Autonomous UAV Capstone

Status Presentation III

1/c Domenico Bulone
1/c Matthew Kim
1/c Gavin McGahey
1/c Cody Meyers
1/c Jacob Schellman
1/c Ryan Von Brock

Advisors:

Professor Hartnett
Lieutenant Blanco
Professor Swaszek

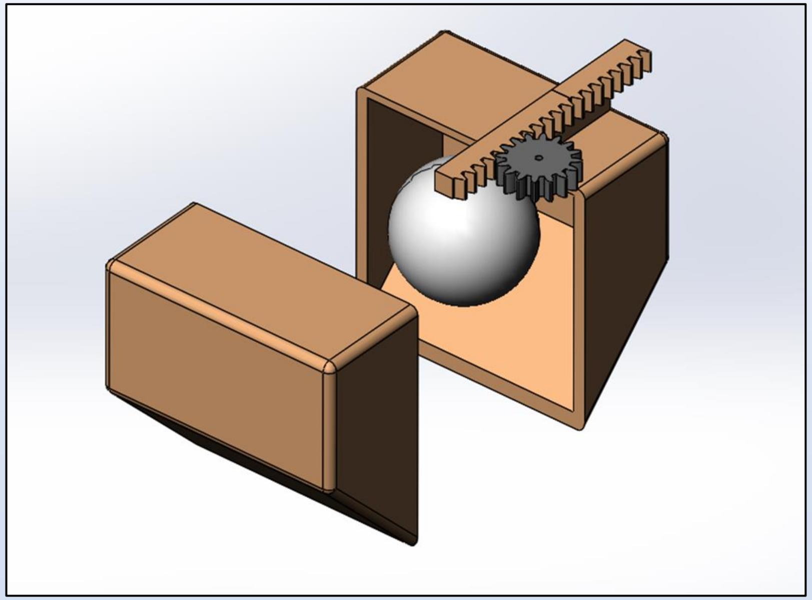
December 10th, 2021

Mission Needs Statement

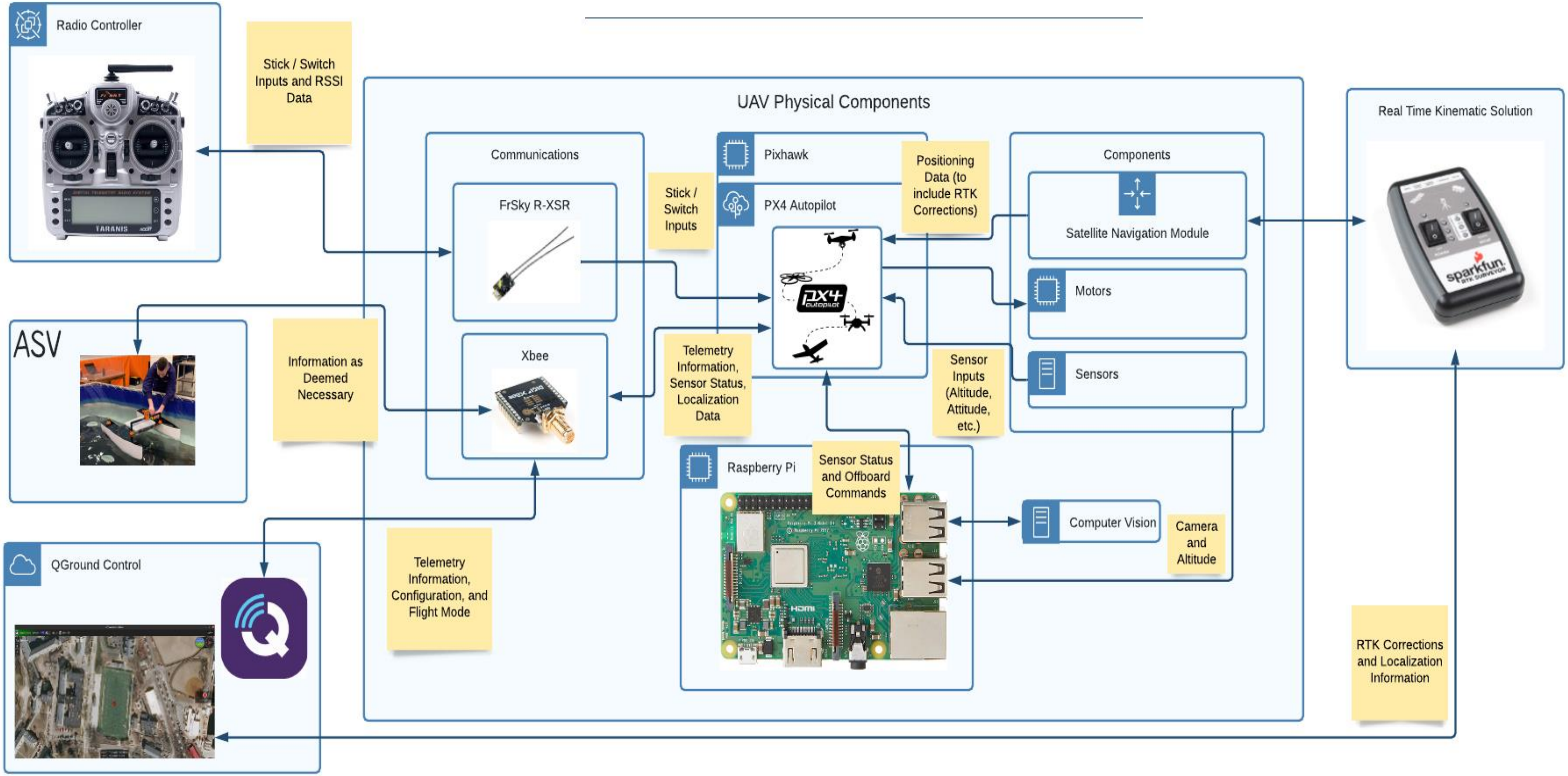
- To design a low cost, open architecture, and cooperative autonomous quadcopter.
  - USCG Missions
  - Supplement success of ScanEagle
- Key Performance Parameters:
  - Stable, autonomous flight
  - Transporting small payloads
  - Coordinate objectives with the ASV
  - Takeoff and landing from the ASV

Platform Requirements

Requirement	Solution
Weigh less than 10 pounds (T), ideally 5 pounds (O).	Small Platform: 3.05 pounds.
Be capable of precision navigation, ideally 10cm (O).	Equipped with GPS-RTK, Lidar, and a camera.
Capable of transporting small objects.	Servo Actuated close/release mechanism.
Positively buoyancy in water for 120 seconds (T), or indefinitely (O).	Foam outriggers underneath propellers. 5.1 lbs of buoyant force.
Safety guidelines: remote kill switch, not exceed 60 V DC.	Remote kill switch configured on RC transmitter. Utilizes an 11.1 V LiPo battery.
Total cost to reproduce less than $1,000 (O).	Current sum of components is approximately $700.

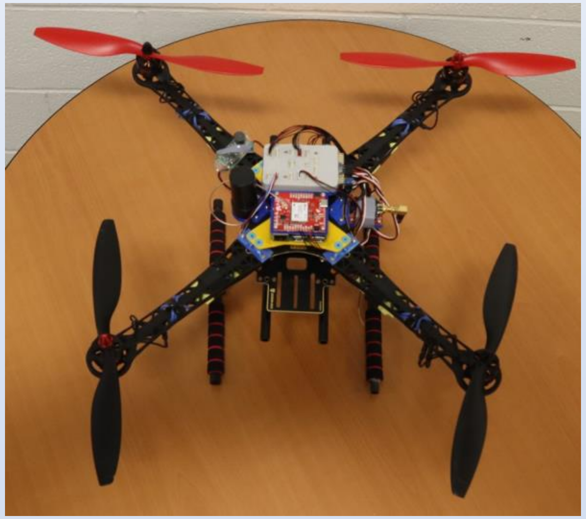


PX4 with Pixhawk Flight Controller



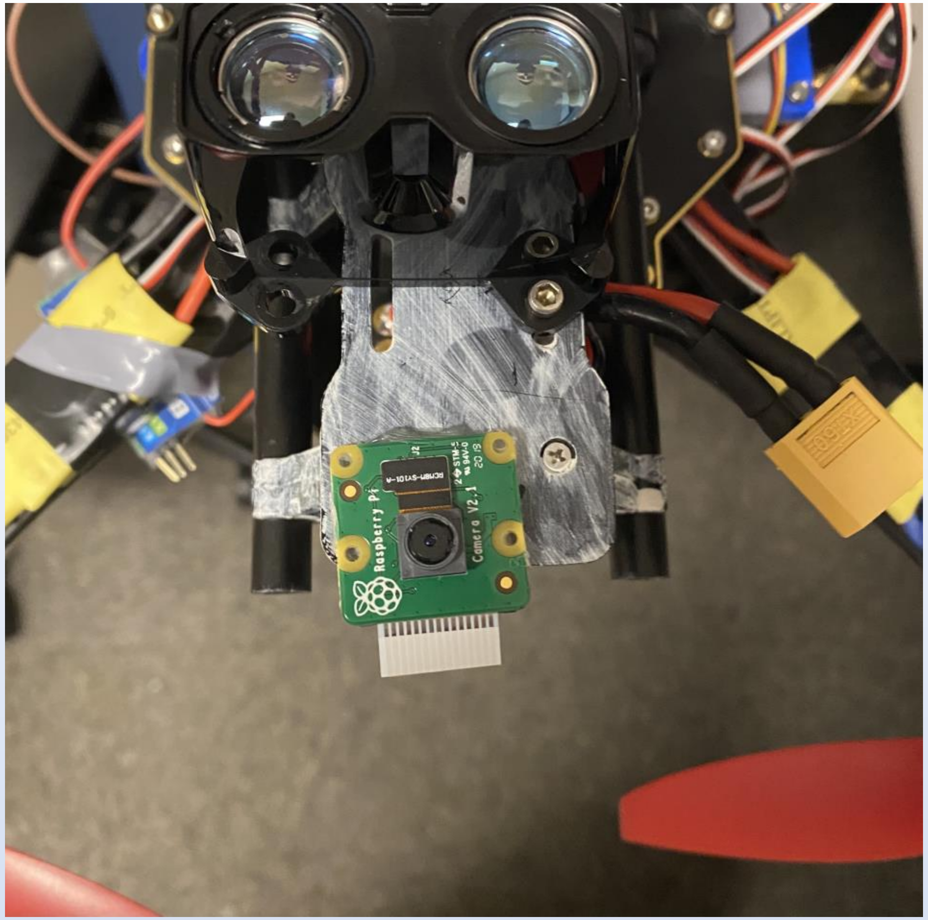
Satellite Navigation with RTK

- Improved accuracy assists ASV
- NAVIO2 GPS Receiver:
  - Existing Alterative: 2.5 ft accuracy
- Sparkfun Real-Time Kinematic:
  - Established RTK Base-Station position of 16mm
  - Theoretical RTK correction accuracy of 24mm



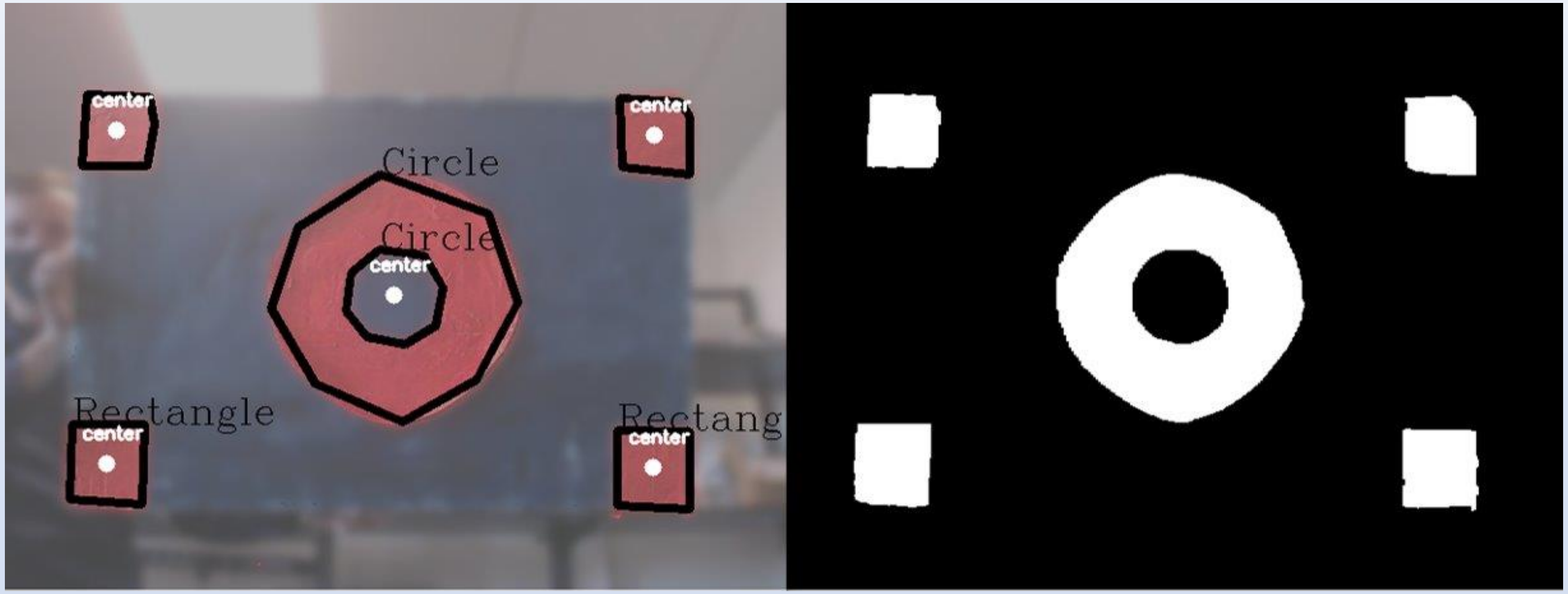
Computer Vision

- Designing the landing pad picture
- Camera implementation
- Raspberry Pi Setup
- Apply image processing algorithm
- Communication with the controller



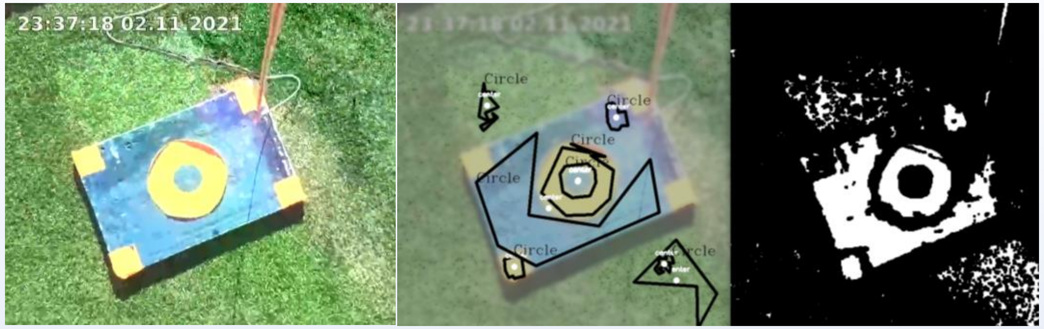
Computer Vision Testing

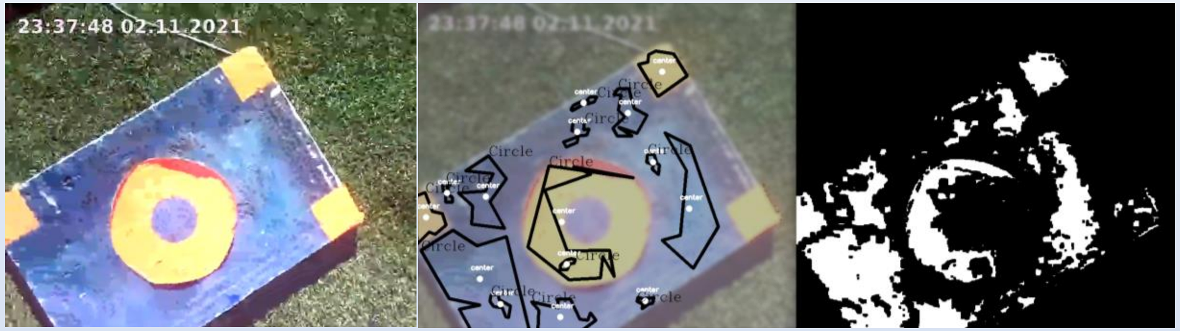
- In-Lab Tests
- Detecting red rectangles and circles, finds centroids



Computer Vision Testing

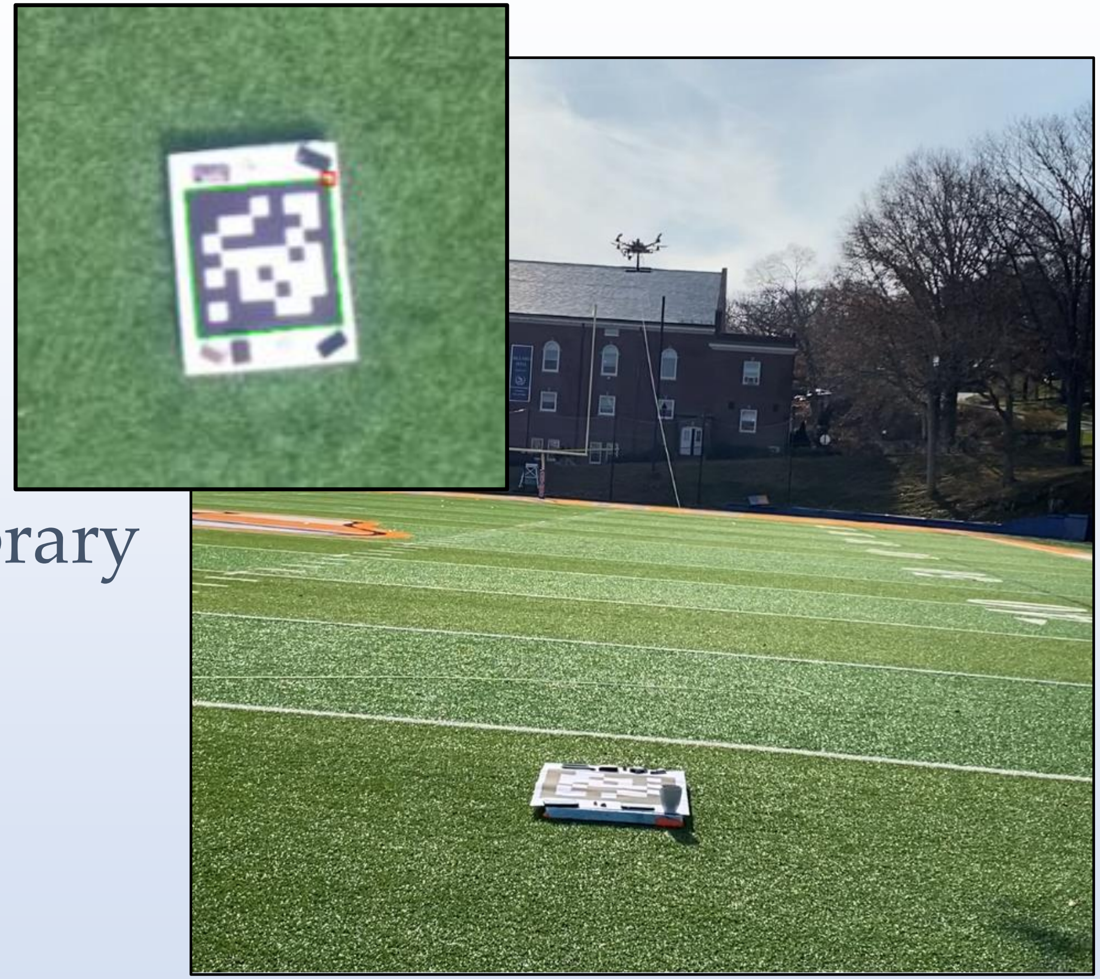
- Field tests not as successful
- Refine color values
- Onboard recording script





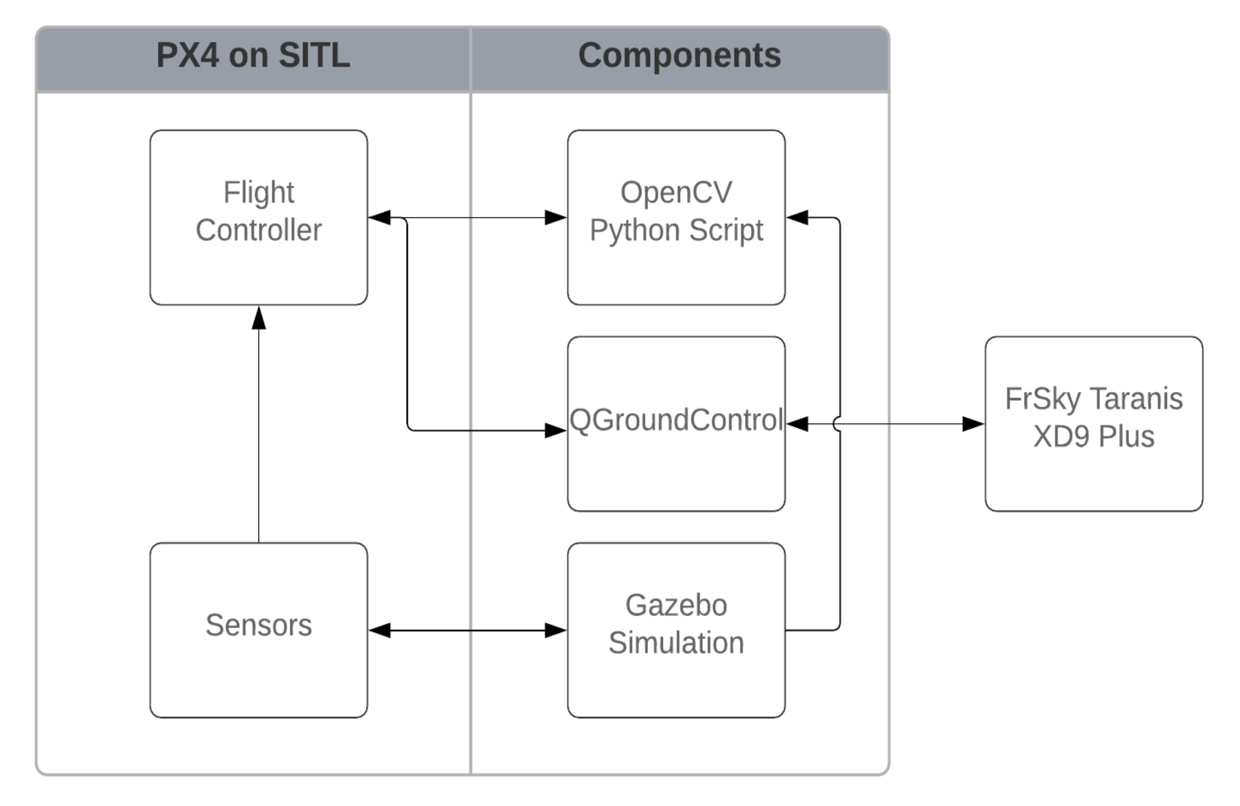
Computer Vision Testing

- ArUco markers
- Pre-determined matrix & database
- Pre-made algorithm in OpenCV library
- ~30 feet in ideal conditions with Pi
- Image smoothing to extend range



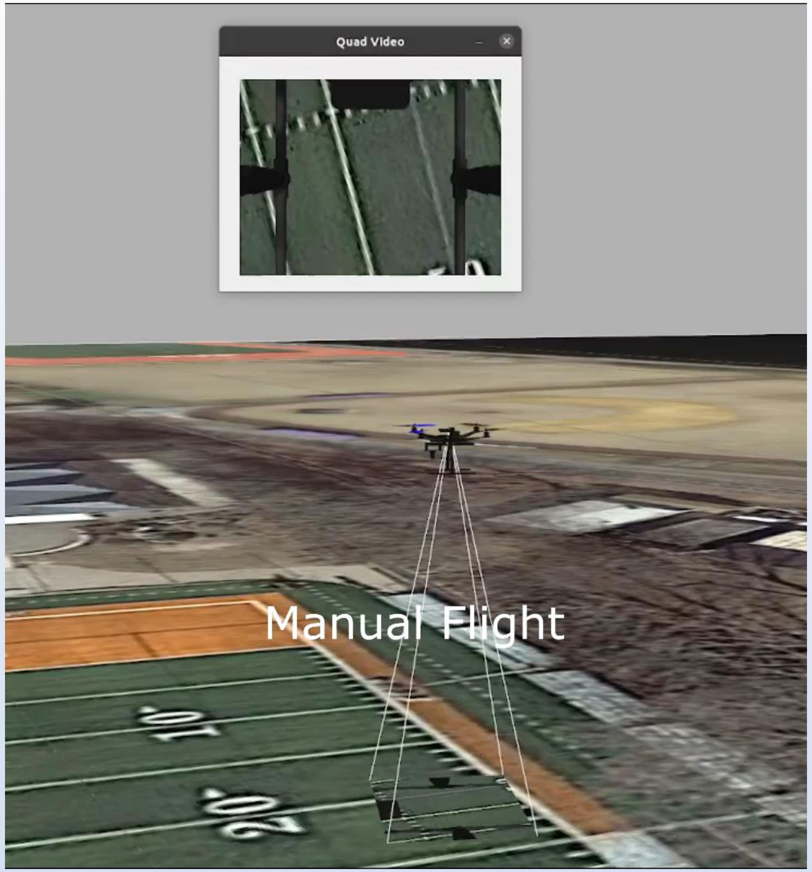
Software in the Loop (SITL) Simulation

- Gazebo Simulation Environment
  - An open-source, high-performance physics engine
- PX4 – Gazebo SITL Simulation
  - Rapid, risk-free testing
  - Merge different workflows



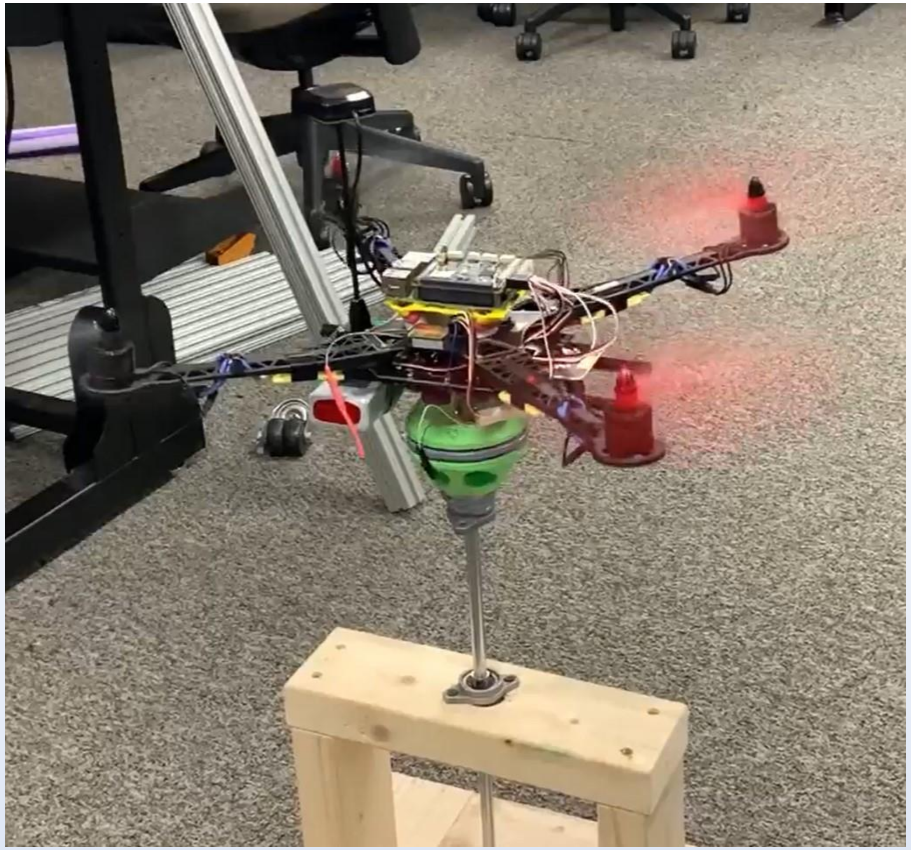
Software in the Loop (SITL) Simulation

- Gazebo Simulation Environment
  - An open-source, high-performance physics engine.
- PX4 – Gazebo SITL Simulation
  - Rapid, risk-free testing.
  - Merge different workflows.



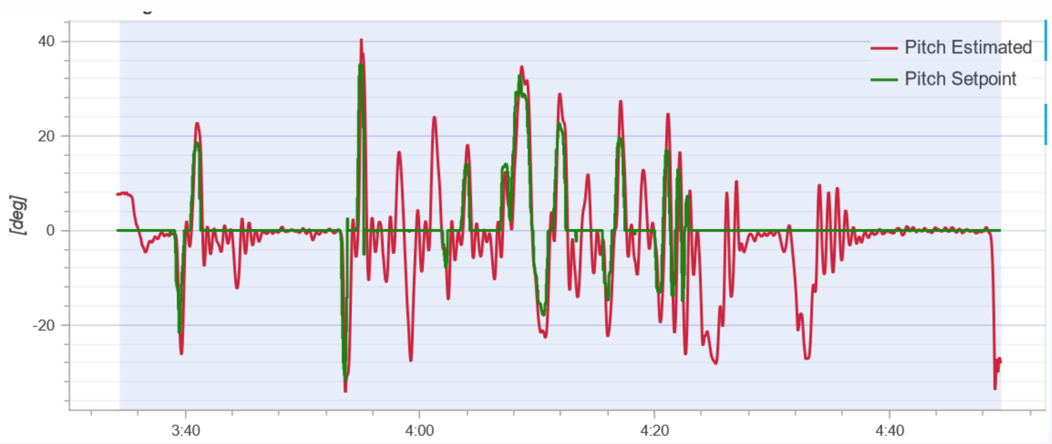
Flight Testing

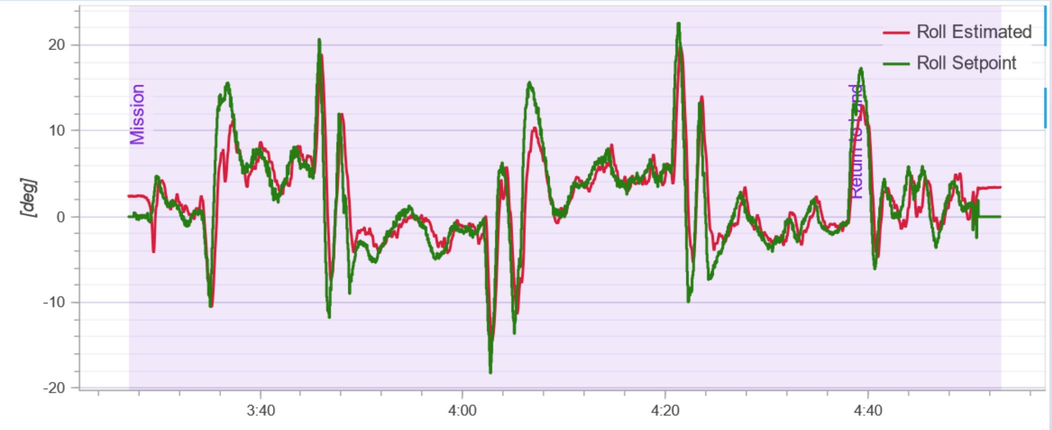
- Manual Flight Mode:
  - Achieved a tuned attitude controller
  - Established communication
- Autonomous Flight Mode:
  - Preplanned missions, waypoints, and search patterns
- Offboard Flight Mode:
  - Velocity based command



Flight Testing

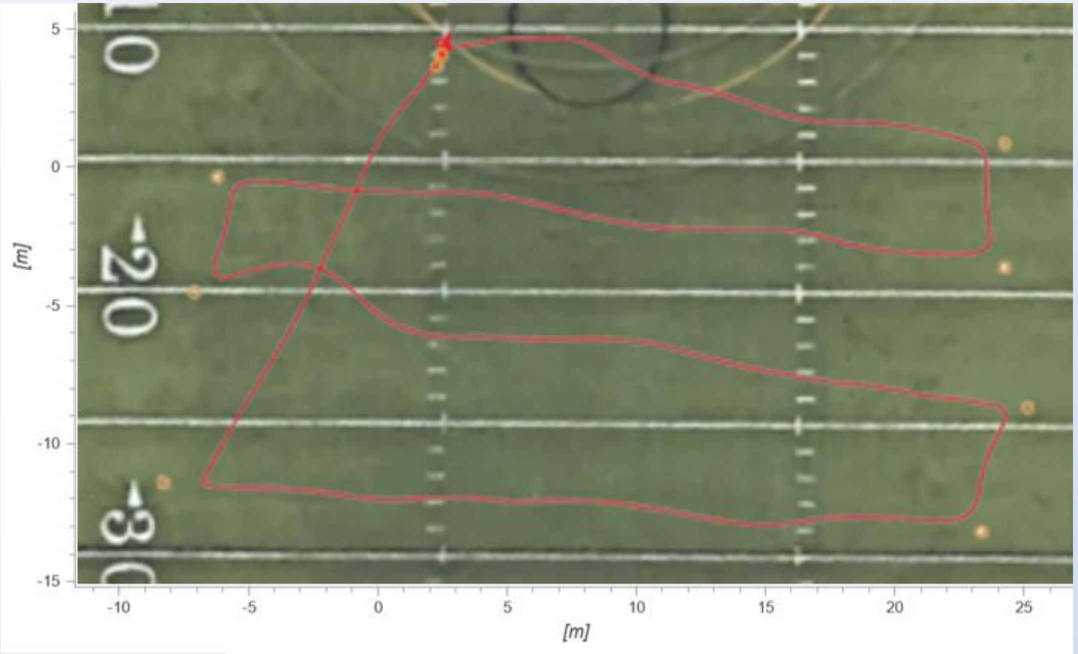
- Manual Flight Mode:
  - Achieved a tuned attitude controller
  - Established communication
- Autonomous Flight Mode:
  - Preplanned missions, waypoints, and search patterns
- Offboard Flight Mode:
  - Velocity based command



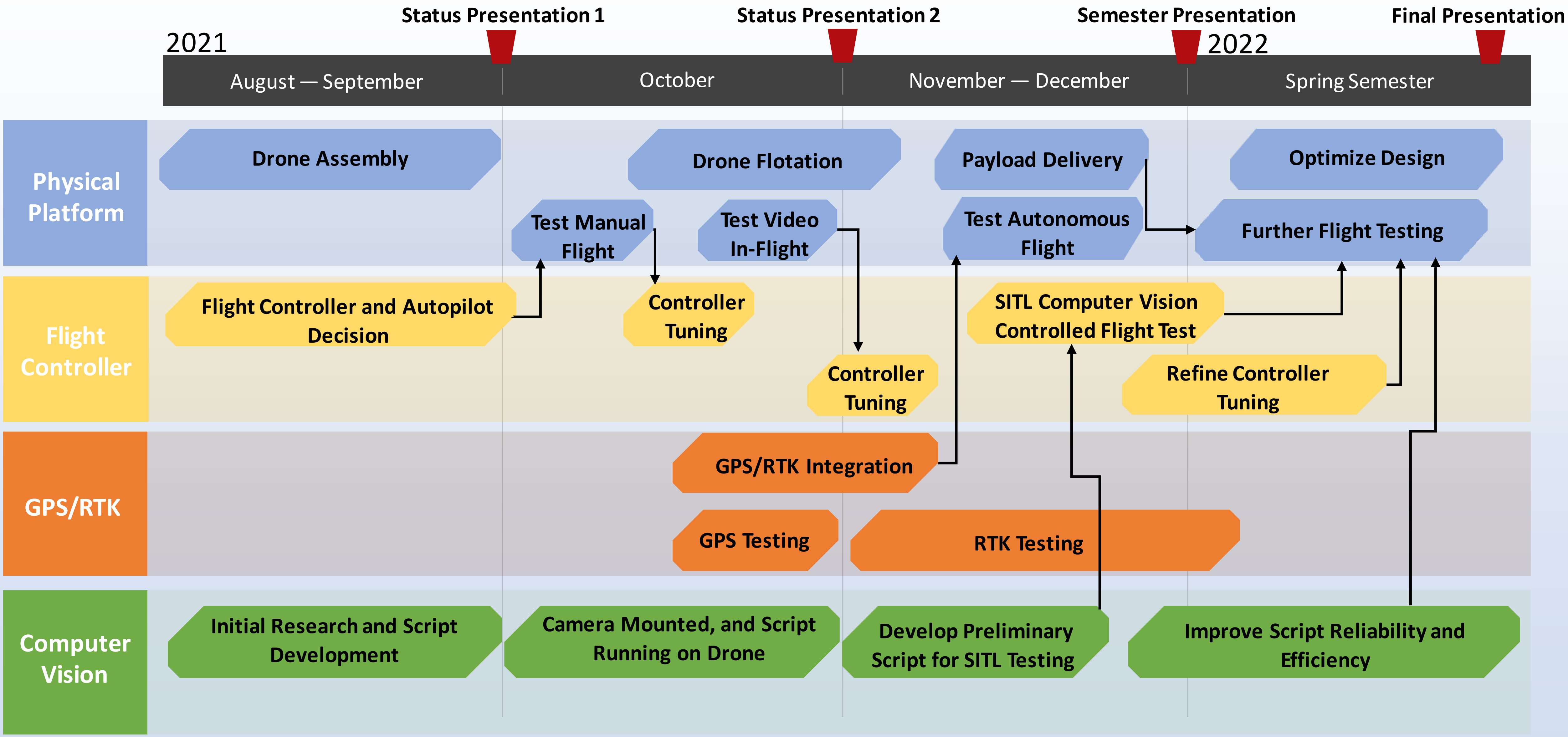


Flight Testing

- Manual Flight Mode:
  - Achieved a tuned attitude controller
  - Established communication
- Autonomous Flight Mode:
  - Preplanned missions, waypoints, and search patterns
- Offboard Flight Mode:
  - Velocity based command.



Research Progression



Questions?

Budget

Major Costs:

- S500 Frame: $59
- Motors: $100
- Raspberry Pi 3B+: $55
- Pixhawk 2.4.8: $75
- RTK: $350

Approximate Drone Cost: $700

Future Costs:

- No anticipated additions to drone
- Dedicated computing resources will add additional costs (on hand versus new acquisition)
- Maintenance costs

The RoboBoat Competition

- RoboBoat is an international competition where an autonomous surface vessel performs navigating and docking tasks.
- Each ASV is allowed to cooperate with a UAV.
- Our role as the UAV:
  - Takeoff from and land on the ASV.
  - Locate and deliver a payload.
  - Fly desired search patterns.
  - Communicate findings with the ASV.

Entrance Criteria

- Have you reviewed comments/questions from Status Presentation # 2? Are you able to provide answers if the same question arises again?
- Has the project implemented effective systems engineering processes?
- Have you completed the detailed design based on the Allocated baseline?

Computer Vision

Designing flight deck image

Camera usage

Raspberry Pi Setup

OpenCV on Pi

Communication to controller

Utilize image processing algorithm

Exit Criteria

- Have all allocated requirements in the allocated baseline been captured in the detail design for each Configuration Item?
- How well have you documented the design decisions made in establishing the developmental baseline?
- **Has the hardware and software design been specified in sufficient detail that a different teams could continue development without any additional information from the design team?**
- What tests have you conducted so far, and what additional tests are planned?
- Are procedures in place for correcting deficiencies identified during system integration processes?

General thoughts on presentation

- There is a small nuance between PDR and CDR…in other words there may not be a whole lot more "new" work to present…..so use this as an opportunity to summarize your entire semester.
- The CDR construct portrays the level of detail you should be at as the semester closes.
- Status presentation 3 should be the culminating presentation of everything you have done this semester.
- Find a way to show off the hard work you have put in
- Most importantly talk about where you plan to go next semester.

Stakeholder Analysis

Leading Advisors:

Professor Hartnett and LT Blanco

Additional Support:

Professor Swaszek and LCDR Veara

Interested Groups:

CG Research Development Center and CG UAS Program

Key Design Decisions

- Xbee Communication
  - Xbee range statistic.