D.R.O.P. - Delivery Robot with ‘Otonomous’ Parachute

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- Scenario: Emergency delivery of medicine or blood to remote areas

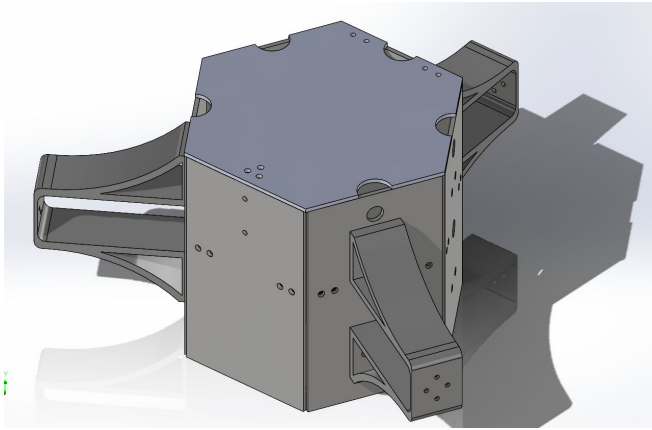
- Solution: Self-guided airdrop device that is
  - Precise
  - Cost-Effective

Solution Approach

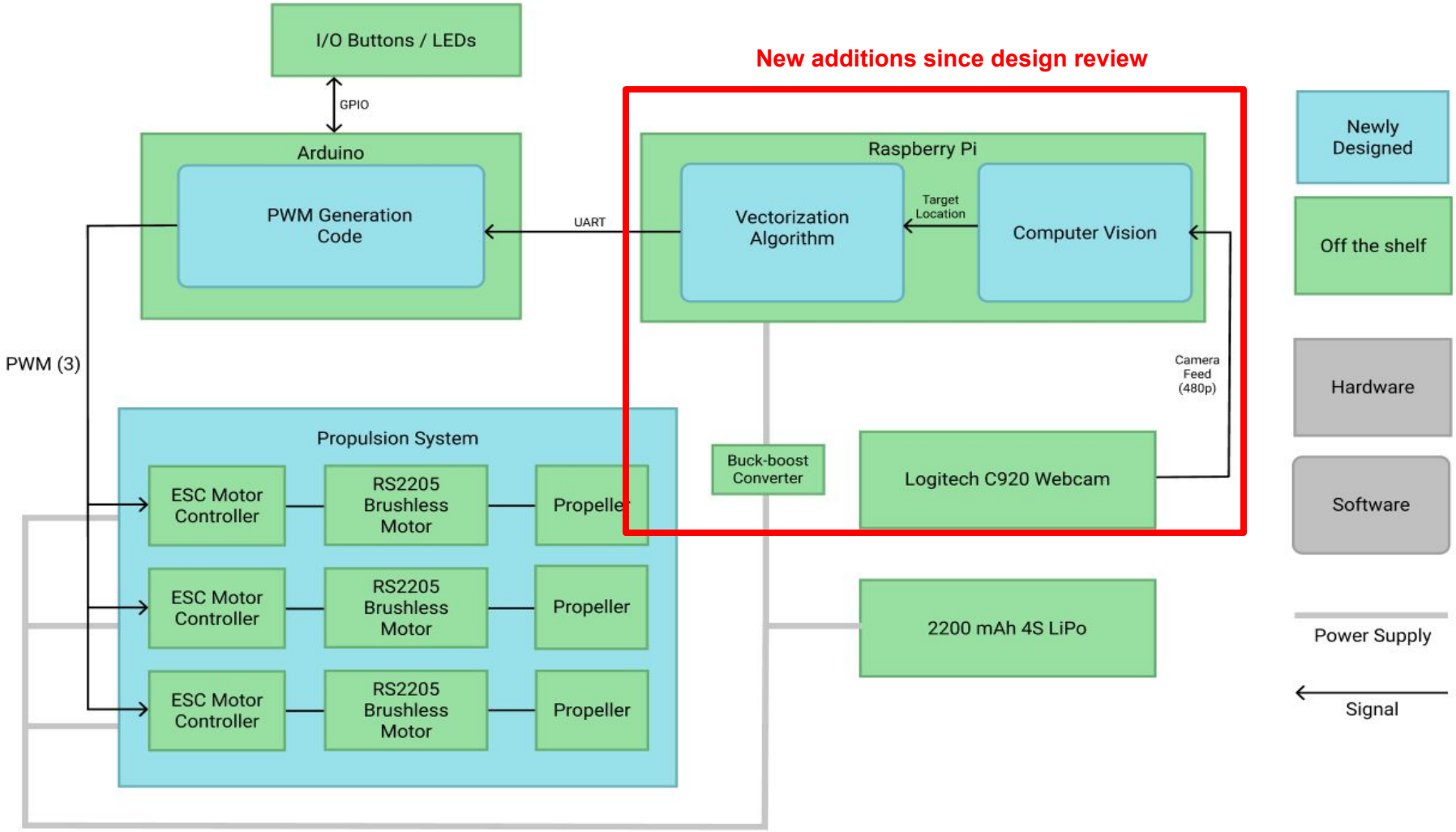
- Main Subsystems
  - Perception via webcam, computer vision
  - Propulsion via brushless motors and propellers

- Key changes since Design Review
  - Camera instead of antennas
  - Arms to improve thrust

Proposed housing

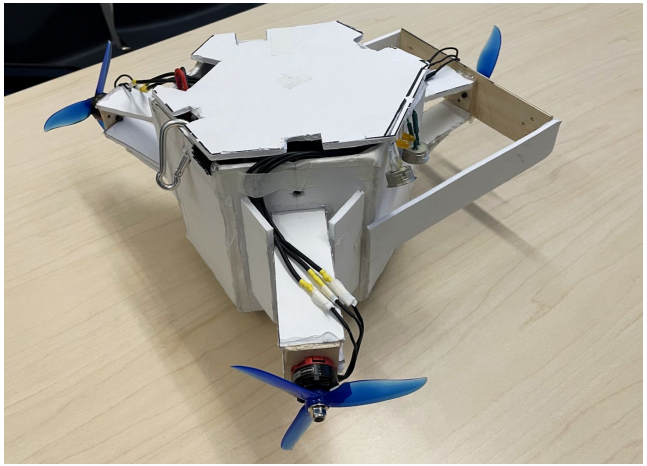


Final housing

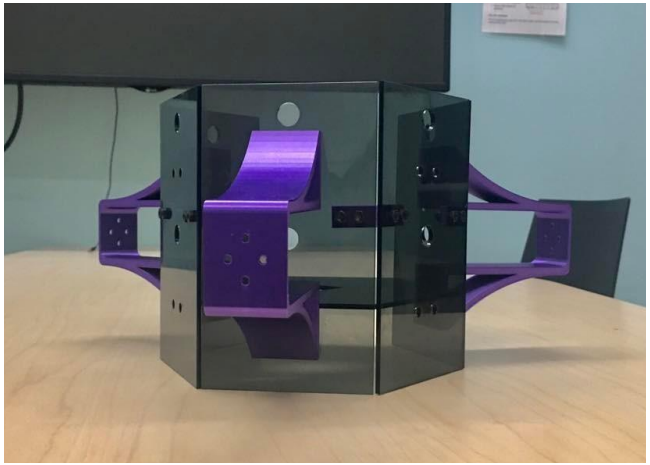

I/O Buttons / LEDs
GPIO
Arduino
PWM Generation Code
UART
Raspberry Pi
Vectorization Algorithm
Target Location
Computer Vision
New additions since design review
PWM (3)
Camera Feed (480p)
Propulsion System
ESC Motor Controller
RS2205 Brushless Motor
Propeller
ESC Motor Controller
RS2205 Brushless Motor
Propeller
ESC Motor Controller
RS2205 Brushless Motor
Propeller
Buck-boost Converter
Logitech C920 Webcam
2200 mAh 4S LiPo
Newly Designed
Off the shelf
Hardware
Software
Power Supply
Signal

Complete Solution

- Construction
  - Foamcore body, 3 angled propellers
  - Hexagonal shape
- Computer Vision
  - Thresholding, Circle Detection (HoughCircles), Tracking
- Direction-Finding
  - Convert direction in pixel space to 3 PWM values



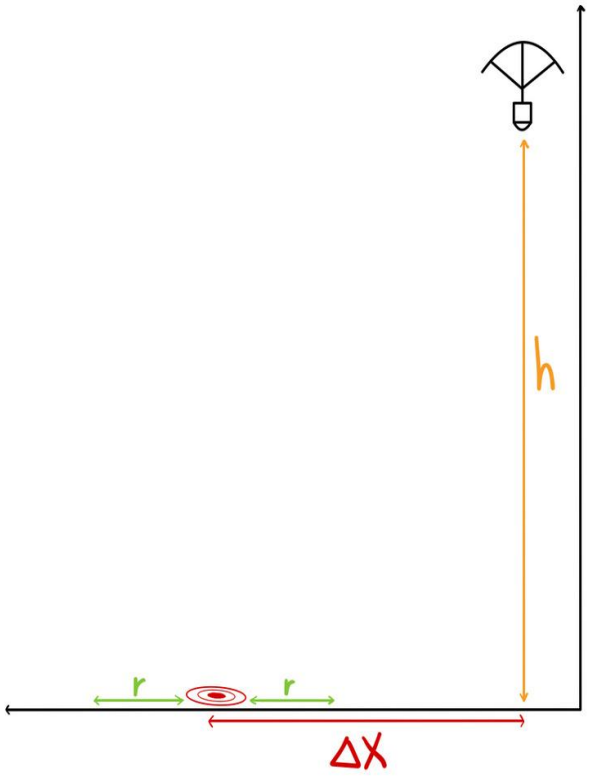
Prototype housing



Final housing

Requirements Overview

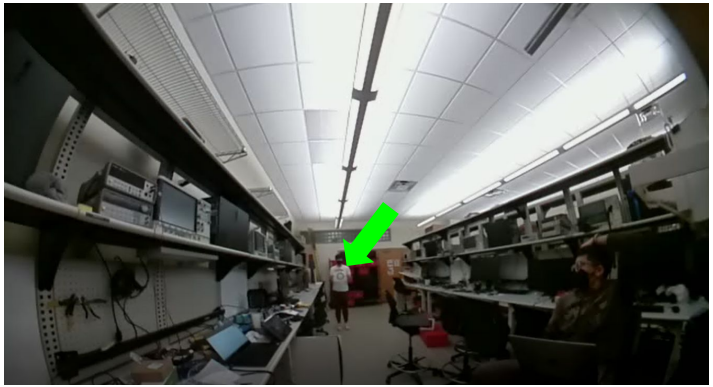
Requirement	Goal	Actual
Payload Weight	450g	450g
Initial Lateral Distance (Δx)	3m	4m
Average Landing Distance (r)	1m	2.08m

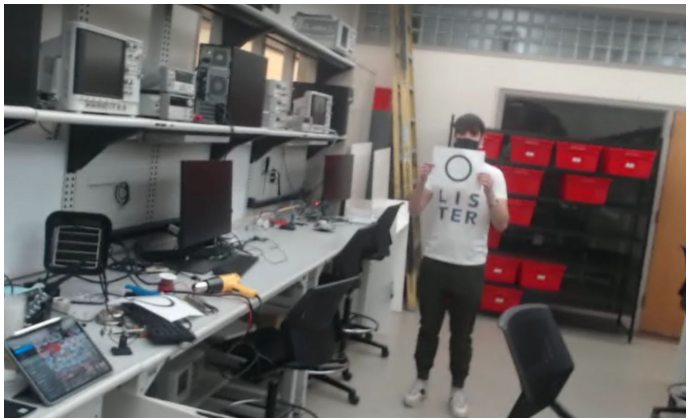


Drop test parameters

Trade-offs: Camera Lens

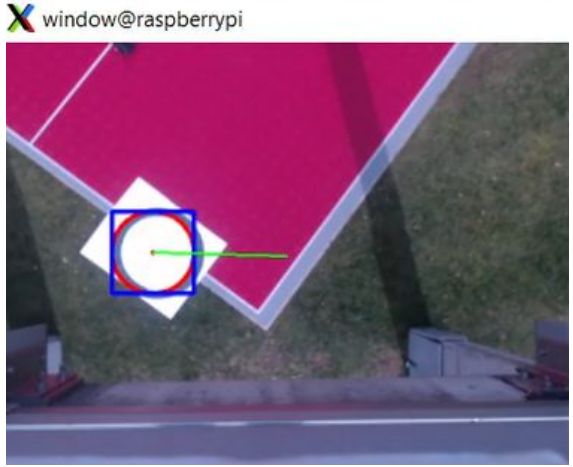
- Fisheye (160°) vs Equirectangular (78°)
- Equirectangular has better detection
- Fisheye has larger FoV
  - Detection impossible due to distortion (0%)
- **Choice: Equirectangular**
  - Detection drops off at 4m lateral distance
  - Much better detection rate

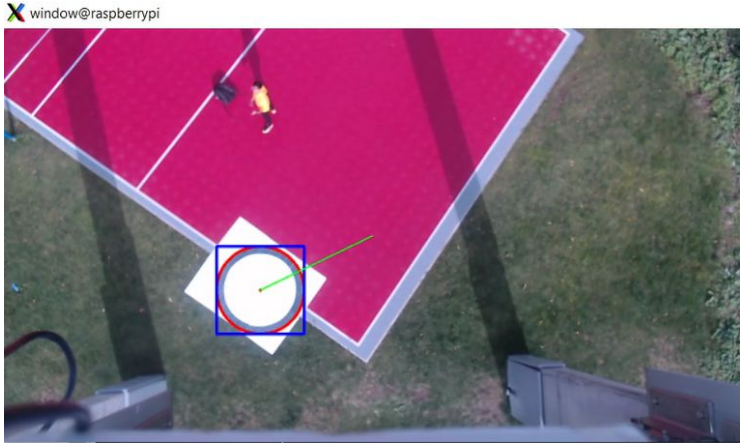




Trade-offs: Image Resolution

- 640x480 vs 1280x720
- 640x480 offers higher frame rate
- 1280x720 offers higher detection rate
- **Choice: 640x480**
  - Frame rate is >3x higher: 8 FPS vs 2.7 FPS
  - Detection rate is only 16% lower: 62% vs 78%



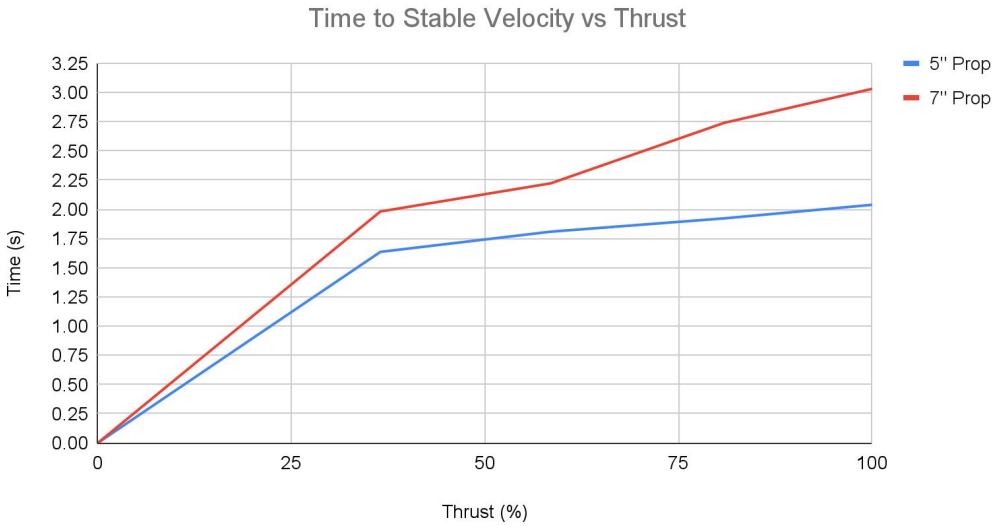


Trade-offs: Propulsion

- Battery: 4S vs 3S (16.8V vs 12.6V)
  - 4S heavier by 30g, 60% more thrust
  - 4S is more capable of moving the device
  - **Choice: 4S**

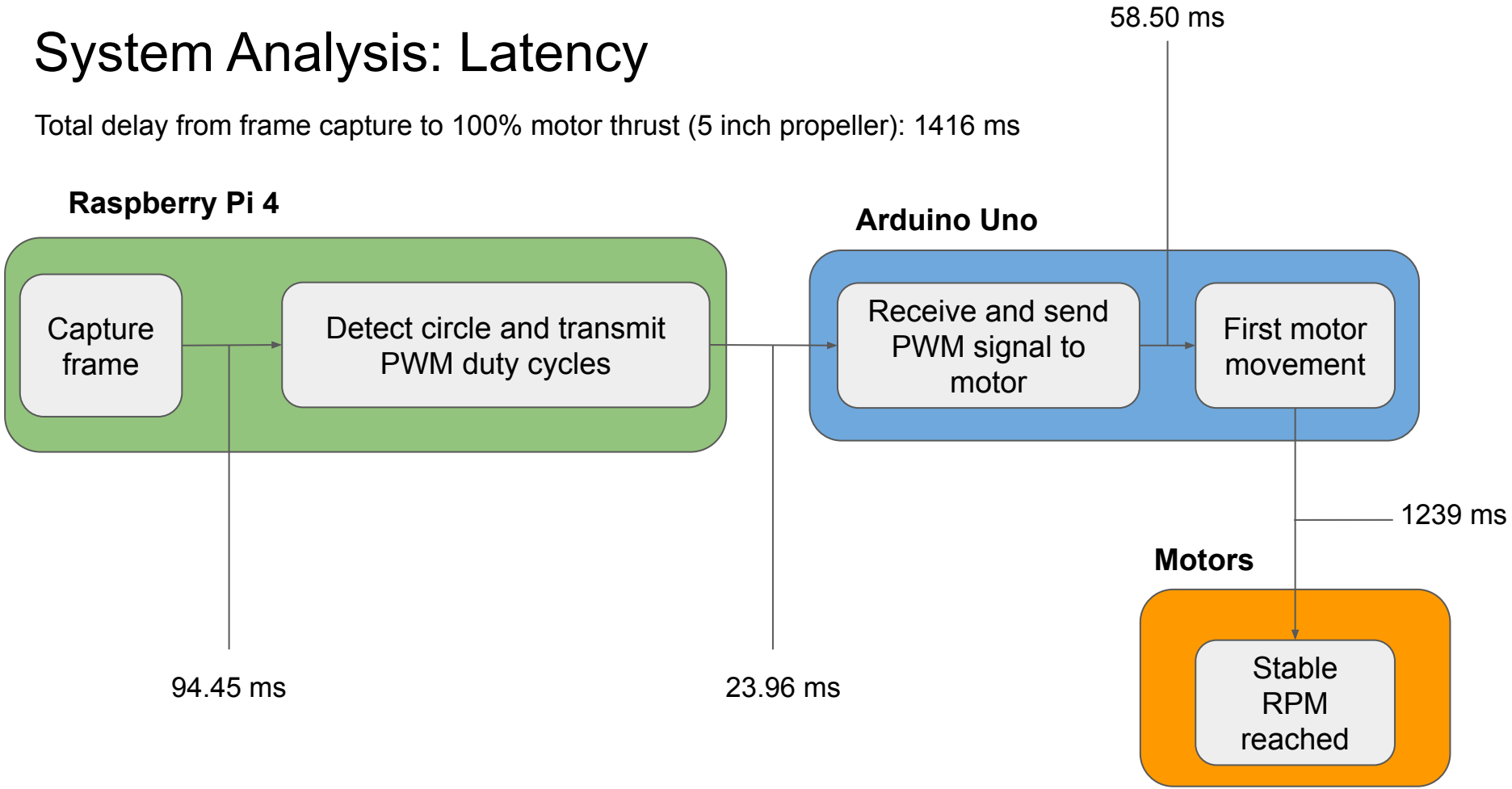
- Propellers: 5” vs 7”
  - 7” provides more thrust, but takes more time to ramp up
  - Impacts possible motor operations per second
  - 7” propeller has heat issue
  - **Choice: 5”**

Propeller Size / Battery Size	5 inches	7 inches
3S	402g	510g
4S	670g	815g



System Analysis: Latency

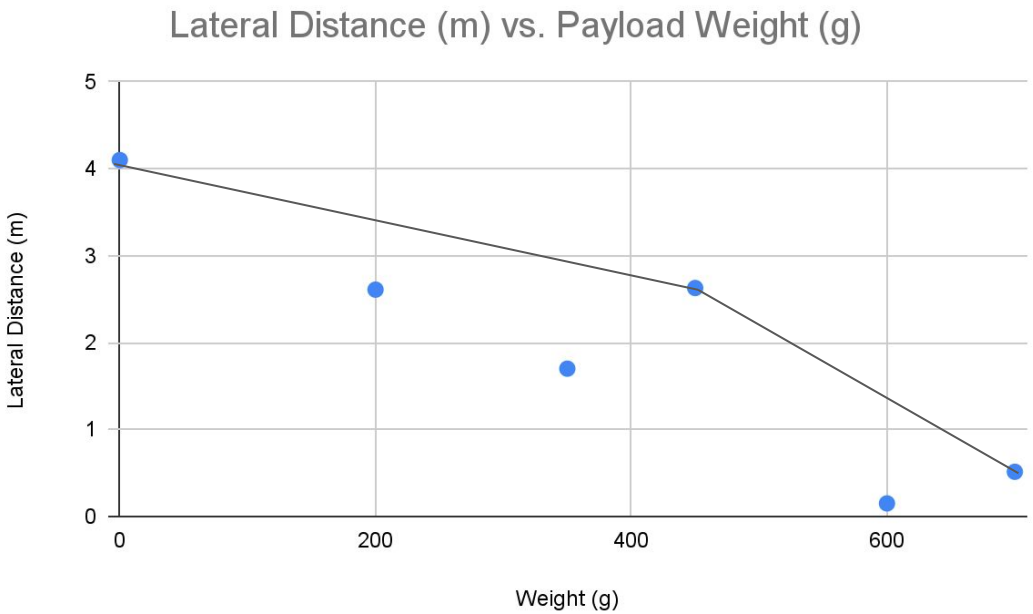
Total delay from frame capture to 100% motor thrust (5 inch propeller): 1416 ms



System Analysis: Pareto Tradeoff

- Use case tradeoffs between payload weight and measured lateral movement

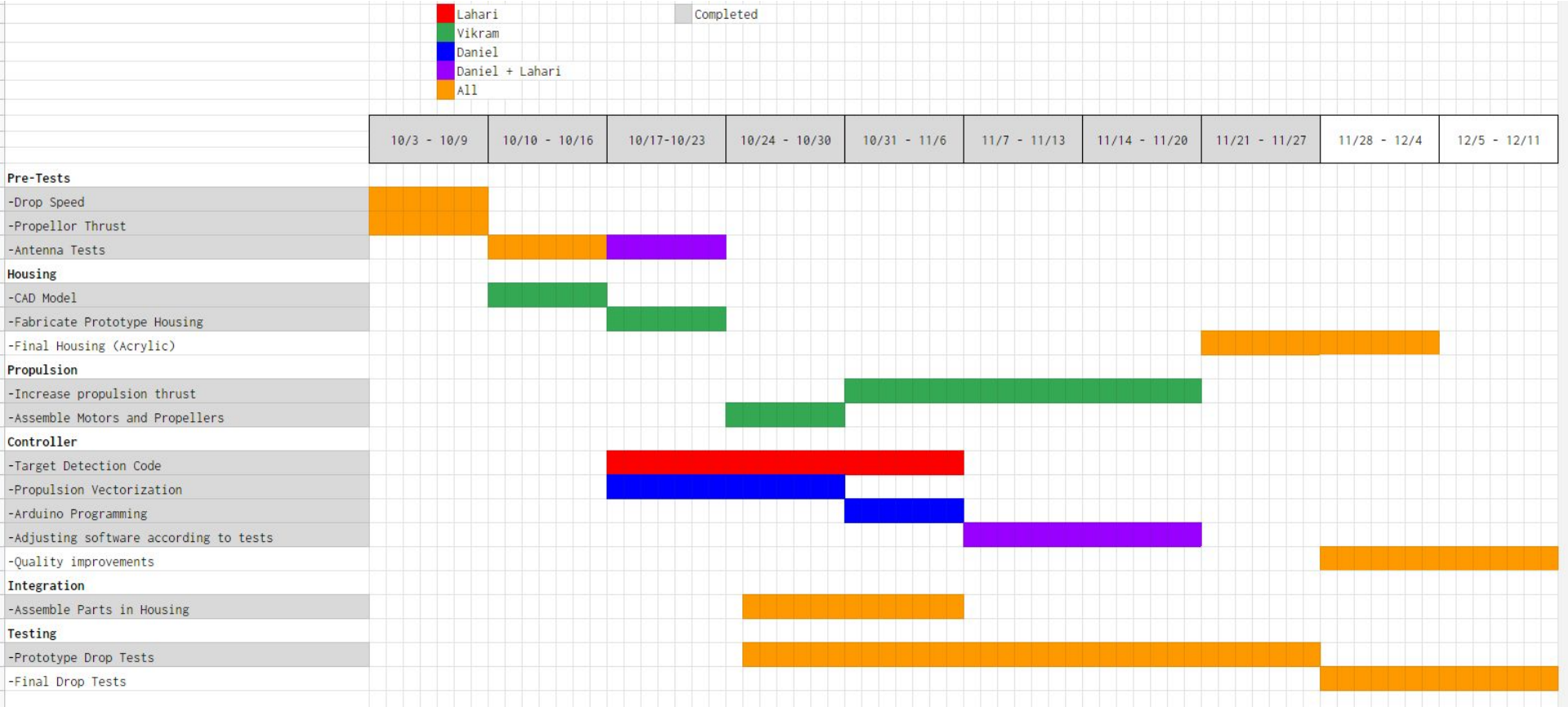
- Dropping with multiple payload weights at maximum thrust to get maximum lateral movement



Full System Testing

- Drops off the Pausch bridge:
  - Height: 13.1 meters
  - Lateral distance: 4 meters
  - 2 diameter circular target

- Measure distance from device to center of circle


Lahari
Vikram
Daniel
Daniel + Lahari
All
Completed
10/3 - 10/9
10/10 - 10/16
10/17-10/23
10/24 - 10/30
10/31 - 11/6
11/7 - 11/13
11/14 - 11/20
11/21 - 11/27
11/28 - 12/4
12/5 - 12/11
Pre-Tests
-Drop Speed
-Propellor Thrust
-Antenna Tests
Housing
-CAD Model
-Fabricate Prototype Housing
-Final Housing (Acrylic)
Propulsion
-Increase propulsion thrust
-Assemble Motors and Propellers
Controller
-Target Detection Code
-Propulsion Vectorization
-Arduino Programming
-Adjusting software according to tests
-Quality improvements
Integration
-Assemble Parts in Housing
Testing
-Prototype Drop Tests
-Final Drop Tests