Team Some Assembly Required

UAS 4 STEM

Some Assembly Required EST. 2016

Flight Readiness Review - 4/30/25

Introductions and Flight Mission Roles

Lindsay

Team Captain/ Airboss

Veronica

Mission Planner Specialist

Jane

Primary Pilot in Command

Sam

Backup Mission Planner Specialist

Elliott

Aircraft Specialist

Introductions and Flight Mission Roles

Daniel

Strategic Technician / Backup AI Specialist

Simon

Scoring Captain/ Backup Pilot

Teddy

Visual Observer/ Backup Pilot

Troy

AI Specialist

Liam

Safety Specialist

Meet ...
JEFF!

Joint
Engineered and
Fabricated
Flier

New Team Support/Training Video

System Overview – Flight Tasks Planned

1) Accomplish waypoint mission, including:
    a) Automated takeoff & landing
    b) Documentation of tower, pickup, & drop-off locations
2) Reconnaissance Mission - Completely Autonomous
    a) Fly to approximate target locations via waypoint navigation (mission planner)
    b) Get within range of QR code by using AI recognition
    c) Record coordinates
    d) Decode all QR codes for pickup and drop-off using decoder script (PYZBAR)
3) Payload Mission - Mostly Autonomous
    a) Fly to pickup target via waypoint navigation (mission planner)
    b) Pick up payload with precision land, if needed pilot nudges the quad
    c) Autonomous drop off to stationary target with precision land
    d) Autonomous drop off of hat to moving target with precision loiter

System Overview – Expected Performance

- Complete autonomous takeoff and landing
- Complete Waypoint mission
- Use AI camera to determine the correct payload for pick up
- Successful mostly autonomous pick up and deposit of payload to stationary target
- Additionally, successful mostly autonomous deposit of the hat onto the moving target
- Complete mission within 30 minutes or less

System Overview – Risk Evaluation

Risks	How They Were Addressed
Absence of Team Member	Most roles have other members trained as backups
AI flying failure	Pilot always able to resume control
AI QR decoding failure	We have created an apple shortcut to manually decode QR
Drone crashing during practice	We have an observer parallel to the drone and the tower to more easily gauge distance from tower
Unexpected battery depletion	Battery power callouts
Inaccurate Coordinates for MP mission	Pilot “bumps” quad or AI is used to automatically center quad for pick-up/delivery
Splintering of 3D Parts	Used higher quality components for final design; put parts through rigorous testing

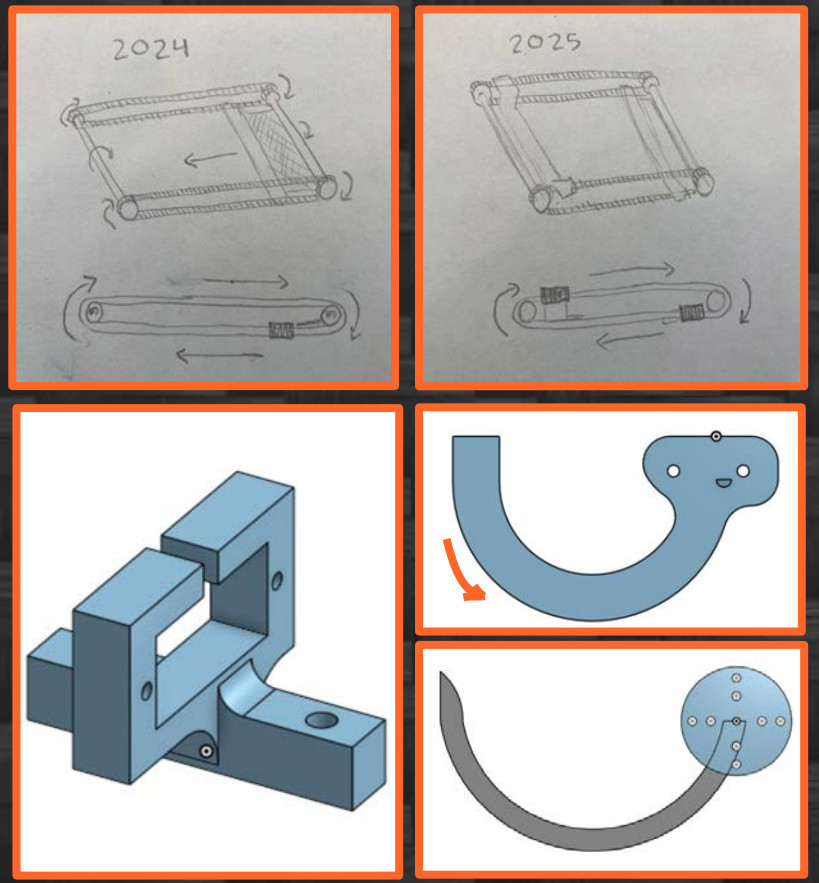
System Safety – Payload Mechanisms

Hammer grabber

- Modified from last year
- Keeps hammer secure in the center
- Mini servo mounted on the grabber itself replaced larger servo mounted on the frame of the quad
- Cable grommets for quick removal

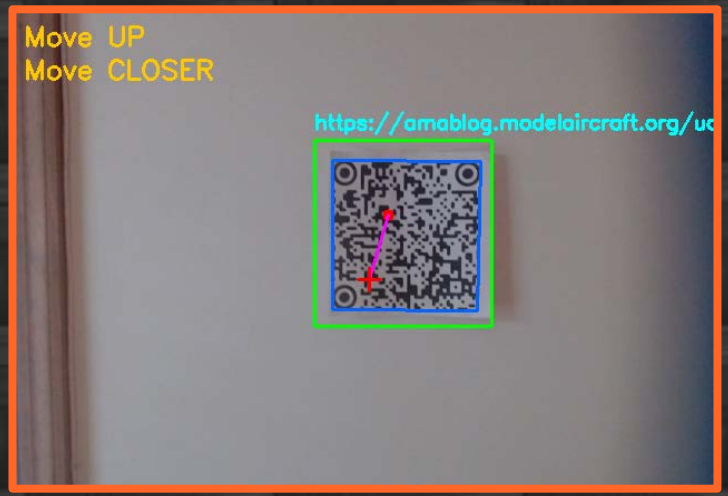
Hat payload

- Designed for minimal weight
- Simple “hook” operated by a mini servo
- Hat can manually loaded into the hook
- Servo rotates the hook to quickly drop the hat



System Safety – QR Decoding

- Trained a custom model to detect QR codes with bounding boxes in real-time
- Used Pyzbar library to decode the QR codes
- Precision Land for accurate descent onto QR-coded targets
- Precision Loiter to track and align with the moving target
- Manual override and kill switch enabled for all autonomous operations
- Use iPhone shortcut to decode QR code as a failsafe



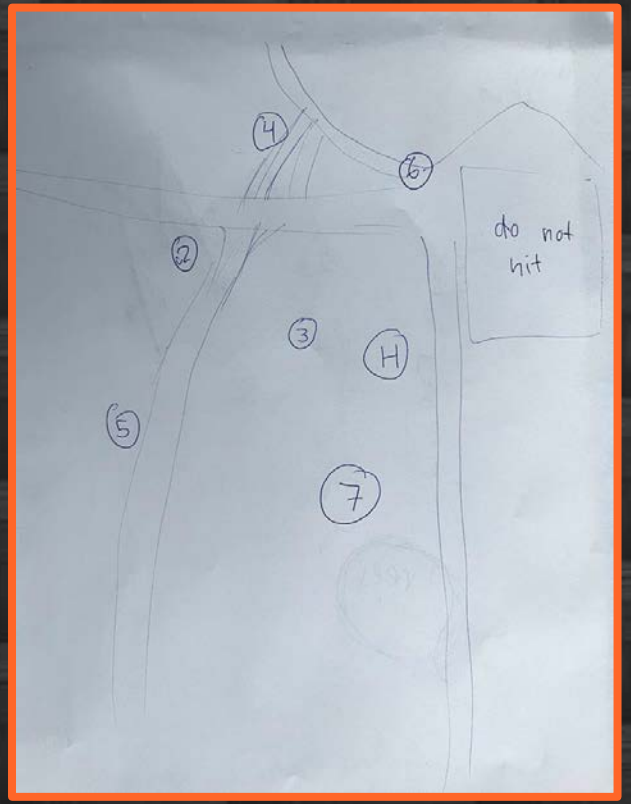
System Safety – Maintaining Situational Awareness

Roles

- Real-time mapping during the mission to keep the pilot aware of environment
- Hazard identification keeps missions safe by ensuring that obstacles are known and avoided
- Monitoring the battery percentage during flight

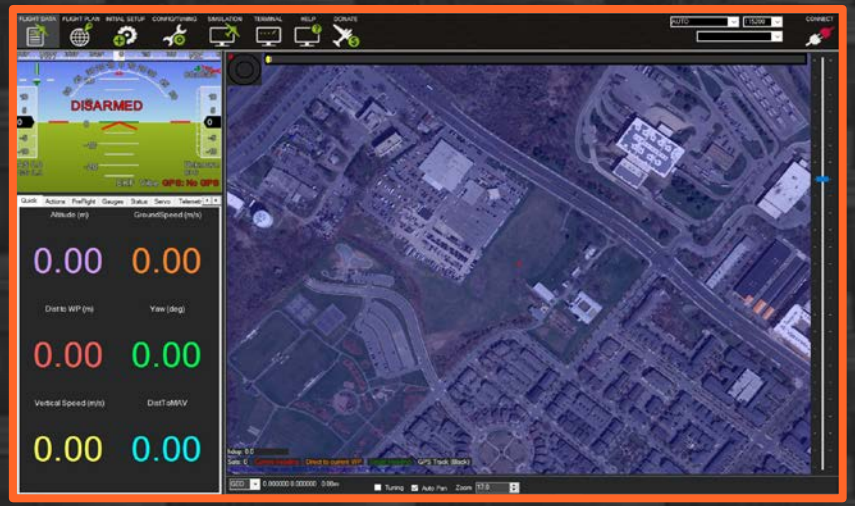
Coordination with team

- Pilot is made aware of spotted targets, obstacles, and navigation steps live
- Communicating the location of targets on the field makes the mission more streamlined



System Safety – Operational Strategies

- Program autonomous mission
- Monitor telemetry data
  - Periodic callouts of voltage and altitude
- Safety Dashboard
  - arm/disarm
  - GPS status
  - Flight mode
- Control payload mechanism servo



System Safety – Operational and Design Strategies

- Preflight inspection: ensure there is no damage to the propeller blades or drone airframe
- Use checklists to enforce safety
- High quality components
- Repairs made regularly
- Hardware Safety Switch
- FailSafes
  - Battery
  - RTL in case of connection loss

Developmental Test Results – Test Plan Schedule

Ground Testing

- As we can not fly in the winter, we focus on building in our makerspace
- Grabber: prototype and conduct off the drone practice
- AI: test on hand-held cameras and a tello drone

Flight and Mission Performance Testing

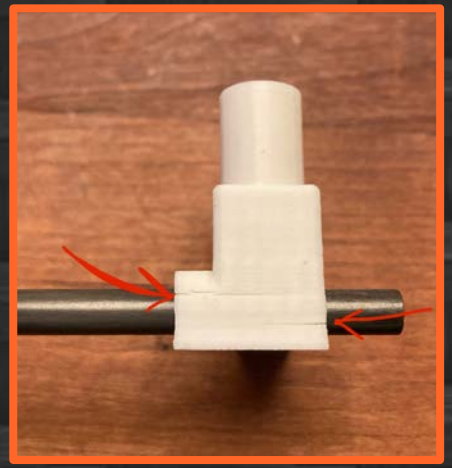
- Plan weekly flights once weather clears
- Incrementally add components to the drone for aerial testing
- Run partial missions once all components are tested
- Run full missions once all partial missions are successful

Developmental Test Results – Payload mechanisms

Initial cardboard prototype
- Could pick up and drop off various objects

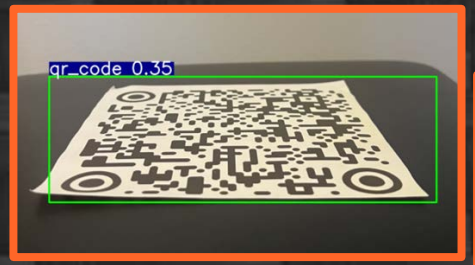
3D printed corners for grabber
- Connects square and circular carbon fiber rods at each leg of the drone
- Mount for cable grommets to attach to legs of the quad

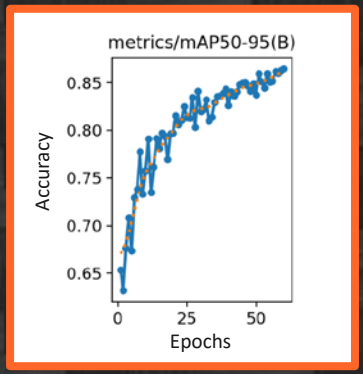
Engineering notebook!
- Potential risks
- Modifications to designs and test results of those modifications
- Action items/next steps



Developmental Test Results – Software

- Object detection model reached an accuracy of 86.5%
- Tested the model on many inference images from the dataset along with the competition QR codes from different positions
  - Successfully detected each image correctly
  - Raspberry Pi camera lens may need changes to reduce image blur
- Tested iPhone shortcut failsafe on video monitor feed
  - Requires drone to be very close to the QR code with minimal obstruction





Evidence of Mission Accomplishments – Tower Build

Design Goals

- Onsite construction
- Rapid Assembly + Disassembly

Challenges

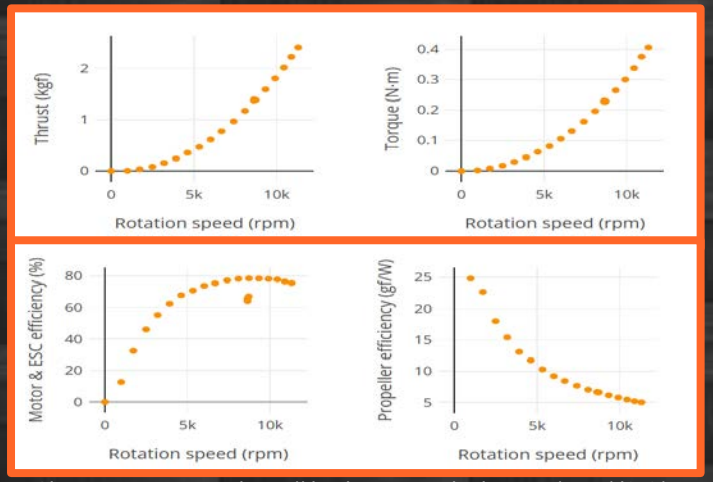
- Initial wobble made tower struggle to stand up to winds.
- Tower's center beam was crooked depending on expansion of wood.

Solutions

- Metal “guy wire” strips to fix wobble and leaning

Evidence of Mission Accomplishments – Hardware

- Props
  - Efficiency and thrust reliant on specific motor used
  - Larger diameters increase airfoil, providing lift
    - Too long = motor less efficient
  - Larger pitch angles increase air moved per rotation
    - Too large = prop stalling
  - Quantity of blades affects performance
    - More blades increase drone responsiveness
    - Fewer blades decrease drag/increase efficiency
  - Materials like Carbon Fiber are good for strength and durability
- Motors
  - Inrunner motor: moves a shaft in the middle of the motor
  - Outrunner motor: spins the entire outside of the motor
    - Commonly used in drones due to effective SWaP and more torque
    - Need to have sufficient surrounding air to maintain safe temperature
  - Strength dependent on volume and density of copper coils used to generate rotation
  - Increasing width increases cooling but not strength



Closest to our motor: https://database.tytorobotics.com/tests/d6x3/t-motor-1050kv-graupner-camfold-25x15-10x6

$$Torque = \frac{B^2 * \pi r^2 h}{\mu_0}$$

B = Magnetic Flux Density (In simple terms, the strength of the magnetic field)
R = Radius excluding shell
H = Height excluding shell
μ = Magnetic Permeability (In simple terms, how well a magnetic field can travel through a certain material)

Source: https://youtu.be/RXy00orSpfU?si=hHyulQBU0h8e0Yvu

Pre-Mission Briefing – Resourcing and Communication

Roles

- Assigned a role to each important aspect of flight
- Appointed based on skills and interests
- Each has specific pre-flight, flight, and post-flight tasks

Communication

- Pre-flight briefing of what objectives we will carry out
- Roles have specific call outs and understanding of who to share information with
- Maintain sterile cockpit during flight
- Post-flight check in of areas of success or improvement
- Keep detailed notes of each flight

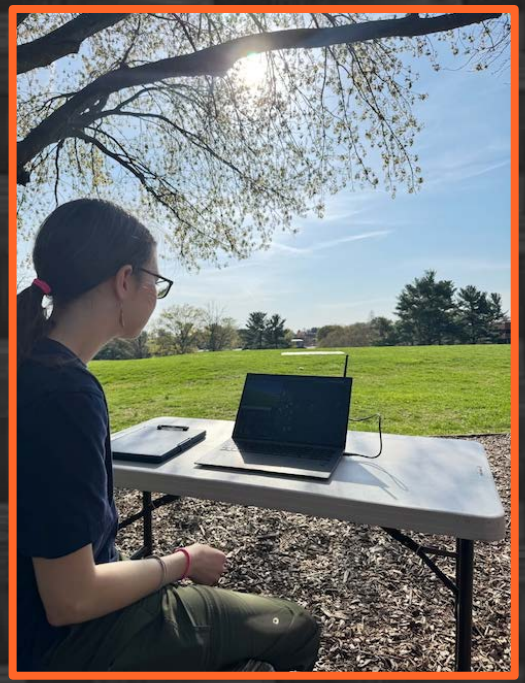
Pre-Mission Briefing – Go/No Go Criteria

Before Flight:

- Confirmation with Visual Observer if the airspace is safe
- Weather check - Winds less than 15 mph
- Presence of people
- Condition of the drone
- Condition of crew

During flight:

- Aircraft performance
- Wind speed
- Battery charge
- Confirmation with Visual Observer if the airspace is safe



Community Outreach

- Team SAR Open House
  - Introduce prospective team-members to SAR and the UAS4STEM competition
- Local Fundraisers
  - Gather fundraising for material and travel costs, partnered with Five Guys
- Rockville Science Day
  - Introduce community to drones/ aviation/explorer post (flight simulators & AI demonstrations)

Thank you for your time!

...Any Questions?