UC DAVIS
MECHANICAL AND AEROSPACE ENGINEERING

RECONFIGURABLE UAV SWARMS

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INTRODUCTION

The goal of this project was to connect and disconnect two quadrotor drones in-flight by means of a mechanical arm. The motivation for this project was to enhance drone productivity by adding docking mechanisms that allow them to lift heavier loads once connected.

DESIGN REQUIREMENTS

- \$1,000 budget
- Distance between drones ≥ 13.6in
- Unit mass ≤ 1kg
- Run time ≥ 15min
- Self powered
- Controlled remotely
- Use VR cameras to help pilots connect units on separate drones

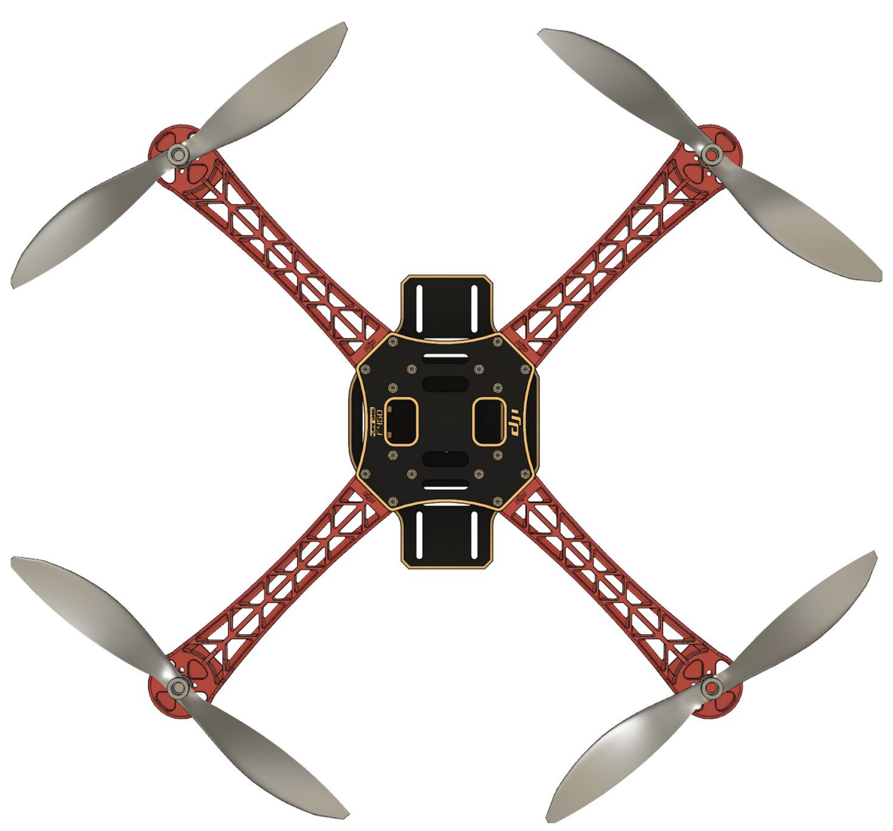


Figure 1: Custom Drone, CHPS Lab

HARDWARE SELECTION

Component	Purpose
Raspberry Pi 3	Process controls and store data
Pi Power/A23/3B24-XA	Supply power to components
VR Camera	Provide visuals of connection
Electromagnet	Connect drones together
Relay Switch	Control and power the magnets
Stepper Motor	Retract and extend arms
Stepper Driver	Control the motor
100µF Capacitor	Regulate power into the driver

DESIGN CHALLENGES

- Maintaining structural integrity while removing material to reduce overall unit mass
- Affordability of compact electrical components
- Predicting environmental conditions around the drone

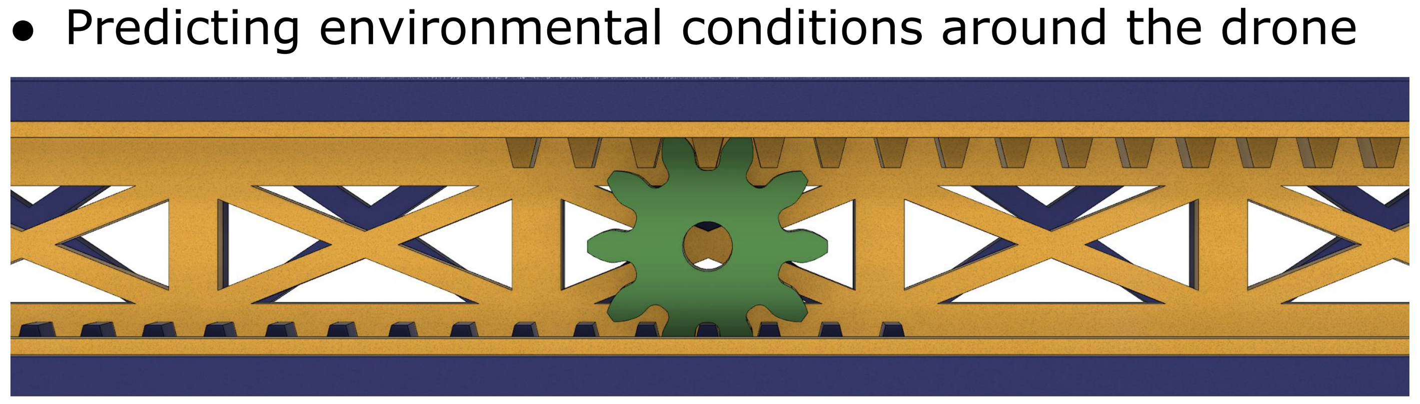
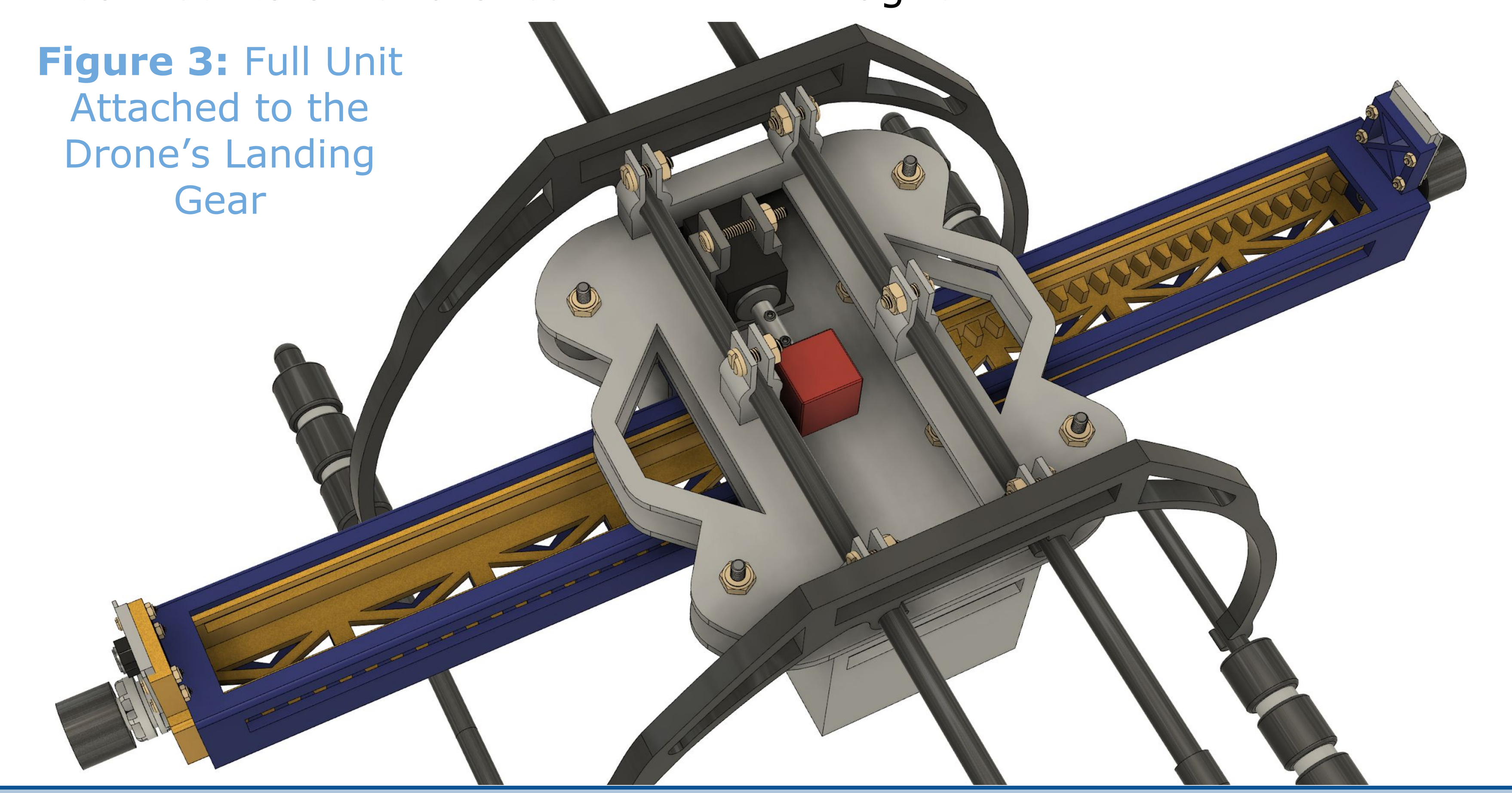


Figure 2: Spur Gear Meshed With Both Arms

DESIGN DESCRIPTION

- Two telescoping arms driven by a spur gear
- Worm gearbox to prevent back driving of the arms
- Electromagnets at arm ends to connect to other drones
- Dampers in place throughout to reduce vibration
- Unit attaches to the landing gear, not the drone itself
- VR camera mounted above each magnet

Figure 3: Full Unit Attached to the Drone's Landing Gear



SYSTEM OVERVIEW

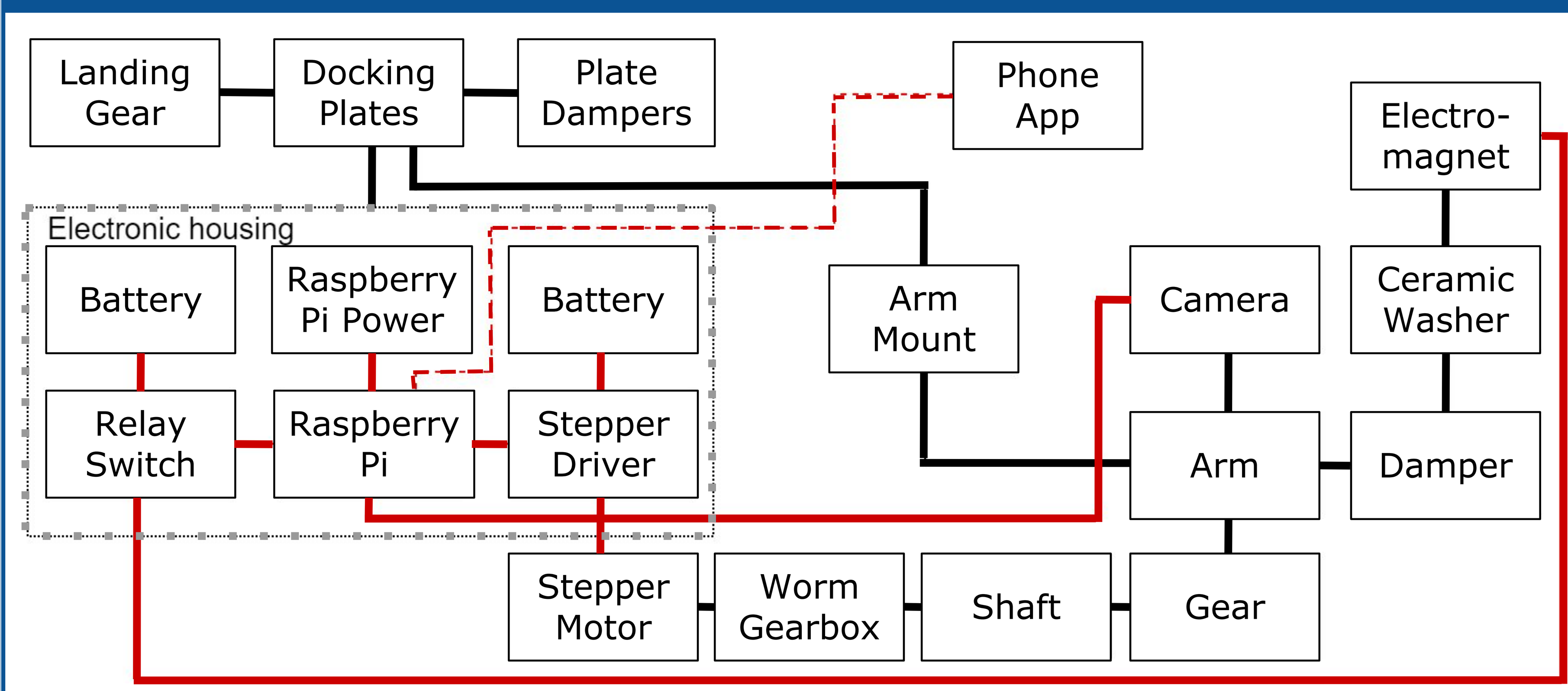


Figure 4: Functional Hierarchy Diagram

MANUFACTURING

Out of 12 custom parts, 10 are 3D printed with PETG, while the others are aluminum and machined using a lathe.

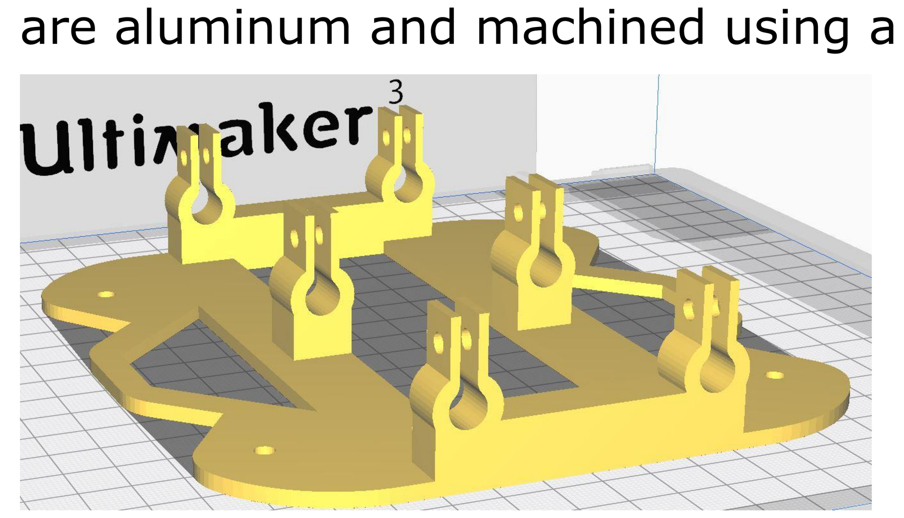


Figure 5: Top Plate STL

- Printer settings: 0.4mm nozzle, 30% tri-hexagon infill and 0.8mm thick walls
- All 10 parts printed vertically in relation to their unit assembly position
- All prototyping completed in the ESDC

CIRCUIT AND CODE

- Raspberry Pi 3 was selected for its wifi capabilities
- Unit controlled over wifi through a phone application
- Batteries selected for individual component needs

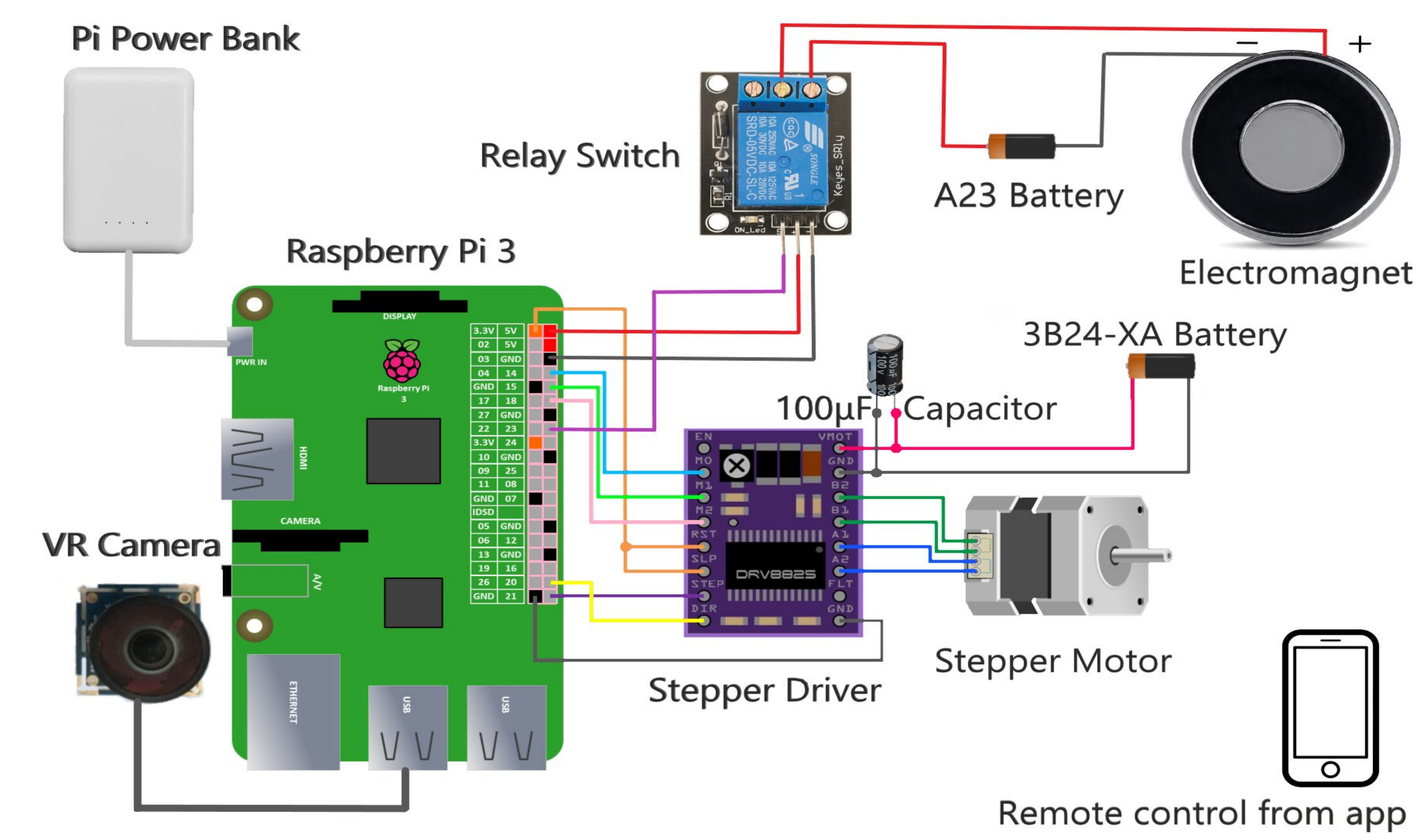


Figure 6: Circuit Diagram

FAILURE ANALYSIS

Finite Elements Analysis (FEA) was performed on five components, selected for analysis through DFMEA: the top plate, inner arm, outer arm and both shafts.

All 12 custom manufactured components passed the analysis with:

- Safety Factor > 5.4
- Cycles before failure > 3,000

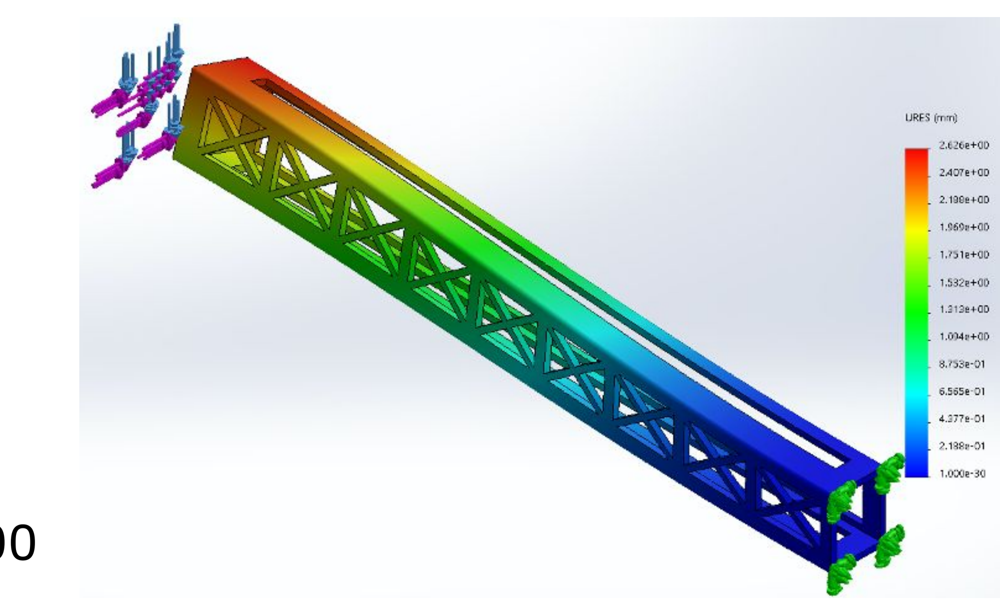


Figure 7: Outer Arm Displacement Study

FUTURE WORK

- Test payload capacity for two drones when connected
- Reduce dimensions for over-designed components
- 3D print parts with lighter materials
- Mid-air unit recharging
- Usage for package delivery, construction, and defense

ACKNOWLEDGEMENTS

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