

Introduction

Aerial radiation mapping platforms must balance coverage efficiency, payload capacity, stability, and cost. Achieving all together remains rare.

- Comparable systems rely on complex architectures and specialized radiation-sensing integrations.
- Typical system cost exceeds \$20,000, limiting accessibility for research

Atlas Falcon addresses these limitations:

- Low-cost, high-performance hybrid VTOL UAV for autonomous radiation mapping
- Modular, scalable platform for detector integration and environmental surveys

Goal

- Low-cost platform (~\$1,200 total)
- Inexpensive structure (<\$250 total)
- Fully reproducible (3D-printed + off-the-shelf components)
- Autonomous navigation for radiation survey missions
- Safe and efficient low-altitude operation for radiation mapping
- VTOL blended-wing body for infrastructure-free deployment

Methods

- 3D-printed airframe in carbon-fiber-reinforced nylon (PAHT-CF)
- Structural validation via finite element analysis (FEA)
- Flight control: Pixhawk 6X (flight computer) + Raspberry Pi 4B (onboard computation)
- Sensor architecture:
 - Overlapping LiDAR measurements + MAVLink telemetry (position, velocity) for obstacle reconstruction
 - Single-point LiDARs (TFmini-S, VL53L1X) for obstacle detection and altitude sensing
- Bench testing of thrust-to-weight ratio and vertical lift capability
- Scintillator-based radiation detection
- Modular 1.5 L payload bay for onboard systems integration
- 7.5 Ah 4S battery (~114 Wh) to balance weight and sufficient energy capacity
- Propeller-induced airflow cooling to reduced electronics temperature, improved operational safety

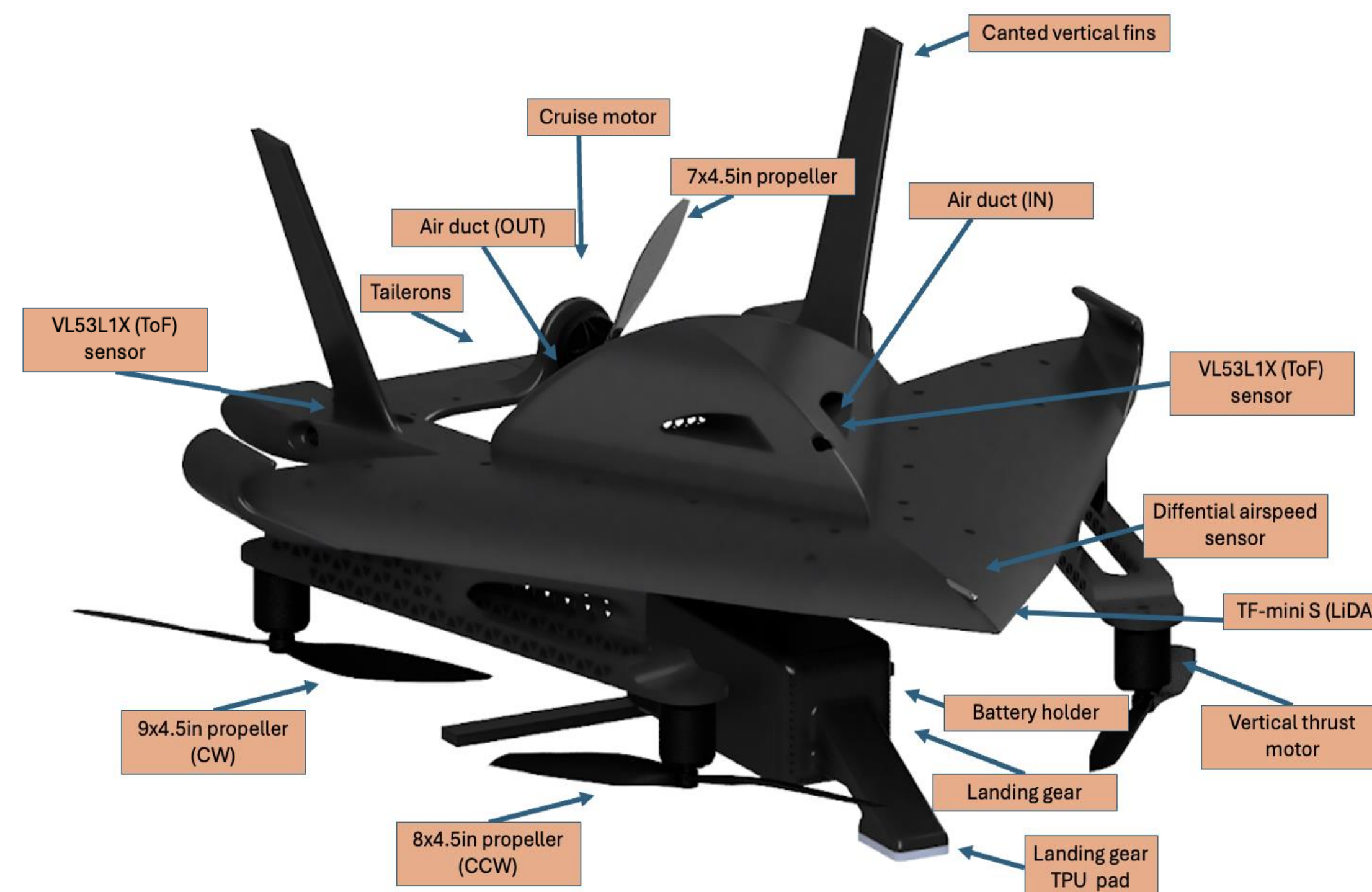


Fig. 1. Atlas Falcon architecture

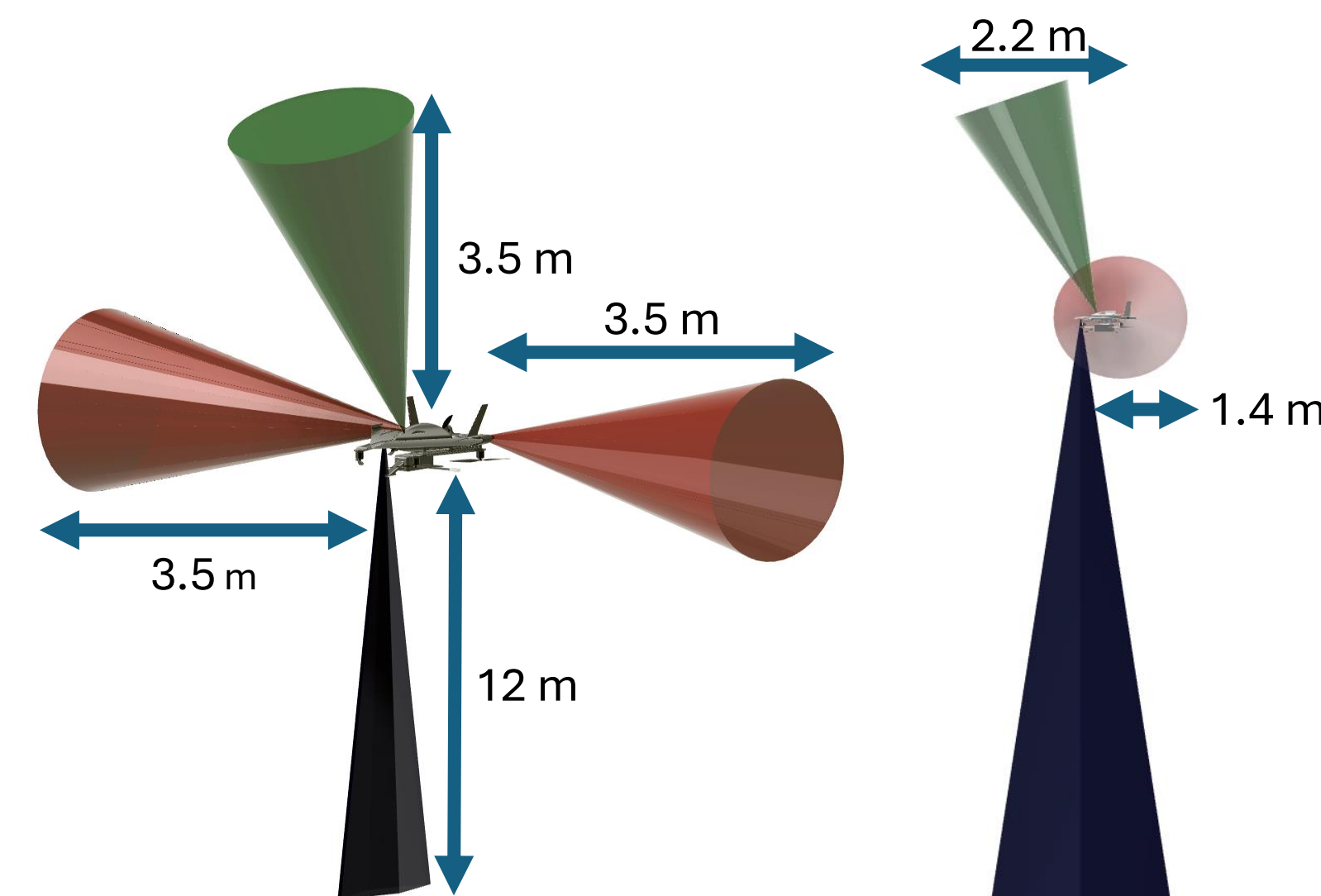


Fig. 3. Sensor coverage diagram

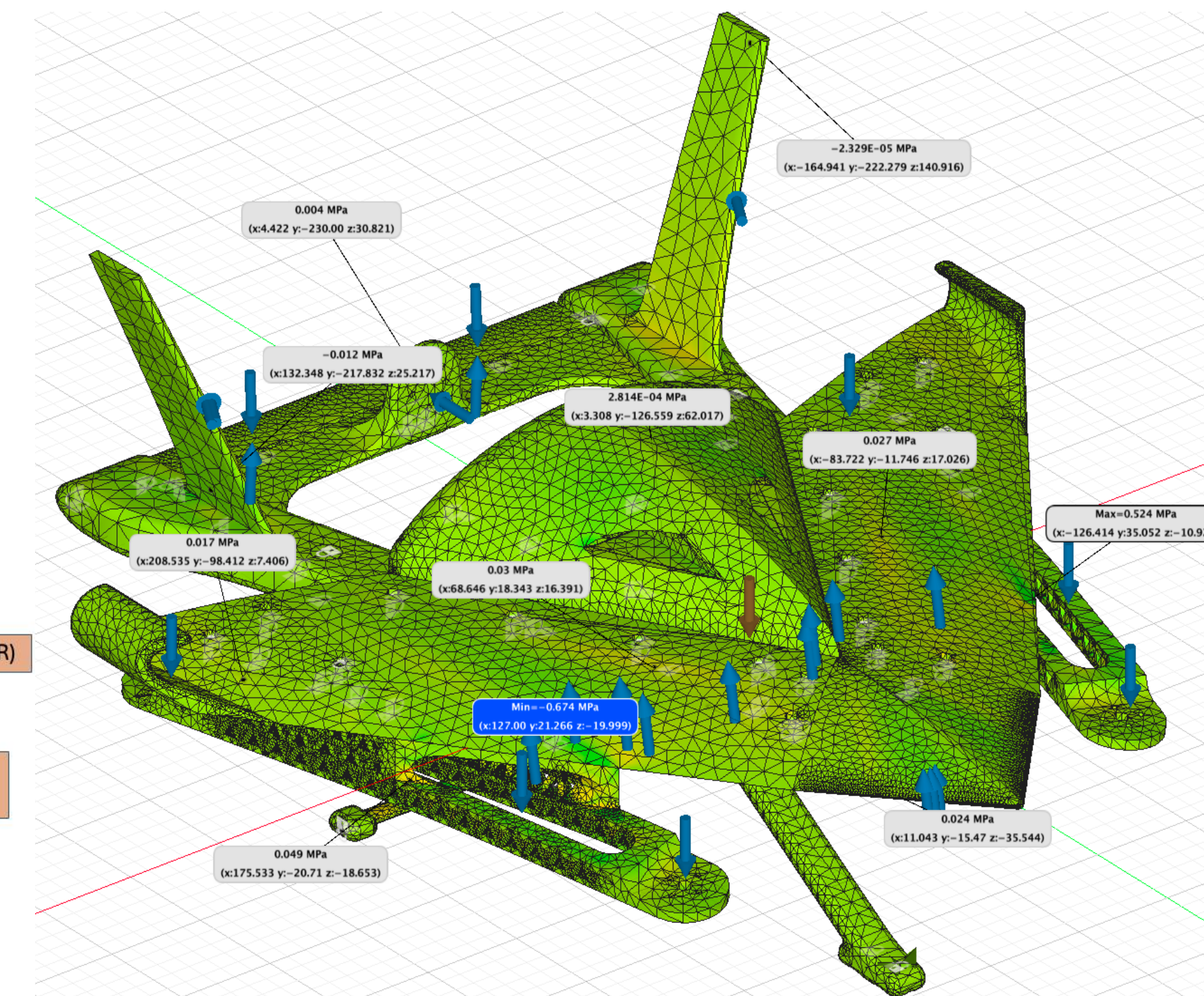


Fig. 2. Airframe FEA analysis

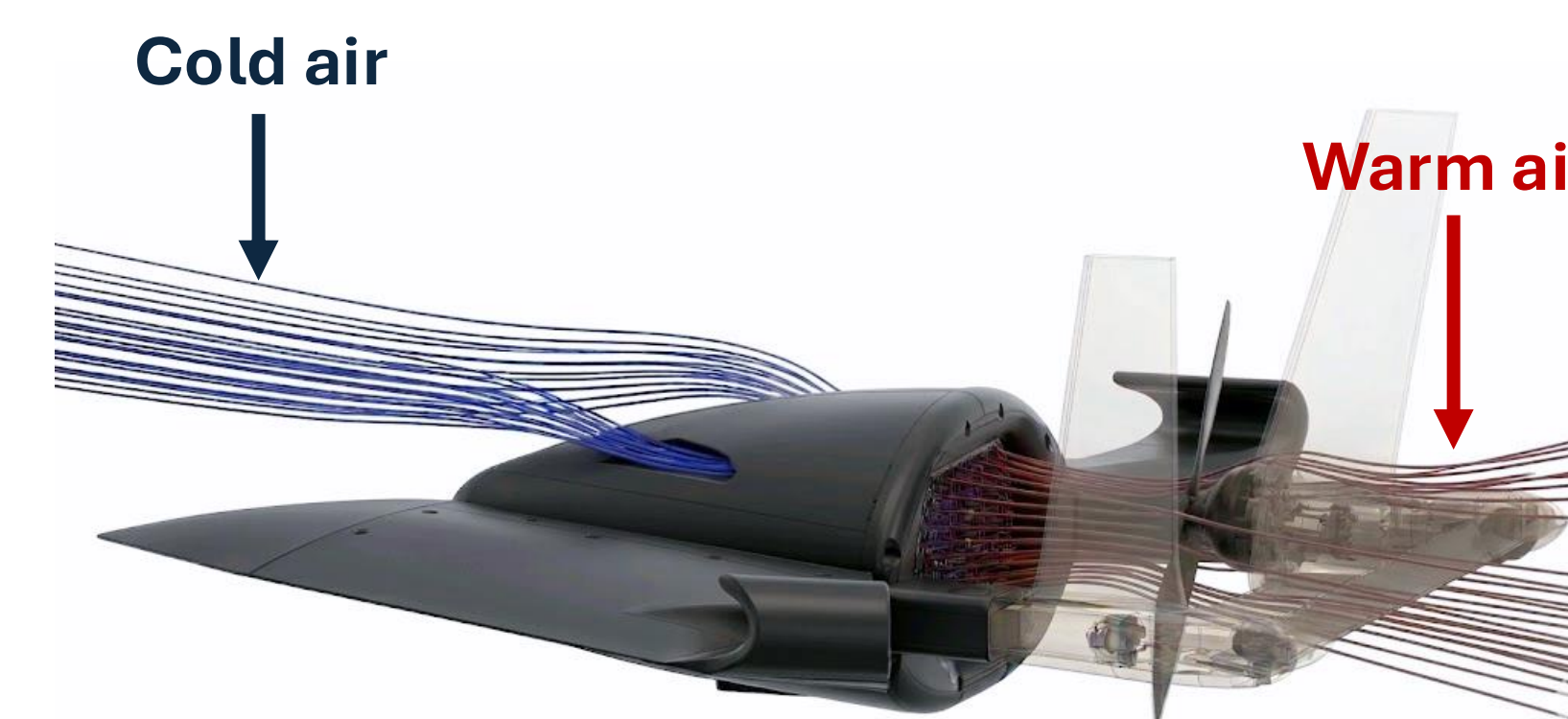
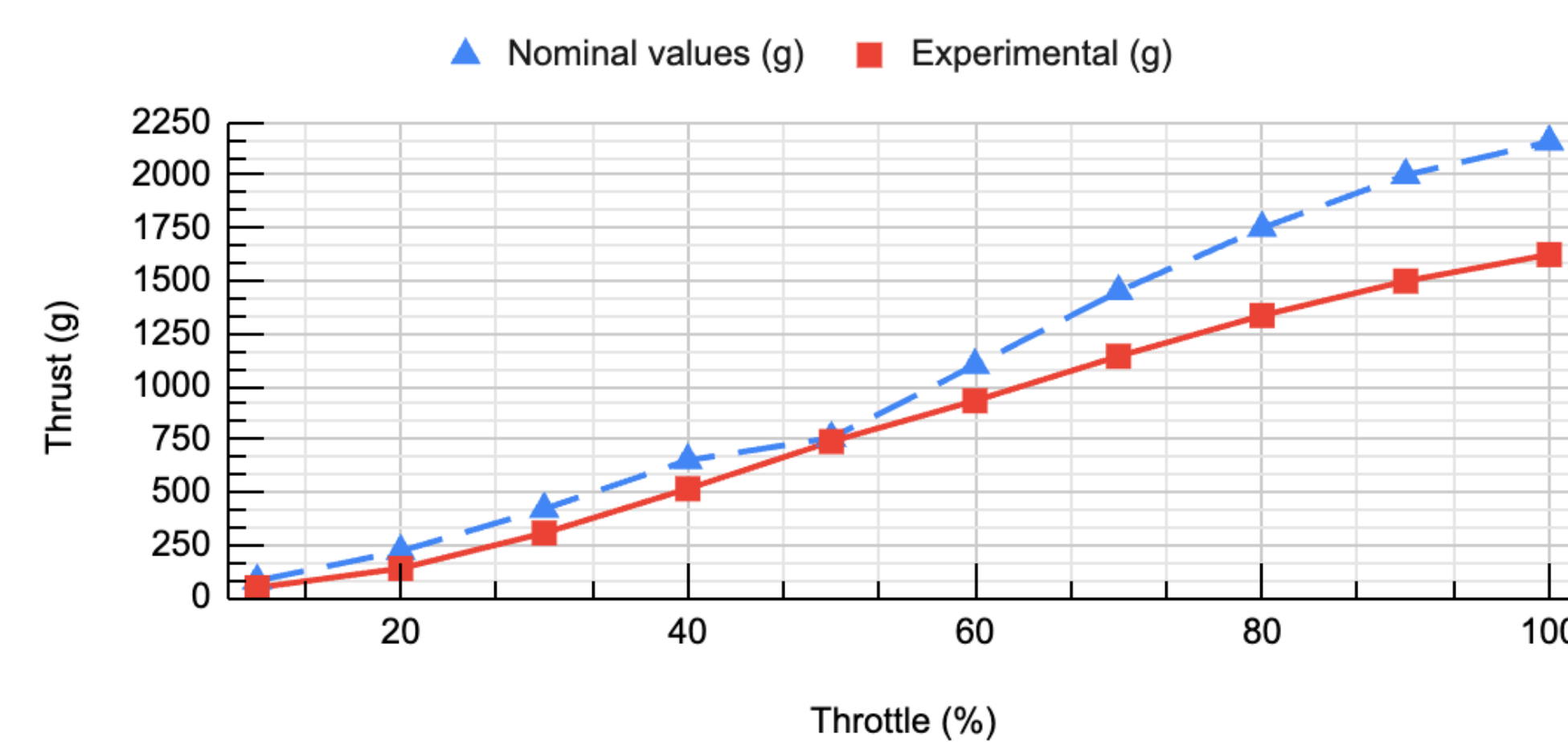
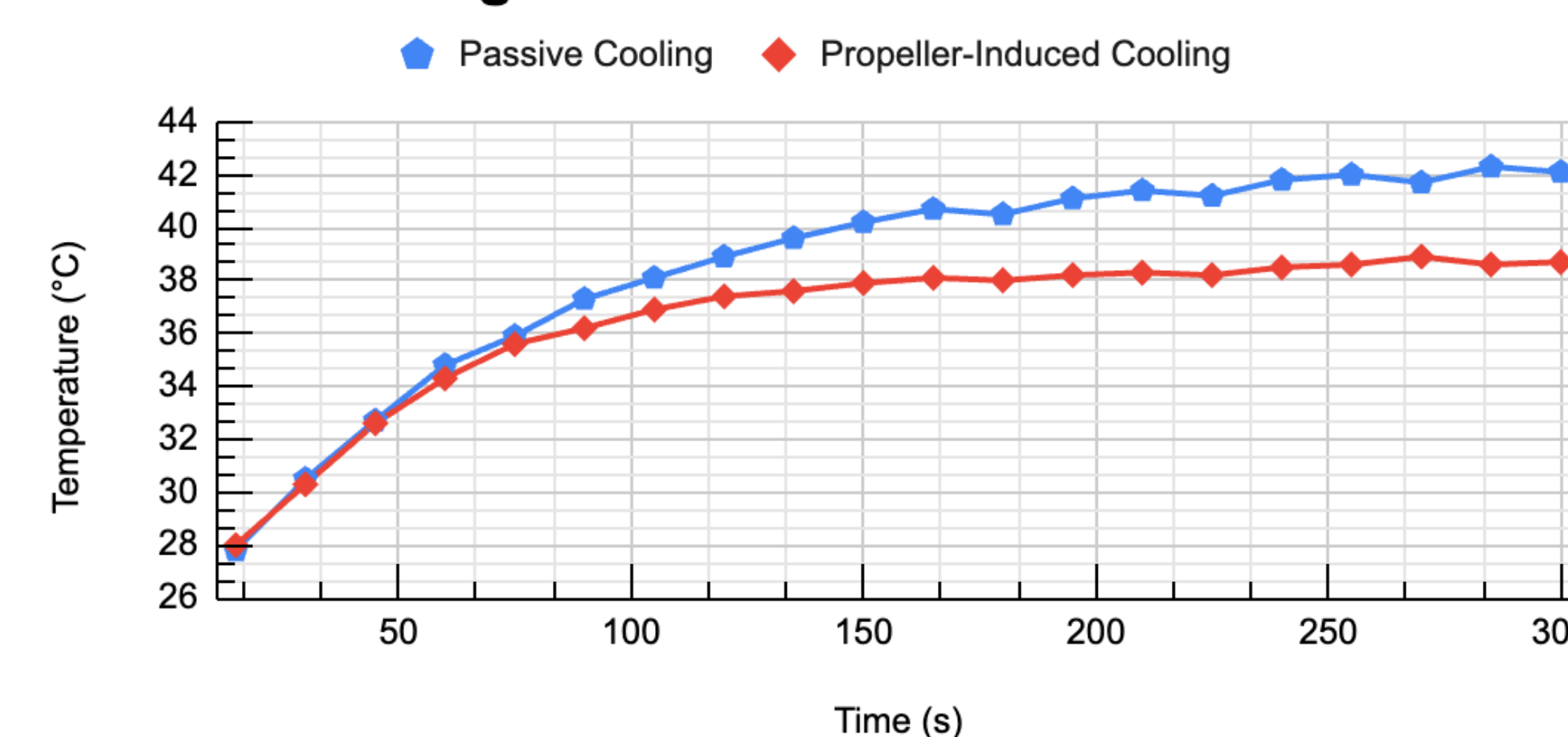


Fig. 4. Cooling system diagram

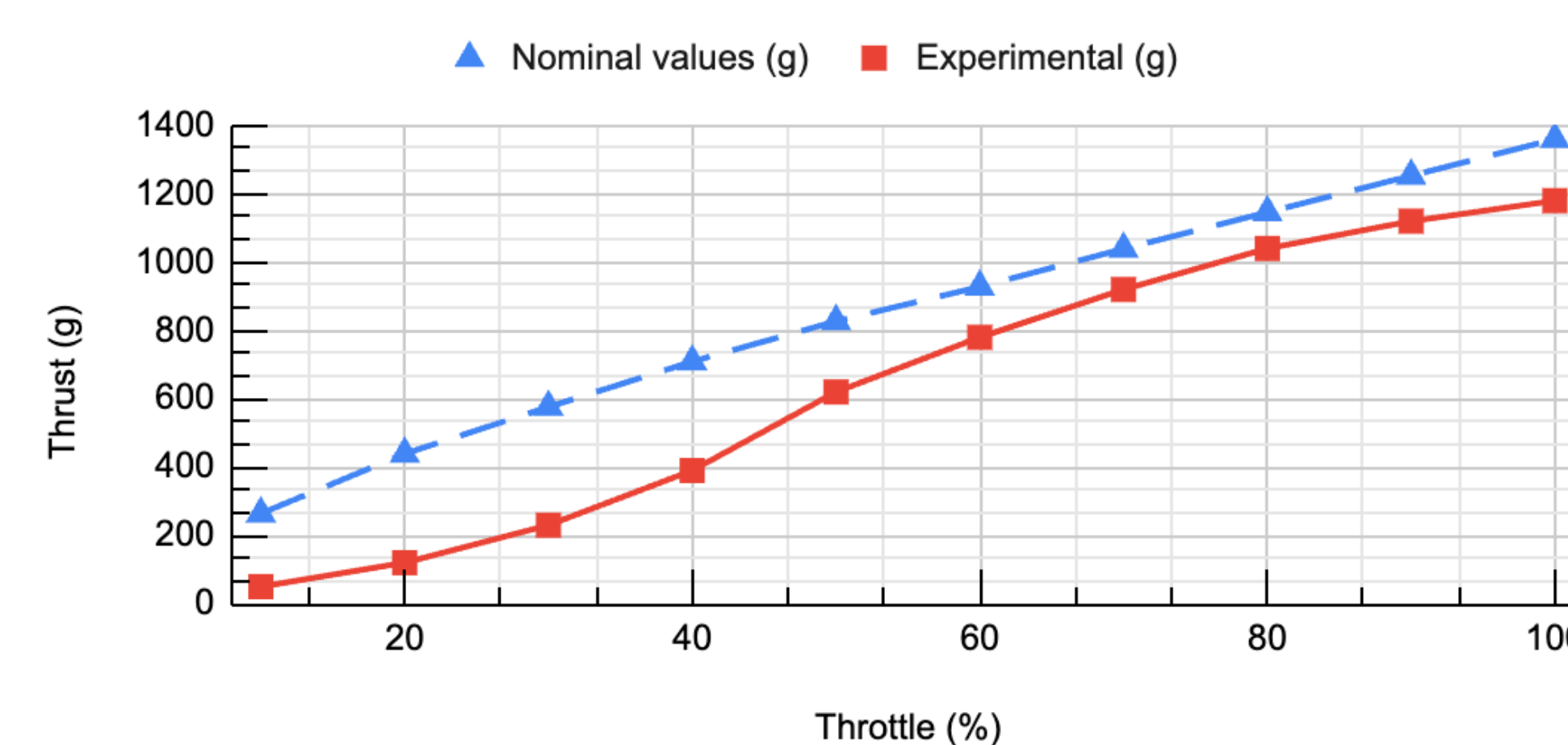
Vertical Thrust: Experimental results compared to nominal values at 4S



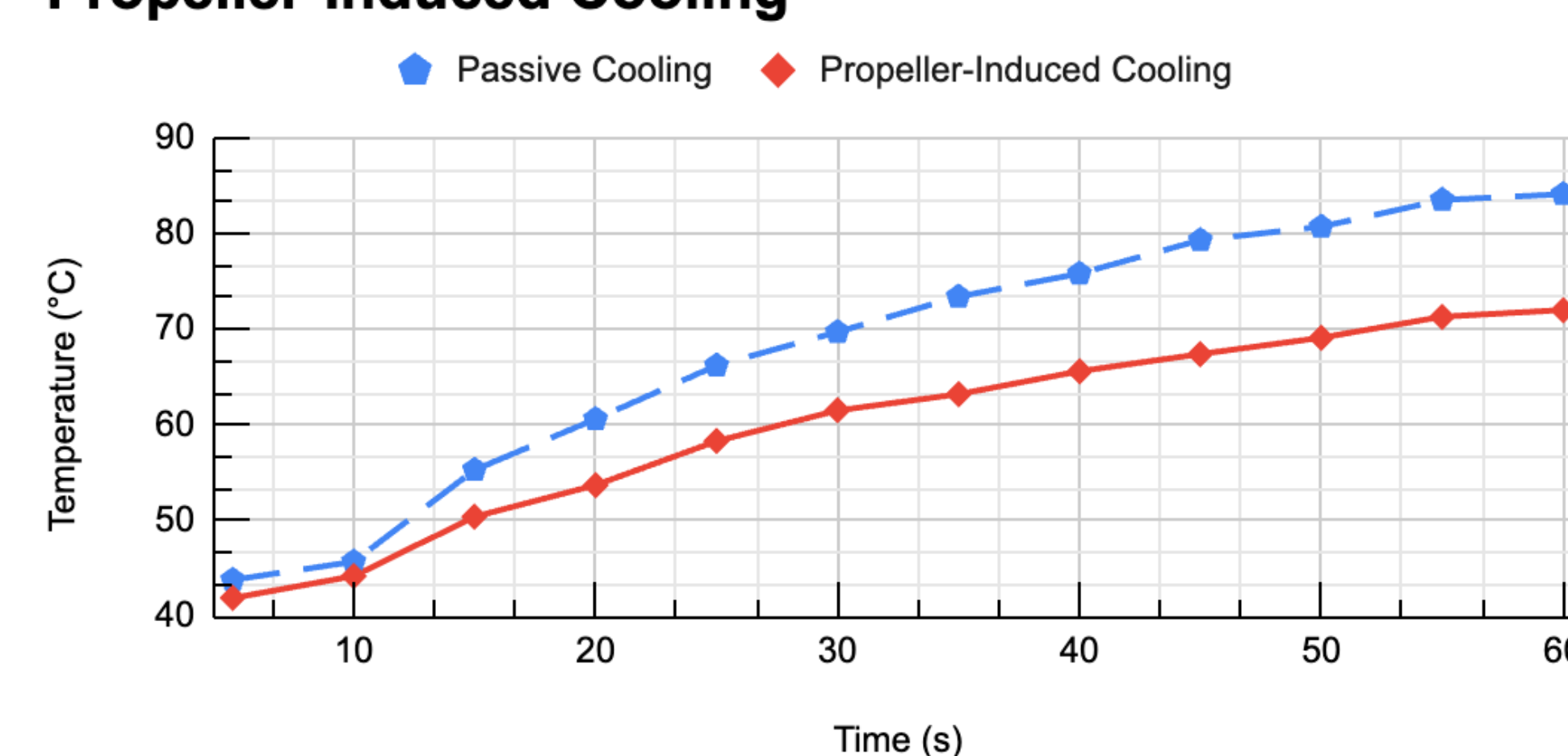
Battery Temperature vs. Time: Passive vs. Propeller-Induced Cooling



Vertical Thrust: Experimental results compared to nominal values at 4S



Raspberry Pi Temperature vs. Time: Passive vs. Propeller-Induced Cooling



Results & Validation

- 2.5 kg airframe with 0.7 kg radiation payload; thrust-to-weight ratio of 1.7:1, confirming sustained lift capability
- FEA indicates load tolerance up to 12 kg, with experimental validation through successful 8 kg load testing
- Propeller-induced cooling reduced electronics temperature by 10–12°C and battery temperature by 3–5°C under sustained load
- ~207° field of view, enabling reliable frontal and lateral obstacle detection within 0.5–3.5 m ($\pm 2\%$), with downward altitude sensing over 0.5–8 m ($\pm 1\%$)
- Cruise speed of 25.1 m/s, with 46 min endurance and a maximum range of 69 km
- Maximum sustainable speed of 42.3 m/s (13 min endurance), with burst up to 49.1 m/s for 5–15 s (~736 m coverage)
- Stable operation in the 1–5 m/s range with ~14 min endurance

Discussions

- Thrust-to-weight ratio and FEA results confirm adequate lift capability and overall structural integrity for radiation payload integration
- PLA-Aero exhibited brittle failure under load, while PAHT-CF provided significantly improved strength and reliability for structural components
- The delta-wing configuration increases internal volume, enabling a larger effective payload space (1.5 L vs 0.6 L at similar wingspan)
- Sensor fusion enables reliable short-range obstacle detection (0.5–3.5 m, ~207° FOV) while remaining low-cost (~\$60 vs ~\$500 for multi-point LiDAR)
- The platform achieves high endurance (46 min) and range (40 km) at a low overall system cost (~\$1200)

Conclusion

Atlas Falcon demonstrates that high-performance hybrid VTOL UAVs for radiation mapping can be developed using low-cost, 3D-printed and off-the-shelf components, achieving competitive endurance, range, and payload capacity.