Designed to be modular, transportable, easily made and easily modified for different research missions

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SCIENCE *WITH* SWIFT

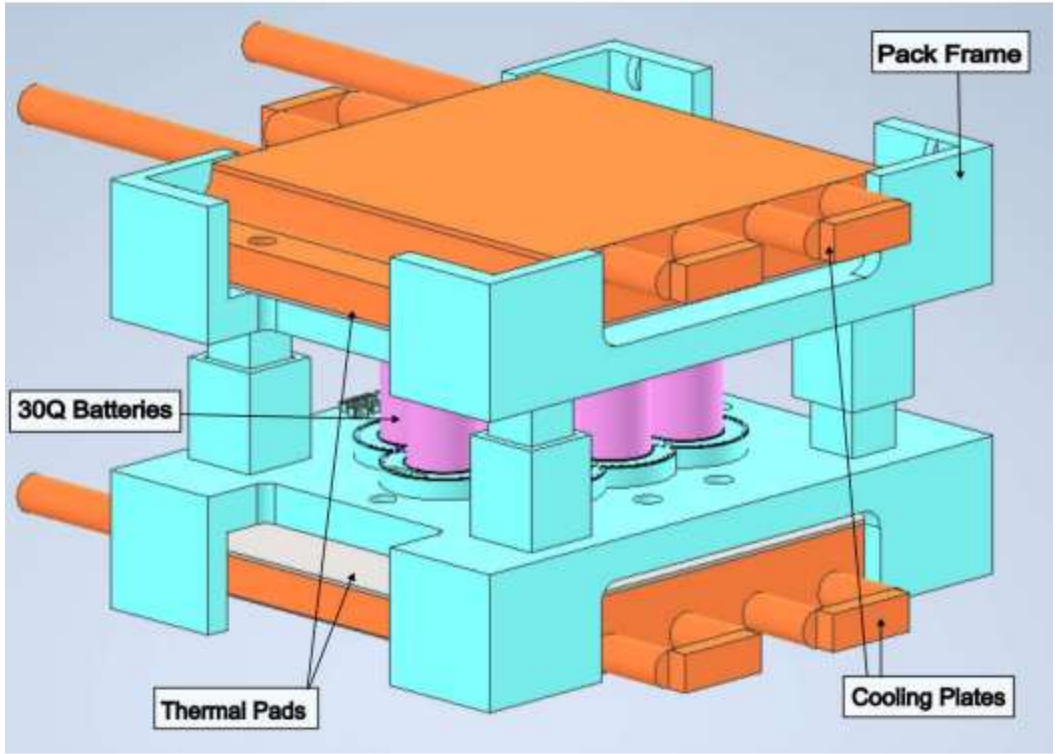
- 5 kg payload capacity and large internal payload bay support substantial scientific instrumentation
- Modular architecture allows the aircraft to be tailored to the mission
- Payload, battery, and airframe choices can be traded:
    - More battery → longer endurance
    - More payload → shorter endurance
    - Alternate wings → different lift, speed, or efficiency
- Payload interfaces and removable subassemblies simplify sensor integration and field modification
- Suitable for atmospheric sensing, remote sensing, surveying, environmental monitoring, and other aerial science missions

SCIENCE *ON* SWIFT

- Open, modular aeronautical research testbed
- Provides a finished, flight-capable baseline aircraft
- Researchers can test new technologies without designing a UAV from scratch
  - Reduces engineering, fabrication, and integration man-hours
- Current work includes:
  - battery studies
  - propulsion digital twins
  - structural batteries
- Supports future research in aerodynamics, structures, propulsion, controls, autonomy, and avionics

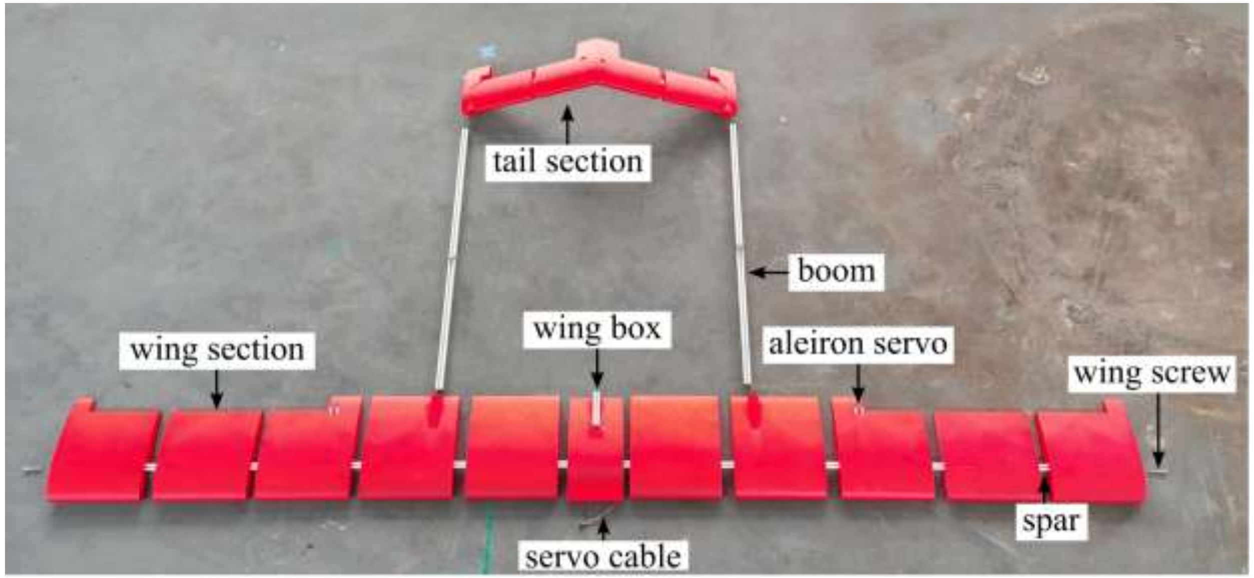
ACTIVE WORK

- 10S1P battery pack with PCB cell balancing
- Cooling plate thermal control
- Using 18650 Samsung 30Q cells
- Digital twin focused on battery behavior and lifecycle predictions



AERODYNAMIC DESIGN

- Wing sized around the 20 kg MTOW design condition
- NACA 4415 selected for high lift, gentle stall behavior, and structural thickness
- 2.6 m span, 0.33 m chord, AR ≈ 8.4
- Classical sizing followed by CFD verification
- CFD design point: ~200 N lift at 30 m/s, ~21.6 N drag, L/D ≈ 9.1
- Future work: aerodynamic optimization and flight-test validation



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STRUCTURAL

- 20×20 mm aluminum extrusion carries the primary loads
- 3D-printed PLA provides aerodynamic shape, interfaces, and local stiffness
- Twin-boom architecture creates a simple load path from wing to tail
- Wing uses an aluminum spar + printed lattice shell
- Segmented wing sections mechanically lock together for load transfer and easy replacement
- **Structure is designed around modularity, repairability, and consumer-scale manufacturing**

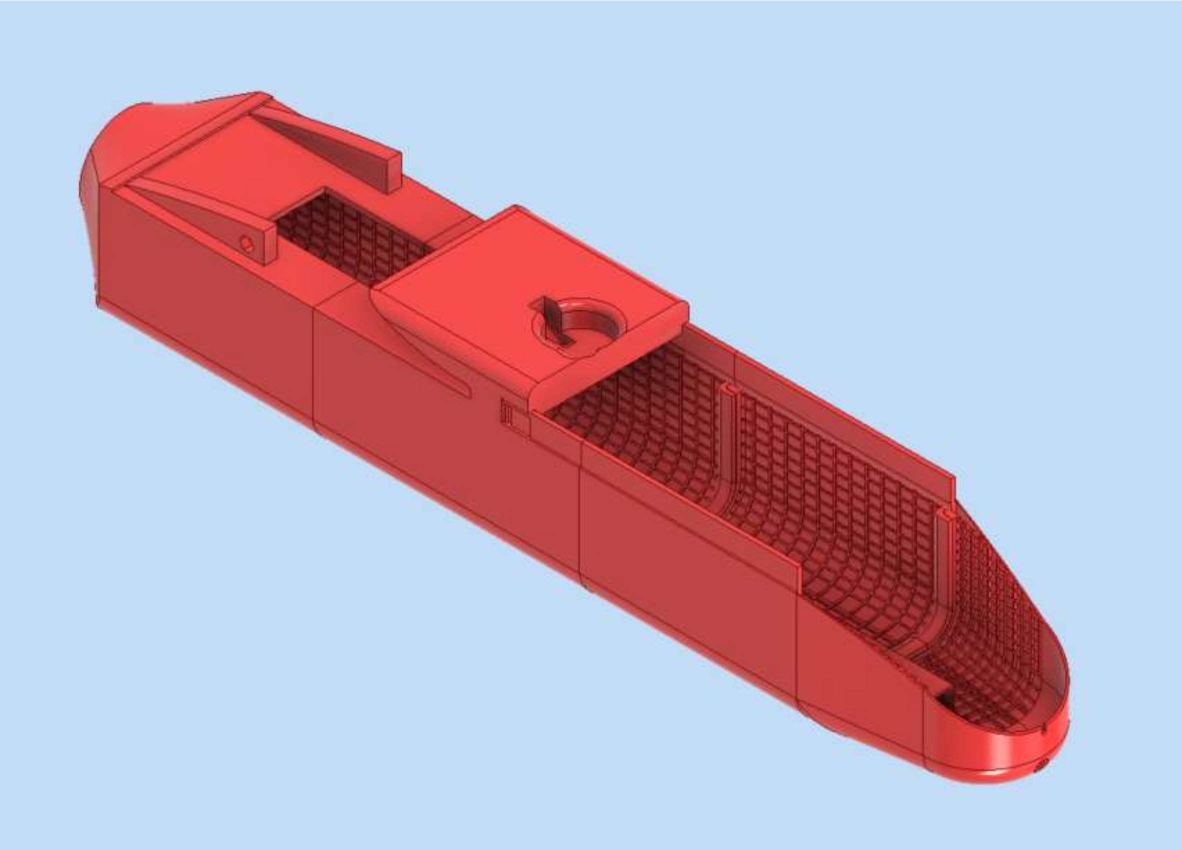
PROPULSION

- MAD X7215 electric motor with 21 in propeller and 12s 10 Ah battery pack
  - **All commercially available**
- Sized for substantial thrust margin: T/W ≈ 0.7 at 20 kg MTOW
- Design battery: 12S, 10 Ah
- Estimated cruise current: ~6 A
- Predicted endurance: ~1.4–1.5 hr with margin
- Cruise operating point targeted around 30–40% throttle for efficient operation

[1] https://mad-motor.com/products/mad-components-brushless-motor-x7215?VariantsId=10591
[2] https://zeeebattery.com/collections/all-lipo-batteries/products/zeee-6s-lipo-battery-10000mah-22-2v-120c-ec5

DESIGN FOR MANUFACTURABILITY AND ASSEMBLY

- **Fuselage constructed with zero adhesives**
- Trivial to disassemble for modification or repair
  - Bolt-tension system used to hold fuselage taught
- Wing box system used to make removable wing assembly



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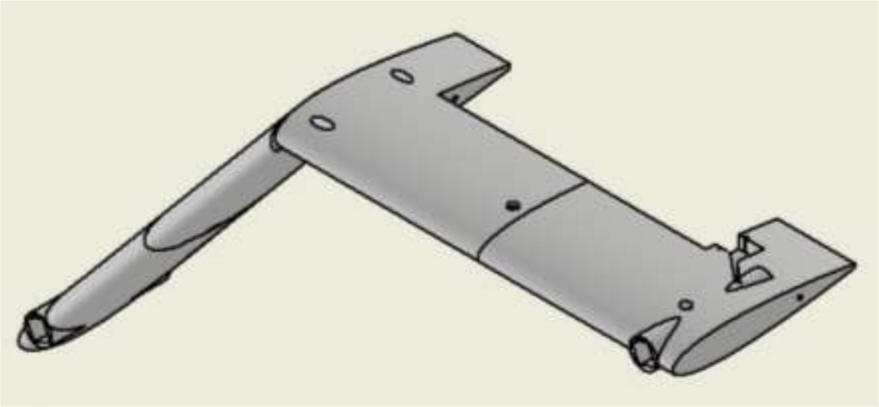
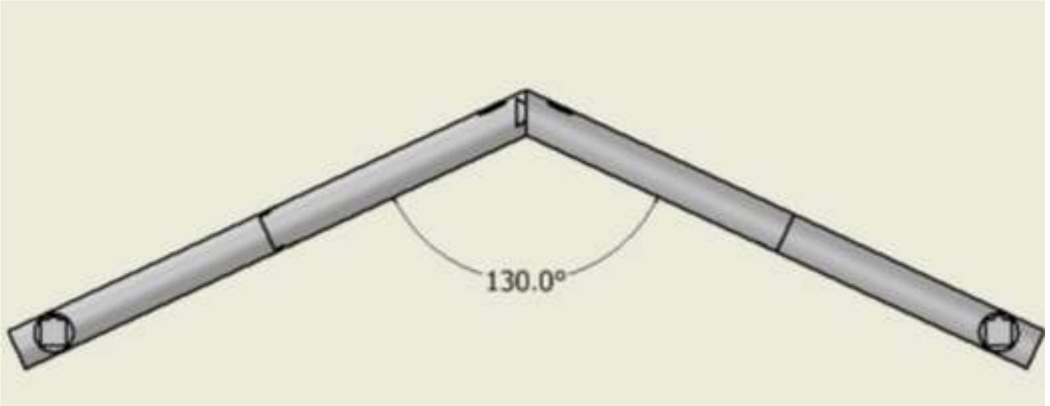
DESIGN FOR MANUFACTURABILITY AND ASSEMBLY

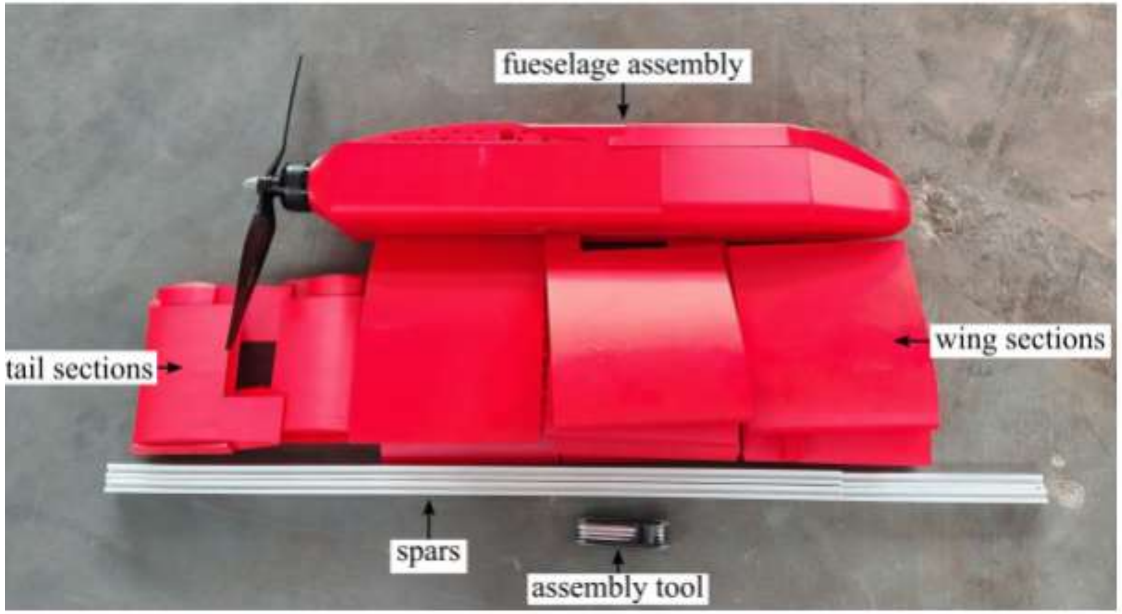
- Tail similarly designed to be fully separable
- Complaint mechanisms are used in non-loadbearing axis to connect
- **Flat packable**





MANUFACTURE & ASSEMBLY

- Flat-packed to fully assembled in ≈15 min, with no specialized tools; disassembles into a compact ≈1.5 m × 0.5 m footprint for transport.
- **UAV joined without adhesive**



FUTURE WORK

- Ground tests **this week**
- Flight test next month

(some of) The Team

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THANKS!

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