A Scalable, Modular UAV Platform for Autonomous Flight Research

Zeina Rmaile, Lunar Lab
Georgia Institute of Technology
11/14/2025

Motivation

- Simulation vs real-world deployment
- Cutting-edge robotics testing often requires proprietary platforms

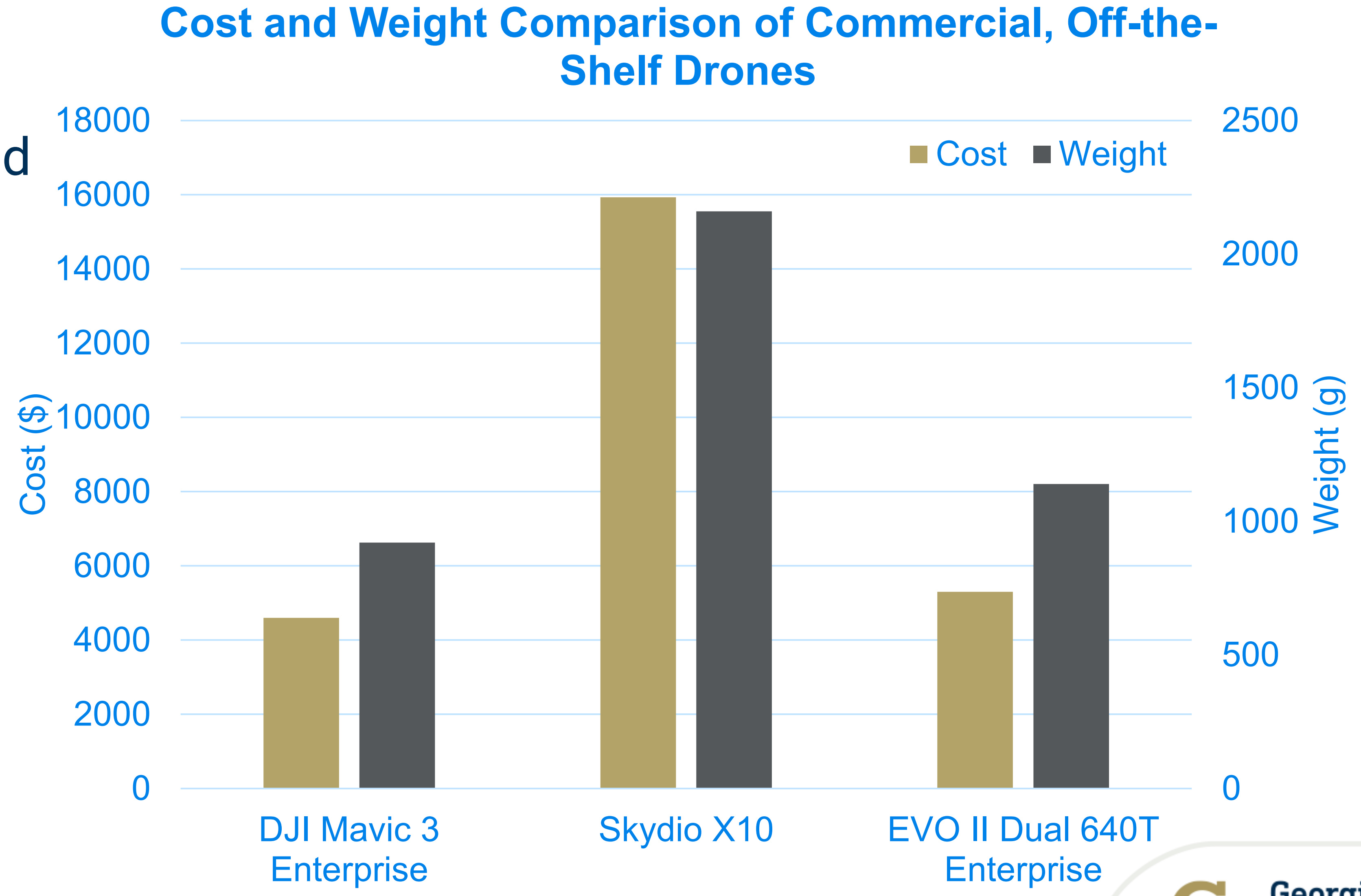
Barriers in the Advancement of Autonomous Flight

Pros

- Advanced sensors and flight software

Cons

- High cost
- Limited adaptability
- Proprietary platforms



Related Work

- Open-source physical testing platforms
- Optimizing for cost, flexibility, and performance

From Specialized UAVS to Scalable, Open Platforms

AirSwarm [1]

- Commercial off-the-shelf drones for multi-UAV research
- Relied primarily on software customization
- Lacks hardware flexibility, limiting experimental use

RMF-OWL [2]

- Collision-tolerant UAV for autonomous cave exploration
- Hardware specialized for confined, cluttered environments
- Prioritized mission and durability, not modularity or affordability

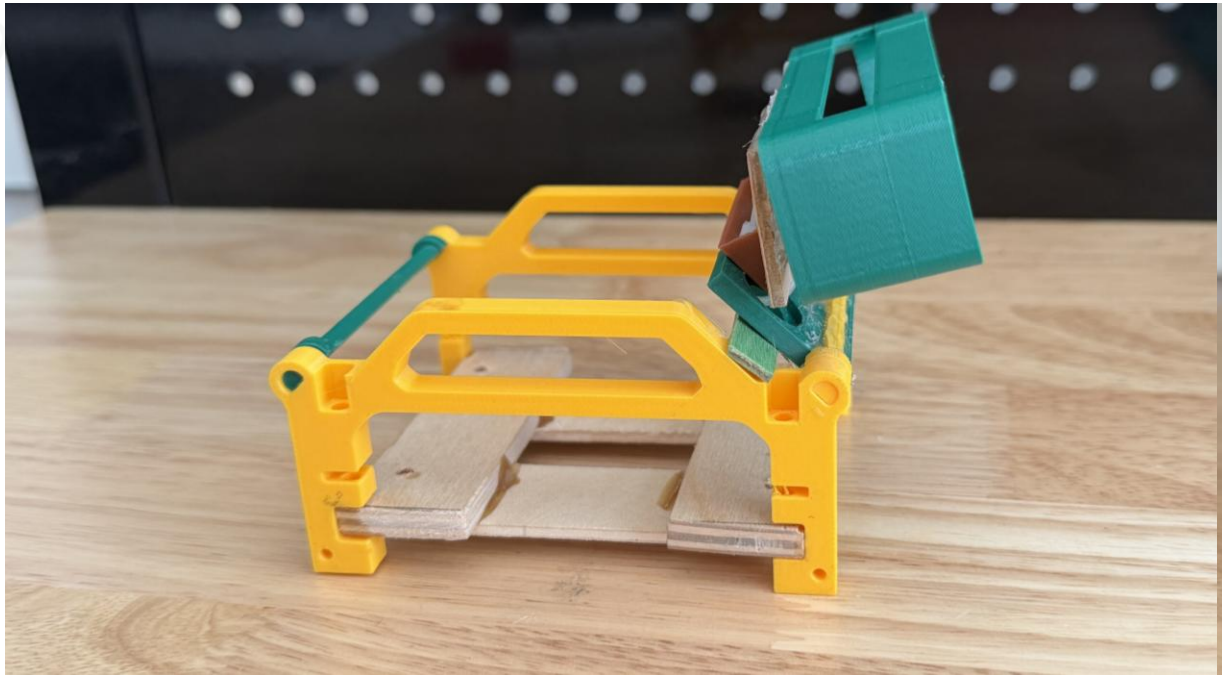
Agilicious [3]

- Open-source and agile for vision-based flight
- High-speed maneuvers
- Required complex fabrication and expensive components
- Limited accessibility and scalability

Design Overview

Prototype – Computer and Camera Casing

- Intel RealSense D435i, NVIDIA Jetson Orin NX
- Camera FOV
- Efficiency and cost benefits of 3D printing

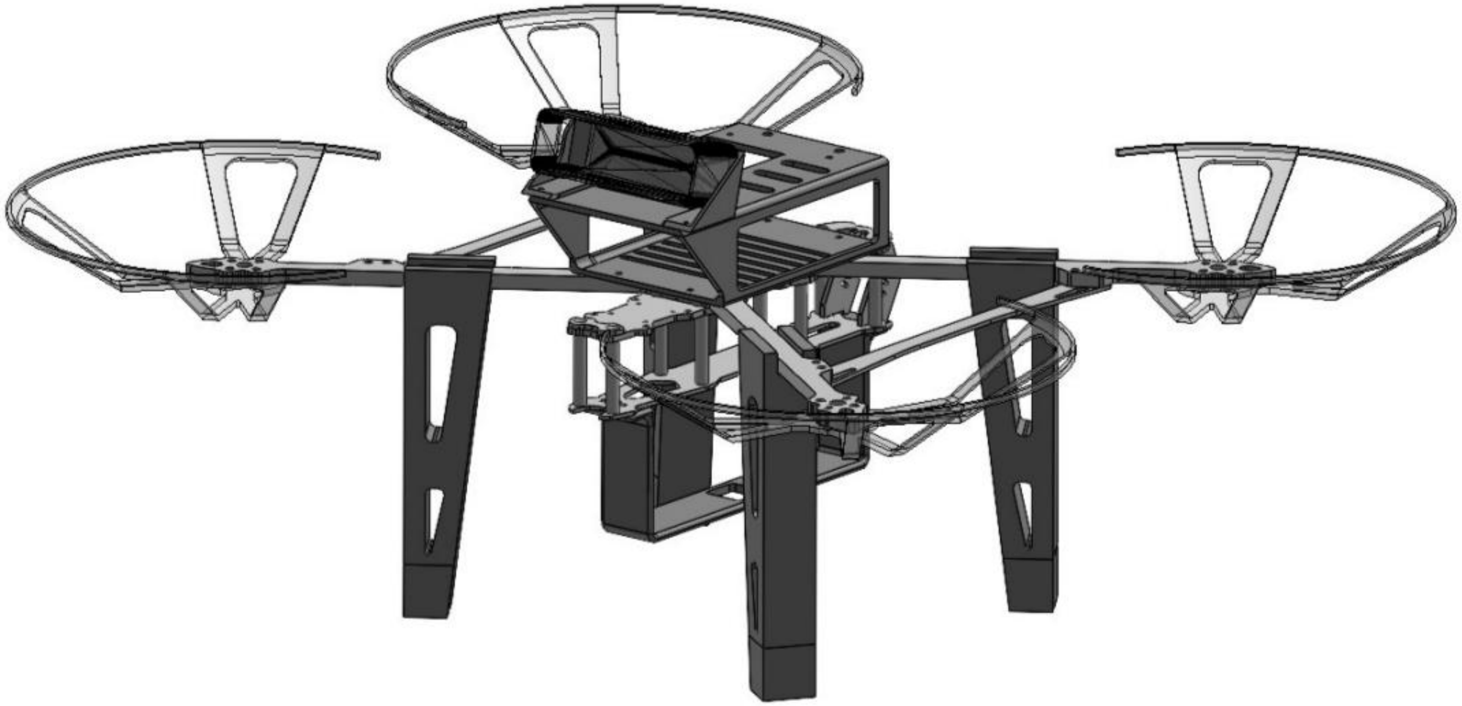


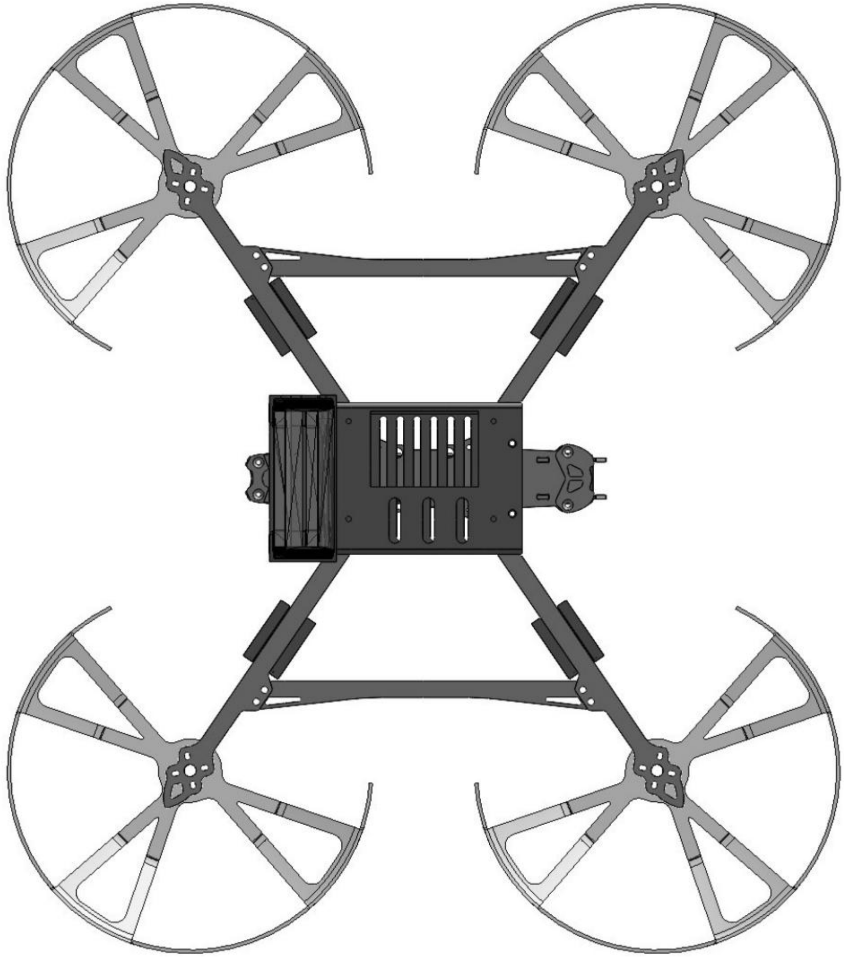

Lunar Lab

Georgia Tech

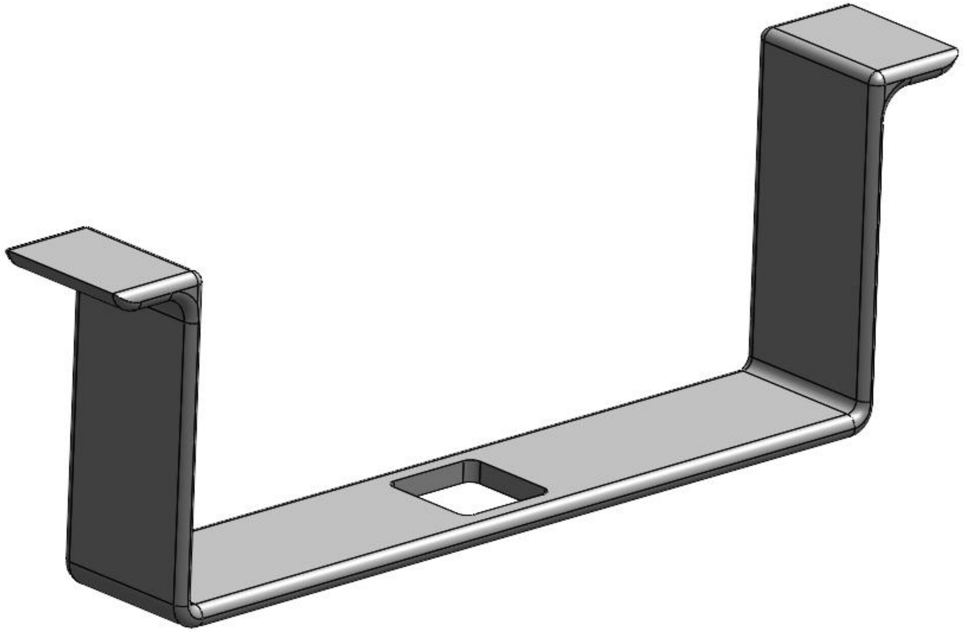
Initial Assembly

- X-frame, mounts, propeller guards, landing gear

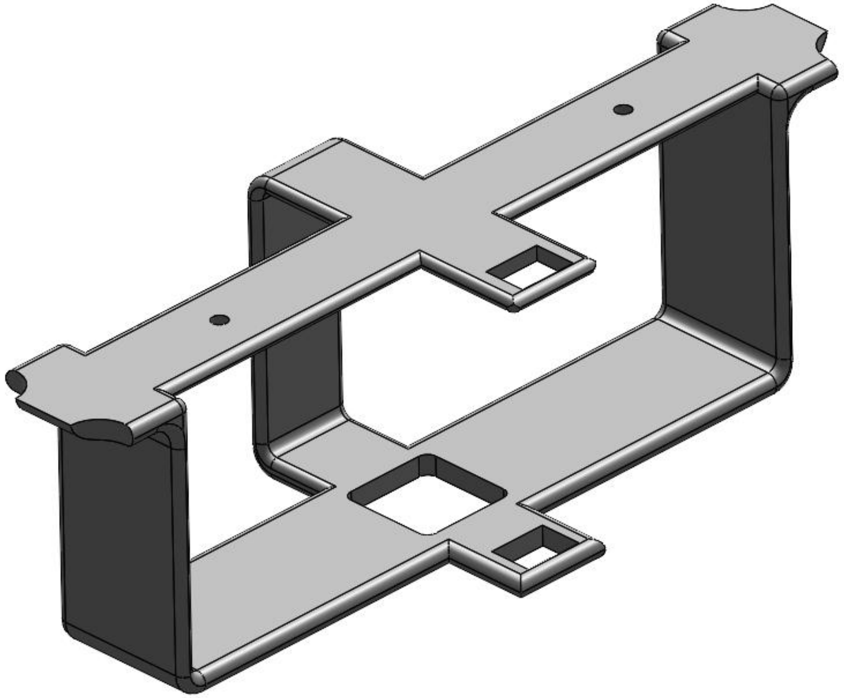




Battery Swap System



- Optical flow sensor mount
- First flight-tested version



- Multipurpose: optical flow sensor mount and battery mount
- Enables rapid testing
- More stable

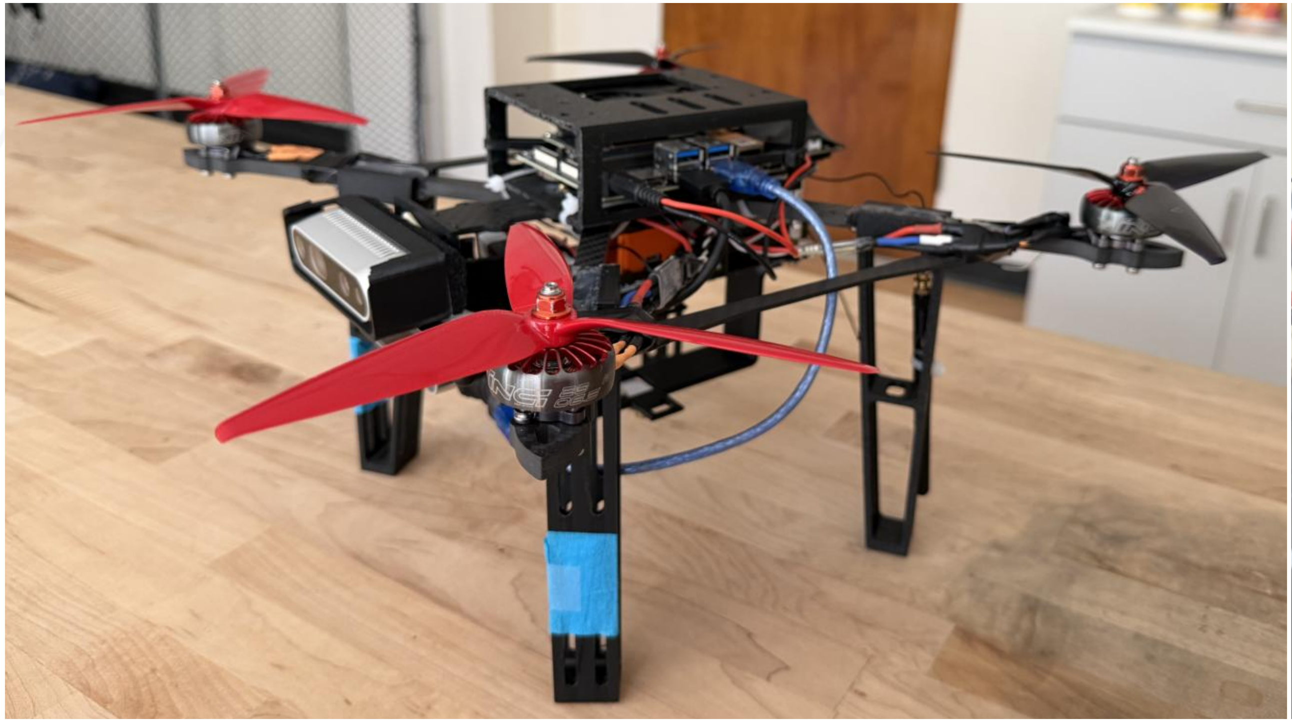
Lunar Lab

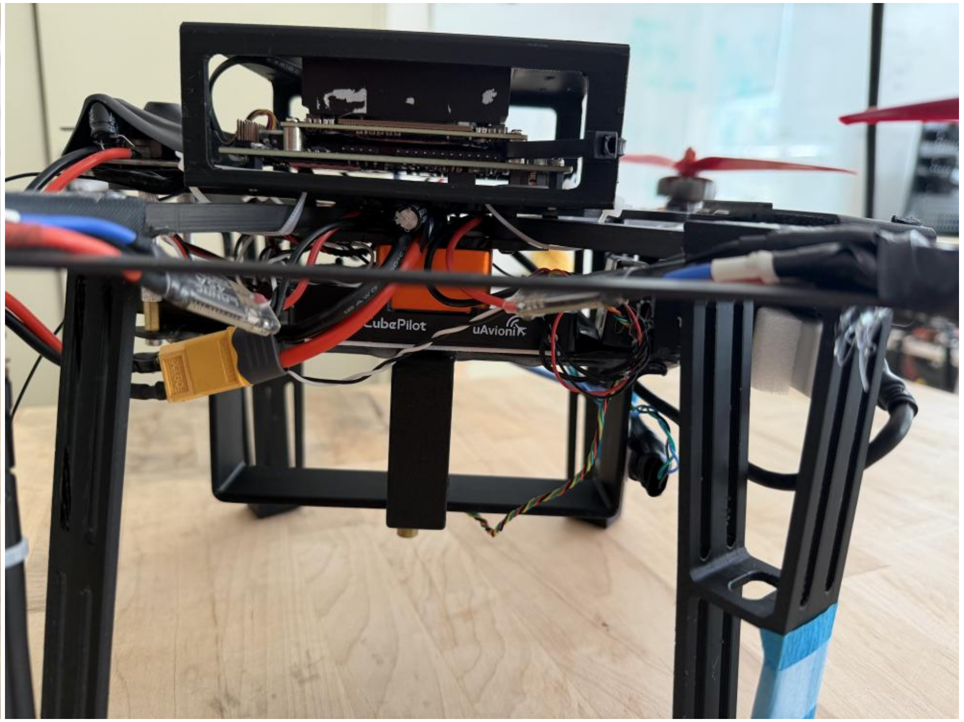
Georgia Tech

Final Version

- Optimized landing gear
- Relocated camera mount

- **Electronics:** Jetson, power distribution board, flight controller





Scalability

Georgia Tech

Cost and Performance Evaluation

Stability

- Indoor and outdoor tests
- Demonstrates autonomous hover using an off-the-shelf visual intertial odometry (VIO) algorithm
- Used PX4 flight logs to conduct stability and vibration analysis

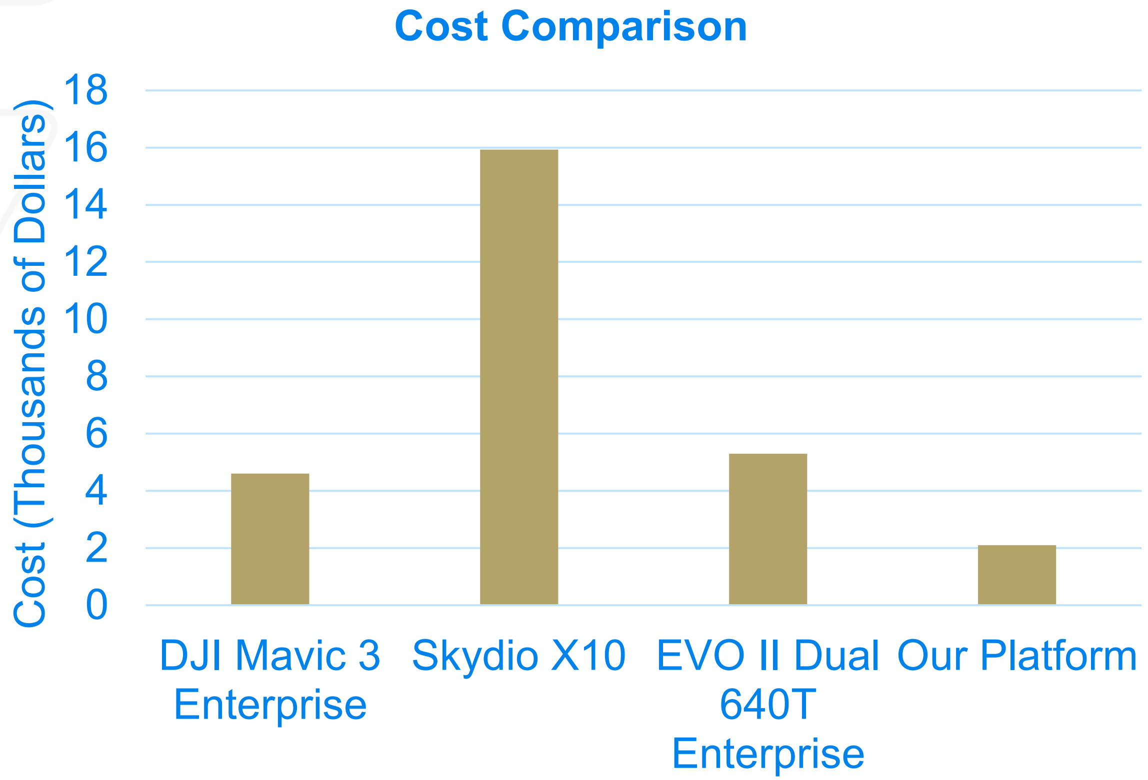
Test Flight Demonstrations

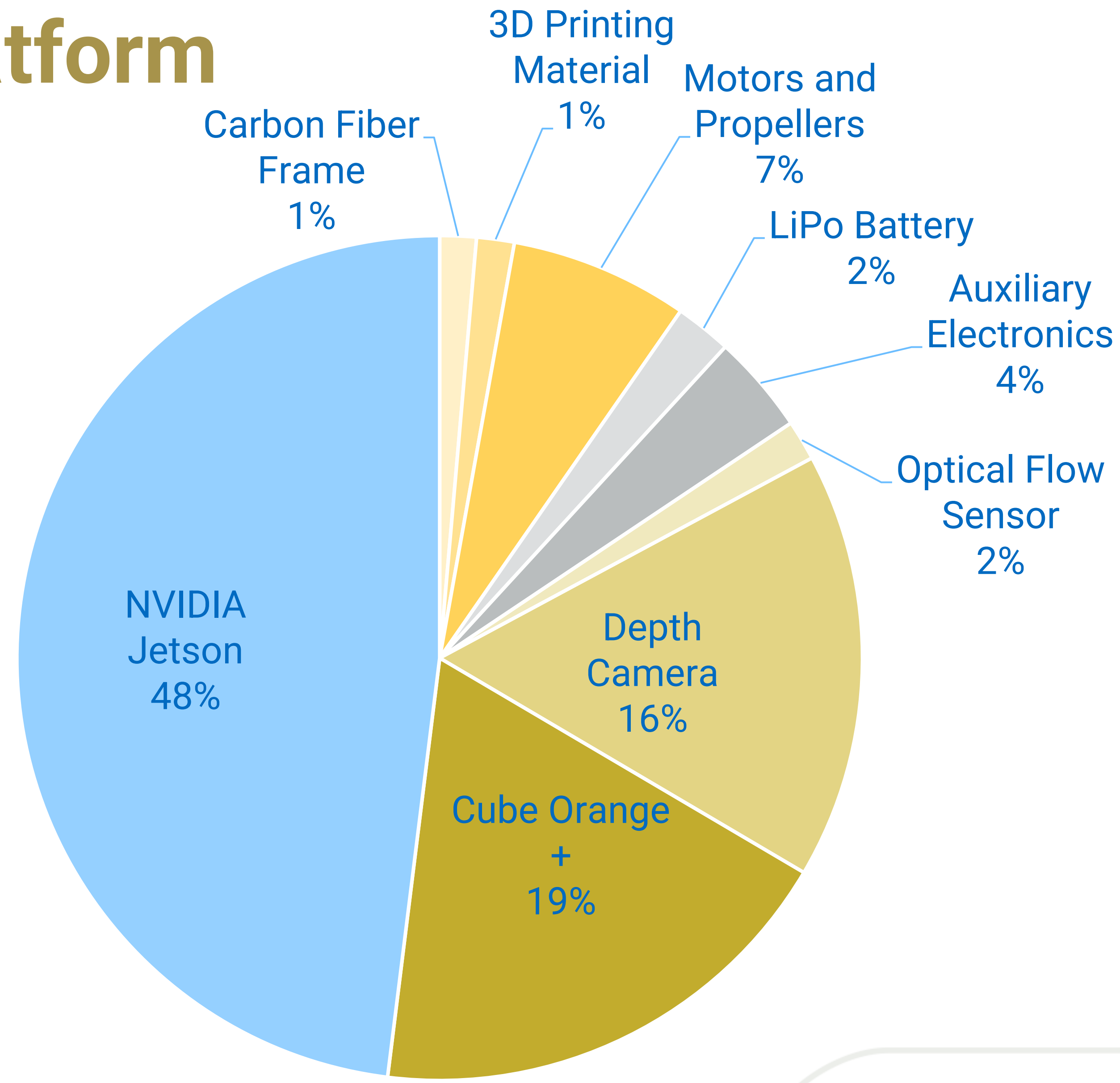
Lunar Lab

Georgia Tech

Cost Breakdown of UAV Platform

- Minimized hardware cost
- 48% Compute, 37% Sensing





Lunar Lab

Georgia Tech

Results

Metrics

- Total Cost: ~$2,100 per drone
- Hover Flight Time: ~13 minutes
- Total Weight: ~1.6kg

Advantages

- Full access to flight logs and sensor data
- Rapid debug-iteration cycle
- Cost-effective
- Flexible

Future Work

Next Steps

- Multi-UAV Autonomy
- Heterogeneous collaboration with other robots
- Integrating perception-based navigation models
- **Release design files and documentation to support open-source UAV research**

Lunar Lab

Georgia Tech

The Lunar Lab

Thank you to Dr. Lu Gan and my team!

Georgia Tech

References

- [1] Li, X., Xu, K., Liu, F., Bai, R., Yuan, S., & Xie, L. (2025). AirSwarm: Enabling Cost-Effective Multi-UAV Research with COTS drones. *arXiv preprint arXiv:2503.06890*.

- [2] De Petris, P., Nguyen, H., Dharmadhikari, M., Kulkarni, M., Khedekar, N., Mascarich, F., & Alexis, K. (2022, June). Rmf-owl: A collision-tolerant flying robot for autonomous subterranean exploration. In *2022 International Conference on Unmanned Aircraft Systems (ICUAS)* (pp. 536-543). IEEE.

- [3] Foehn, P., Kaufmann, E., Romero, A., Penicka, R., Sun, S., Bauersfeld, L., ... & Scaramuzza, D. (2022). Agilicious: Open-source and open-hardware agile quadrotor for vision-based flight. *Science robotics*, *7*(67), eabl6259.

Thank you!

Georgia Tech