Autonomous UAV Capstone

Status Presentation V

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Mission Needs Statement

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

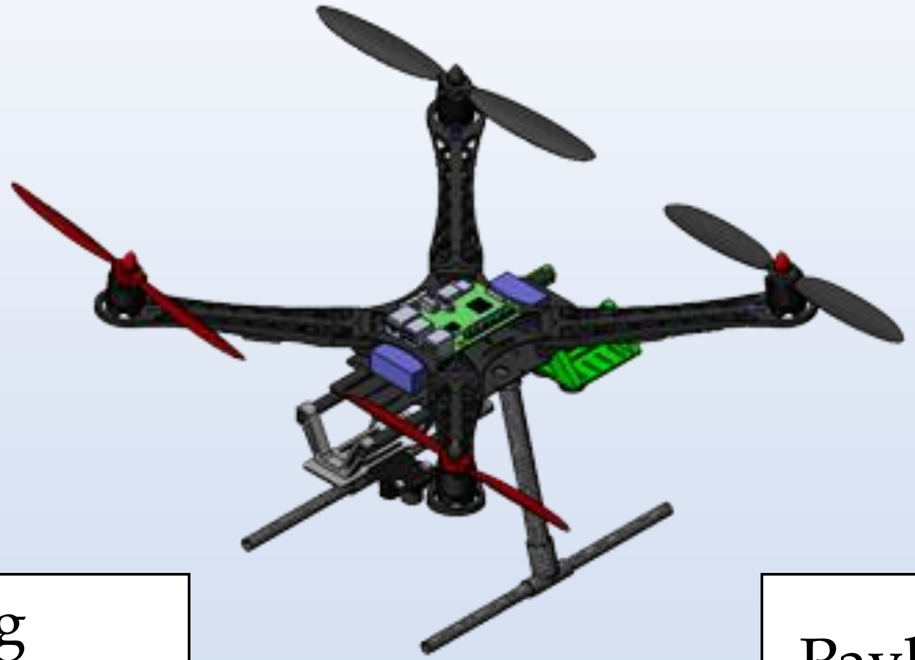
Major Developmental Systems

Communications

Computer Vision

Drone Control

Satellite Navigation



Landing Assembly

Payload Delivery

Drone Hardware & Physical Specifications

- Built on S500 Platform (Total Weight = 3.4 lb)
- Flight Controller: PixHawk 2.4.8
- Microprocessor: Raspberry Pi 4
- Communications: Xbee Series 3, RC XMIT/RCV
- Navigation: LIDAR, ZED-FP9, Raspberry Pi Camera
- Power Supply: 11.1 V LiPo Battery

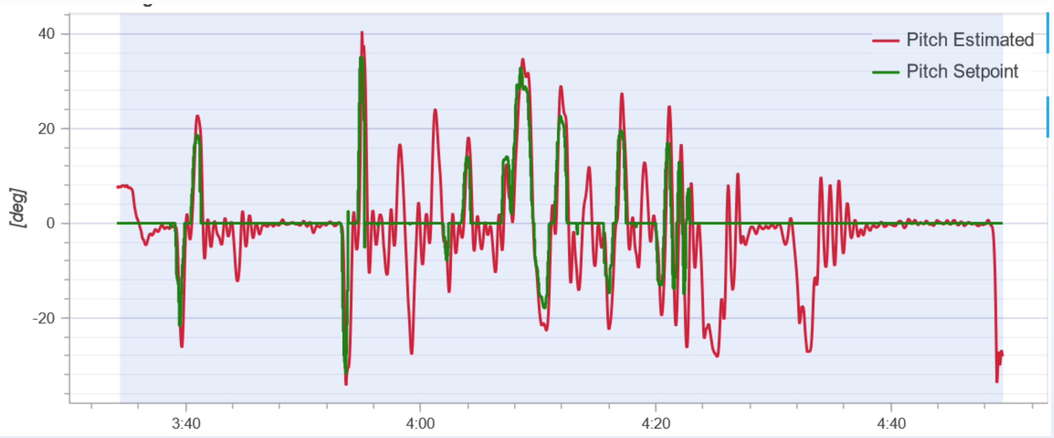
- **Total Weight: 3.4 lbs**
- **Total Reproduction Cost: ~$900**
- **Battery Life: 6-10.7 Minutes**

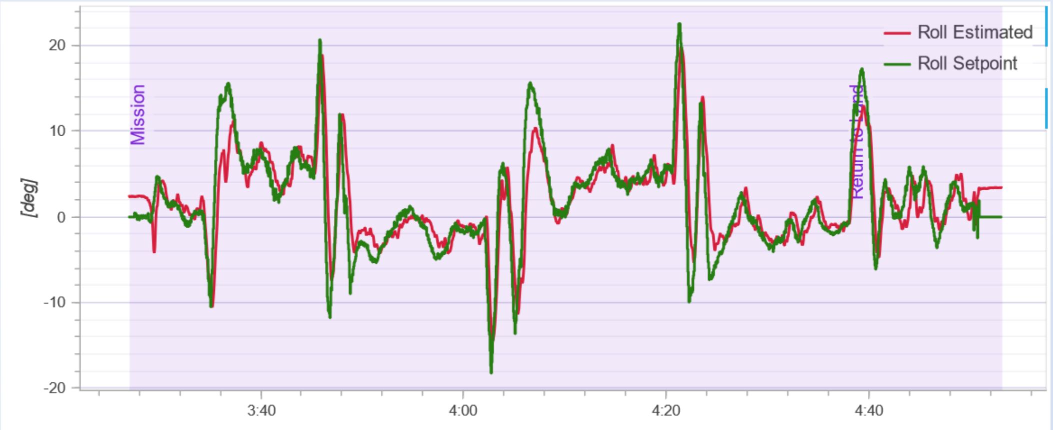
Minimum Battery Life						
Battery Capacity (Ah)		Amperage Draw			**Battery Life (Minutes)**	
4.2		MT2213 Motor x4	38.4		**6.00**	
		Raspberry Pi	3			
		Xbee	0.017			
		Zed F9P	0.12			
		LIDAR	0.085			
		Pixhawk	0.28			
		PiCam	0.095			
		Total	**41.997**			

Average Battery Life						
Battery Capacity (Ah)		Amperage Draw			**Battery Life (Minutes)**	
4.2		MT2213 Motor x4	20		**10.68**	
		Raspberry Pi	3			
		Xbee	0.017			
		Zed F9P	0.12			
		LIDAR	0.085			
		Pixhawk	0.28			
		PiCam	0.095			
		Total	**23.597**			

Drone Control

- Connects the 6 major systems
- Pixhawk Flight Controller
  - Hardware
- PX4 Autopilot
  - Software
- Flight Modes
- Testing





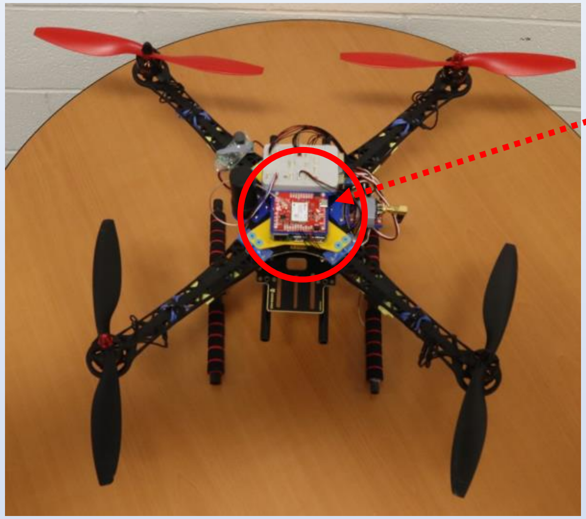
Communications

- Digi DigiMesh®
  - Mesh Networking
    - Communication with ASV
    - RTCM Corrections

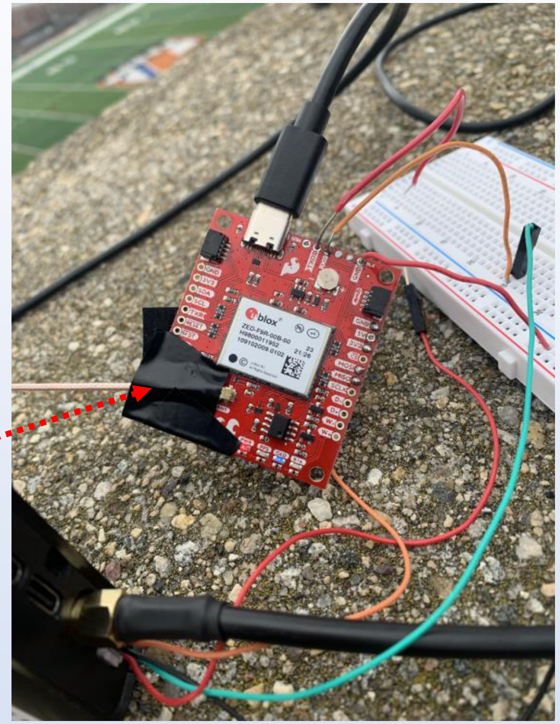
- Digi XBee 3 DigiMesh 2.4 RF Modules

Satellite Navigation with RTK

- 2 Receivers
  - Base Station
  - Rover Receiver
- Improved accuracy
  - Control finely tuned movements
  - Not location, but accuracy for landing pad



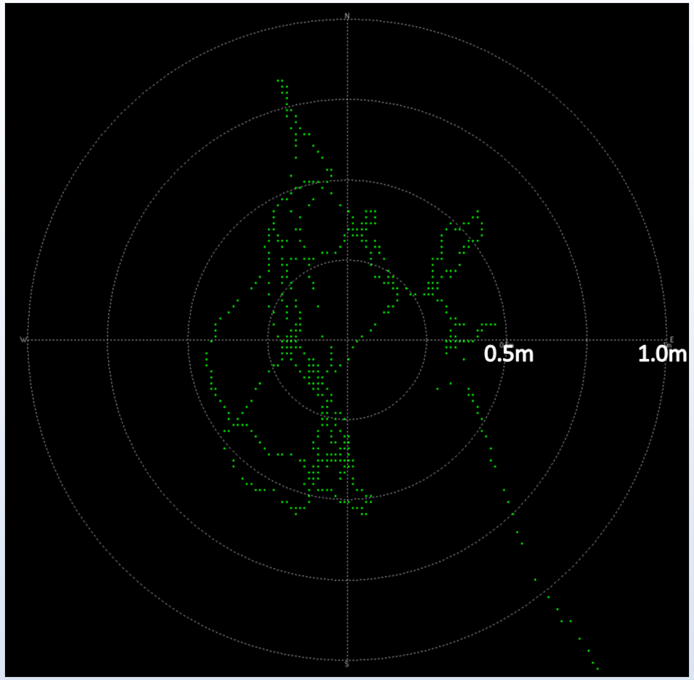
Receiver Placement



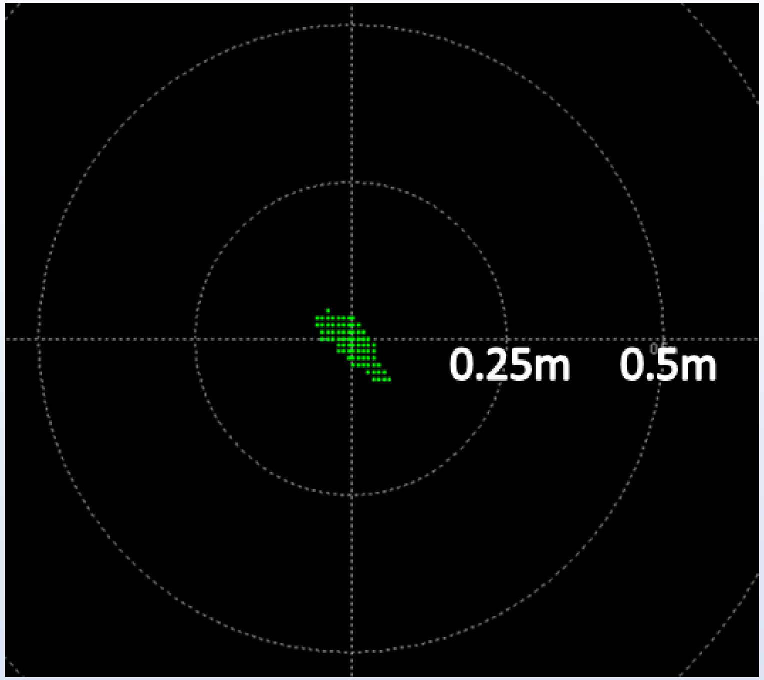
ZED-F9R Rover Receiver

Base Station

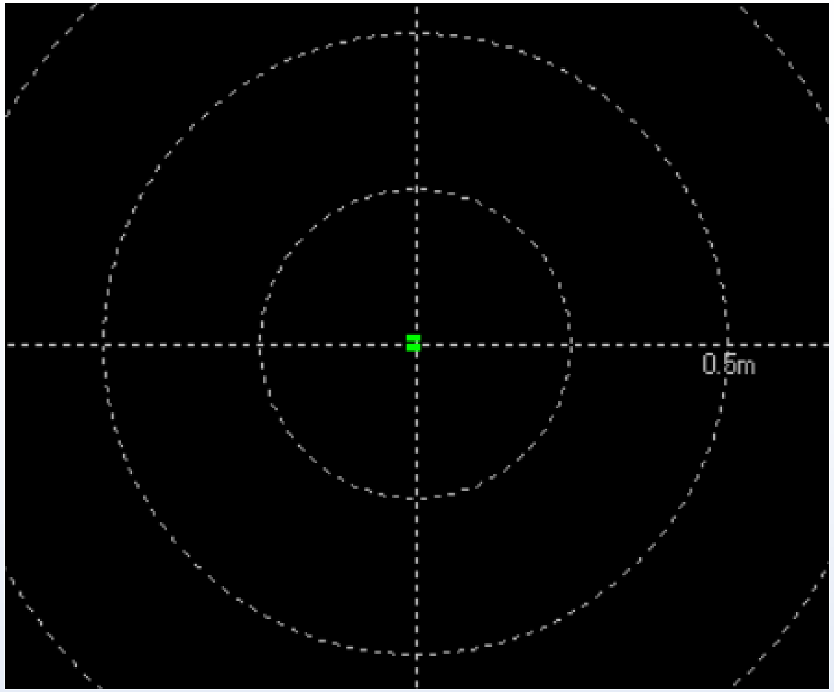
RTK Testing Development

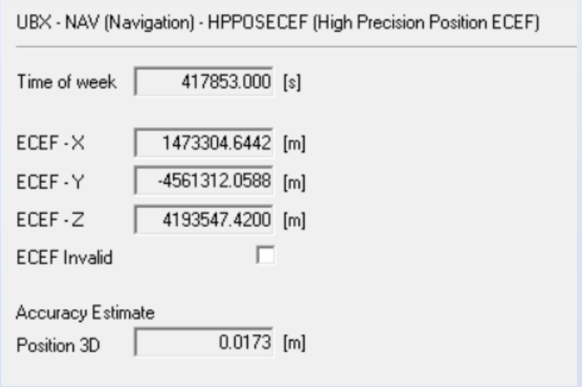


GPS: +/- 60 cm



RTK (QGroundControl): +/- 6 cm

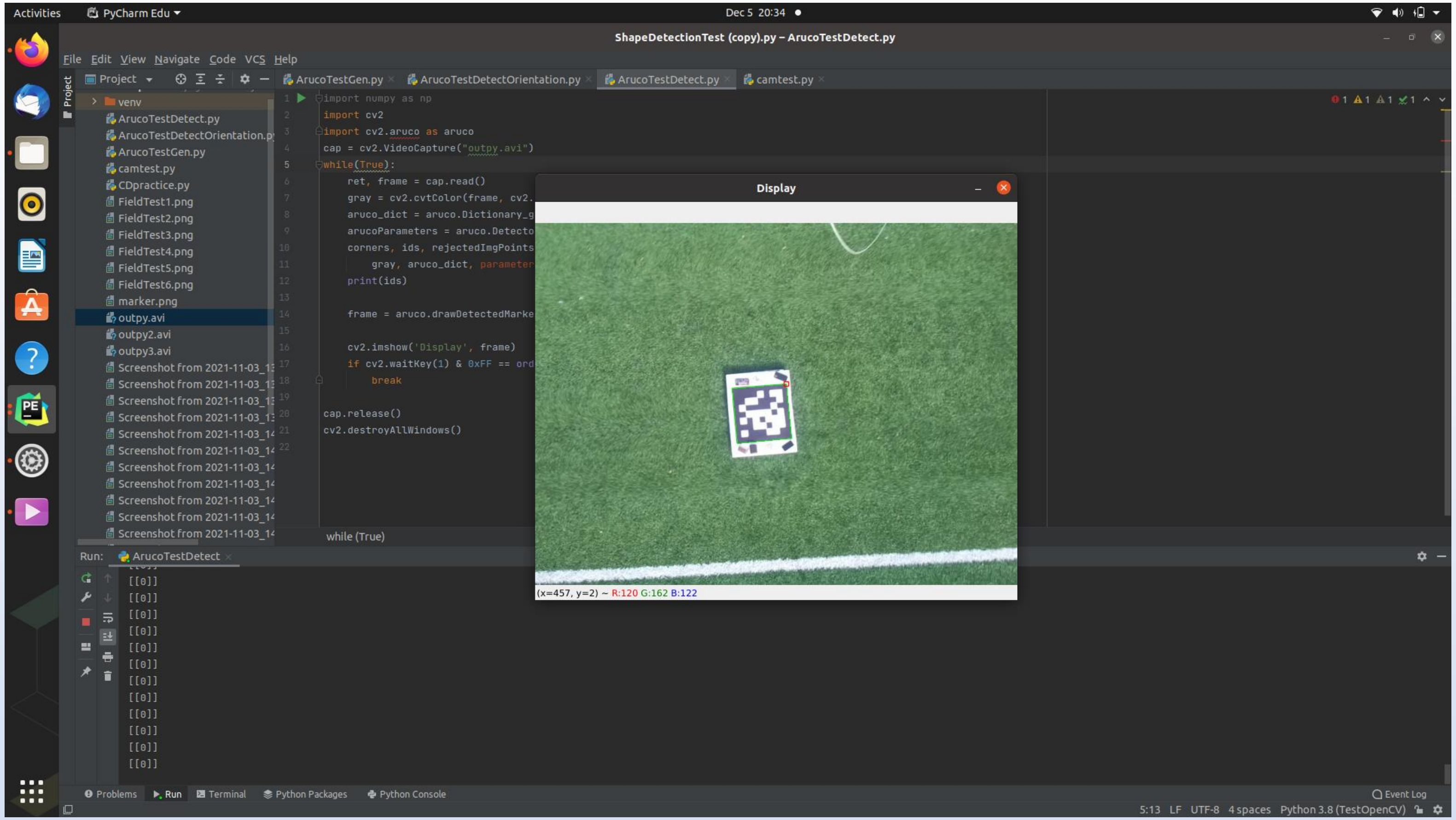




RTK: +/- 1.73 cm

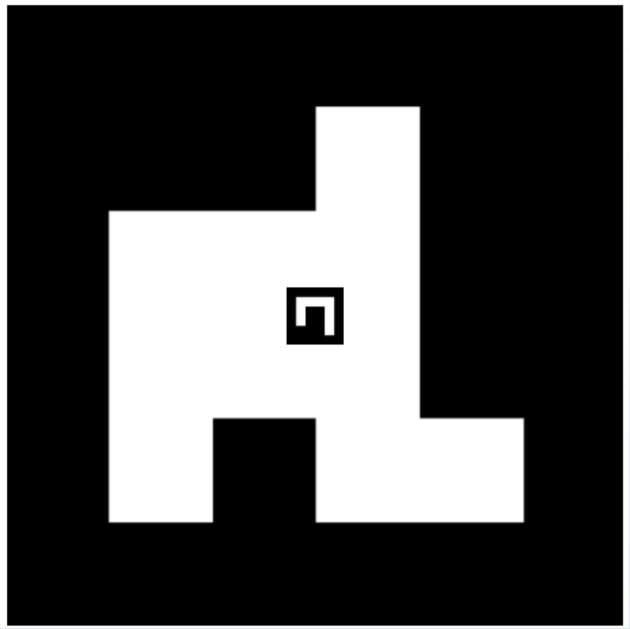
Computer Vision Workflow

- Raspberry Pi4 + PiCam
  - 480p @ 15-20 FPS
- Detection Method
  - ArUco Markers



Dual ArUco Marker Landing Solution

- 2′ x 2′ Velcro ArUco Marker
  - Smaller 4″ x 4″ marker in center
- Successful detection in real-world and simulated tests
- Large marker detectable up to at least 50′
- Small marker detectable at up to ~13′

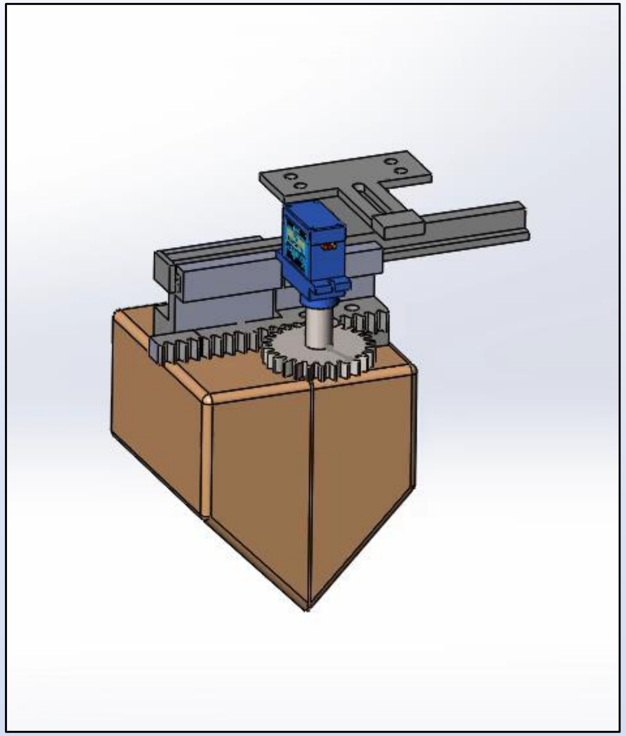


Landing Platform

- 2.5 x 2.5 ft. Plywood
- Velcro ArUco Marker
- Creates enough friction to secure drone *and* allow takeoff

Payload Delivery

- Scoop Mechanism
- Servo Actuated



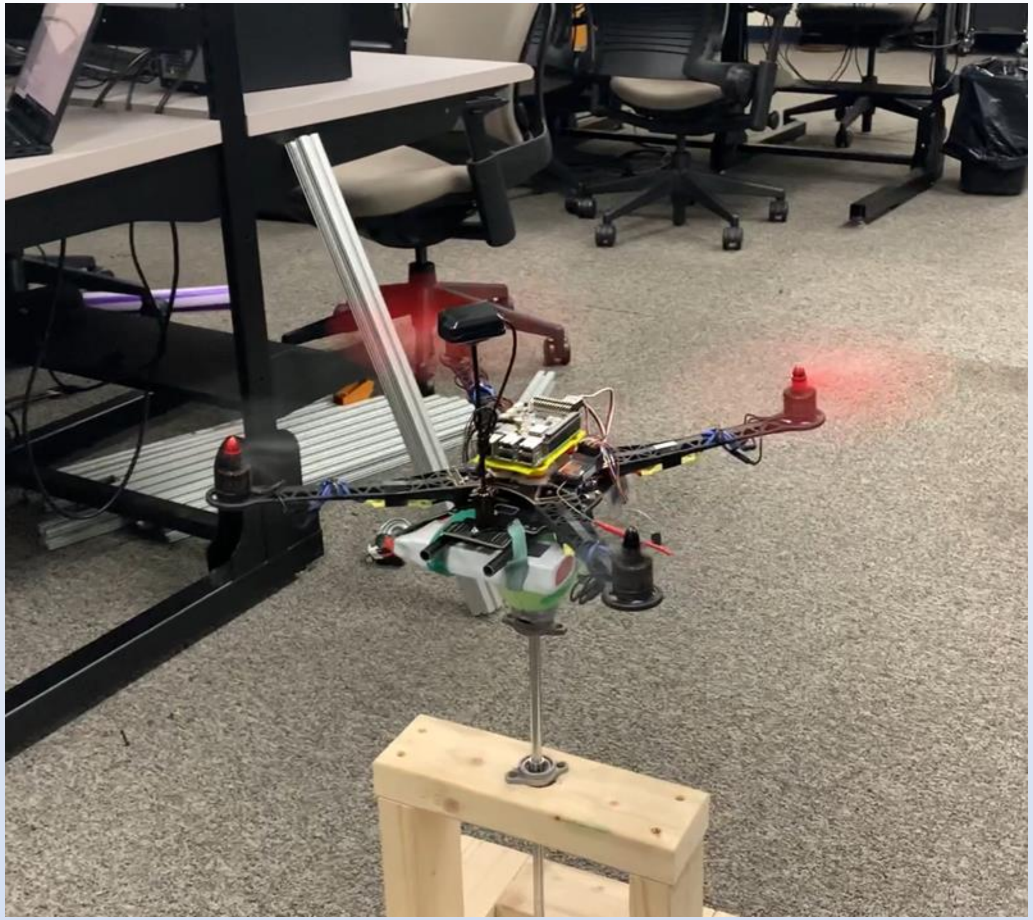
Major Milestones

- Implementation of autonomous search, identification, and landing.

- 15 Oct. 2021: Stable Flight Achieved
- 3 Nov. 2021: Autonomous Flight Achieved
- 26 Mar. 2022: Autonomous Landing Achieved

System Integration – Stable Flight

Stability During Disturbance Inputs

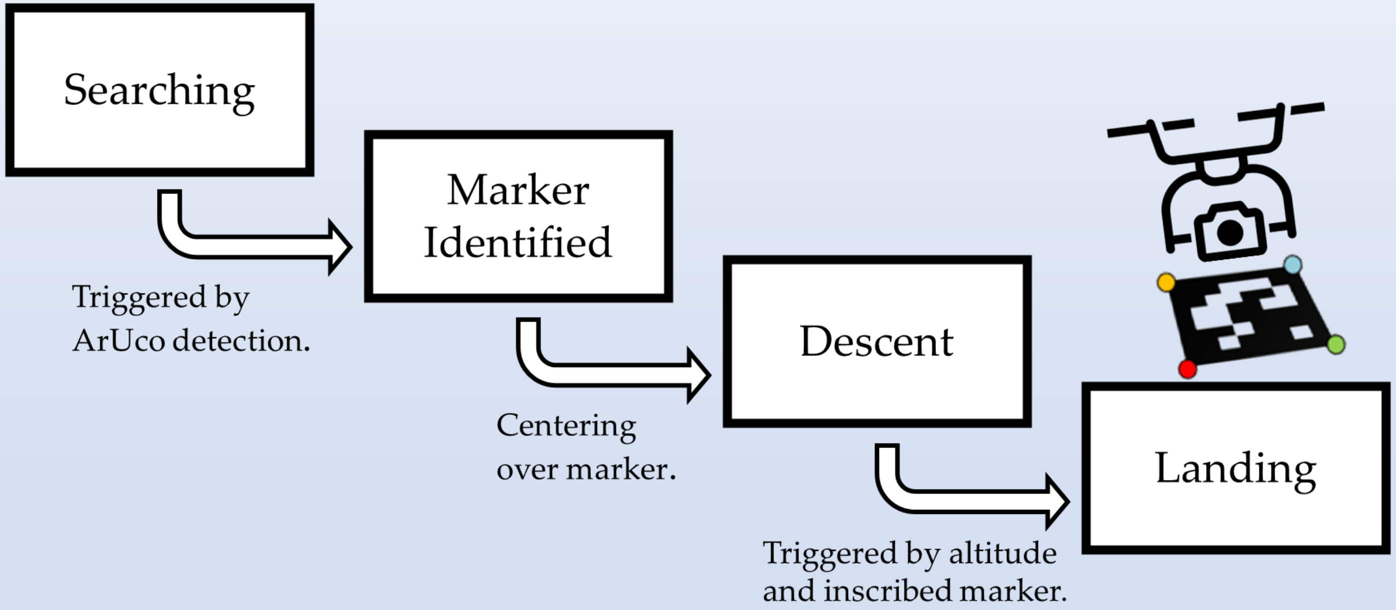


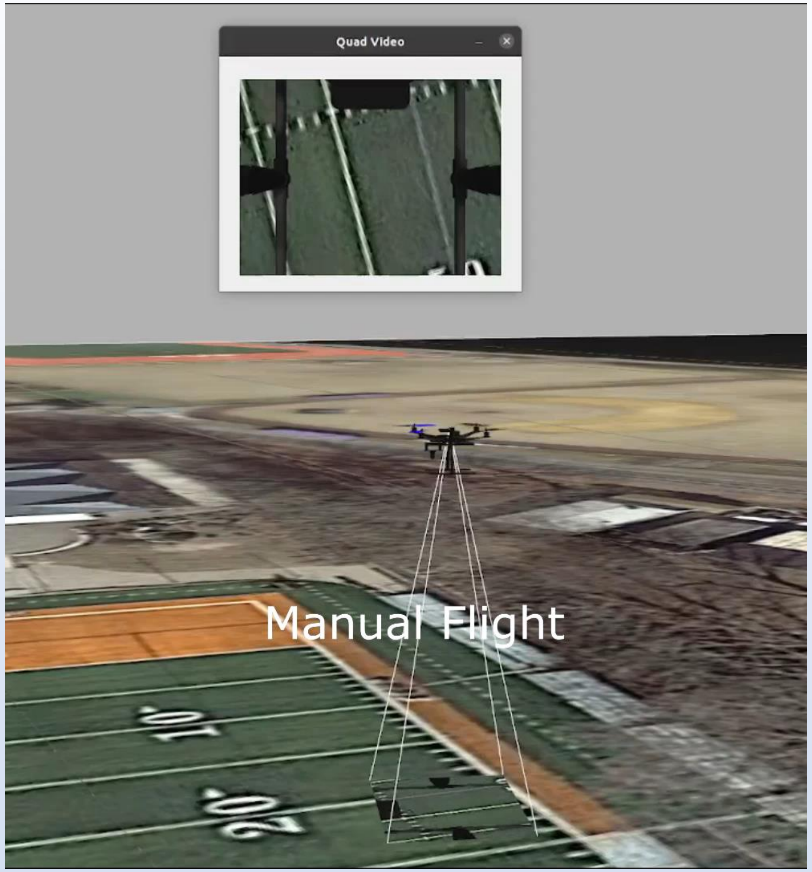
Tuning Flight Controller Gains on Test Bed

System Integration – Autonomous Flight

System Integration – SITL Testing

- Software-in-the-Loop
  - Virtual world, virtual drone.
  - Identify states of the landing sequence.
  - Low risk, rapid testing.



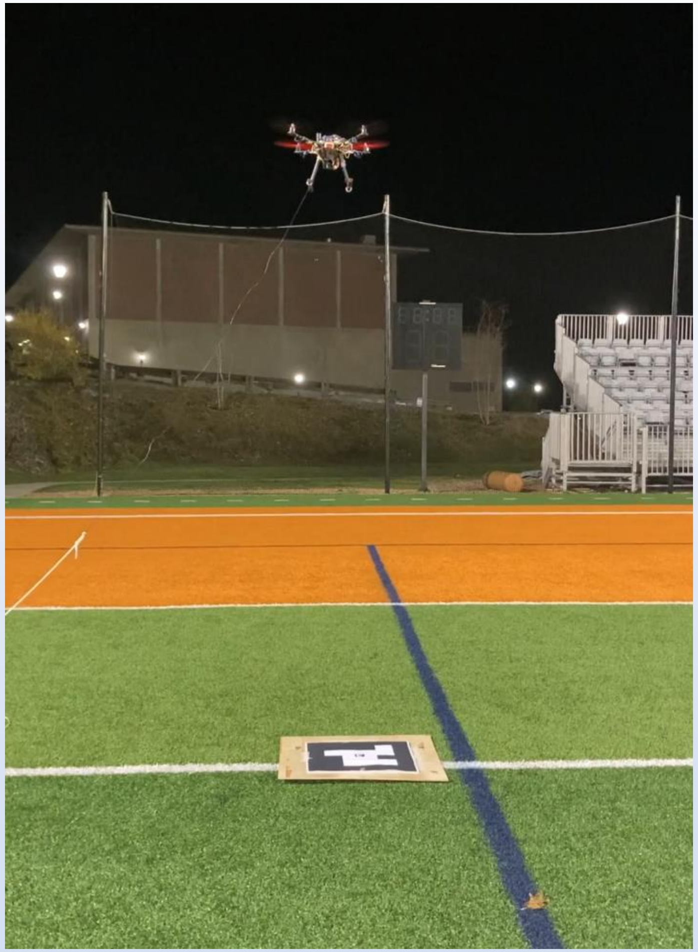


Autonomous Landing in Simulation

System Integration – Autonomous Landing

- Real-World Testing
  - Combine all workflows.
  - High risk.
  - Time-consuming testing.

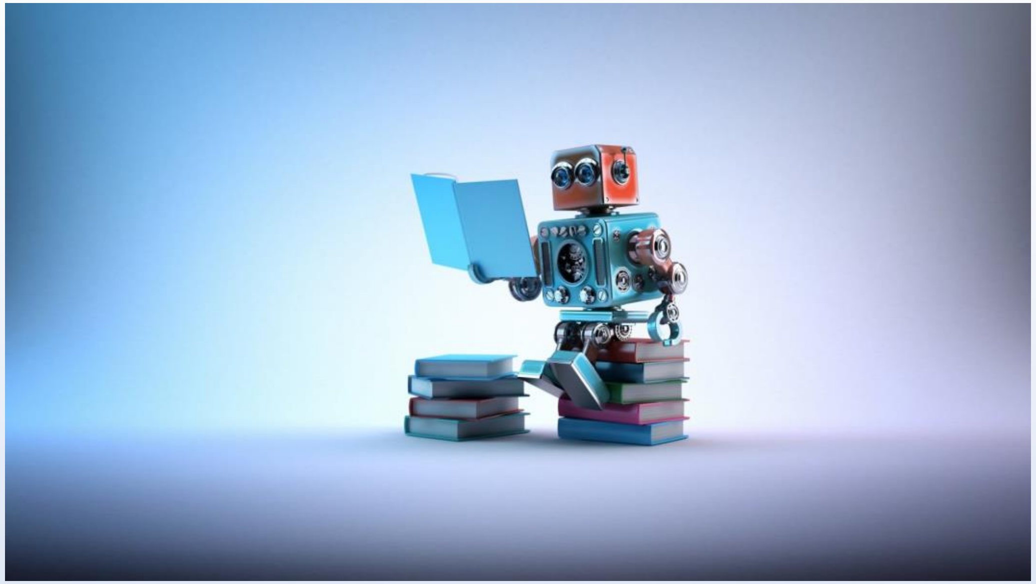
- Generally High Reward
  - Relevant information immediately.



Autonomous Landing (26 Mar. 2022)

Future Development

- Improved AruCo detection.
  - Stabilized Camera
- Optimized RasPi scripts.
- In-flight RTK integration.
- Expanded drone capabilities
  - Multi-drone communications
  - Mapping
  - Hardware optimization



Questions?

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.

Budget

Major Costs:

- S500 Frame: $59
- Motors: $100
- Raspberry Pi 3B+: $55
- Pixhawk 2.4.8: $75
- RTK: $350
- Oak I Camera: $180

Approximate Drone Cost: $900

Future Costs:

- No anticipated additions to drone
- Maintenance costs

Platform Requirements

Requirement	Solution
Weigh less than 10 pounds (T), ideally 5 pounds (O).	Small Platform: 3.4 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 scoop 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 $900.