Team Some Assembly Required

UAS 4 STEM

AMA EAA AMA FOUNDATION

Some Assembly Required EST. 2016

Flight Readiness Review - 7/22/25

Introductions and Flight Mission Roles

Lindsay

Team Captain/ Airboss

Veronica

Mission Planner Specialist

Jane

Primary Pilot in Command

Sam

Backup Mission Planner Specialist

Daniel

Strategic Technician / Backup AI Specialist

Introductions and Flight Mission Roles

Simon

Scoring Captain/ Backup Pilot

Teddy

Visual Observer/ Aircraft Specialist

Troy

AI Specialist

Liam

Safety Specialist

The Duck

Mascot

Meet ...
JEFF!

Joint
Engineered and
Fabricated
Flier

New Team Support/Training Video

System Overview – Flight Tasks Planned

1) Accomplish SPINS mission, including:
    a) Automated takeoff & landing
    b) Documentation of tower, pickup, & drop-off locations
2) Reconnaissance Mission - Mostly Autonomous
    a) Autonomous flight to approximate target locations via waypoint navigation (mission planner)
    b) Record precise coordinates
    c) Automatic decoding of target QR codes using decoder script (PyZBar)
3) Payload Mission - Partially Autonomous
    a) Autonomous flight to moving target (mission planner), manual hat drop
    b) Fly to hammer pickup target via waypoint navigation (mission planner)
    c) Pick up payload manually
    d) Autonomous flight to stationary target (mission planner), manual hammer drop

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 delivery of the hat onto the moving target
- Additionally, successful mostly autonomous pick-up and delivery of payload to stationary 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
Weight including hammer approaching motor limit	Did research on new motors, compared pros and cons (eventually remaining with original motors), and tested old motors with new weight to ensure dependability
AI flying failure	Pilot always able to resume control
AI QR decoding failure	We have created an apple shortcut to manually decode QR
Hammer grabber causing yaw interference	Perforated offending surfaces for less drag
Inaccurate coordinates in mission planner	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

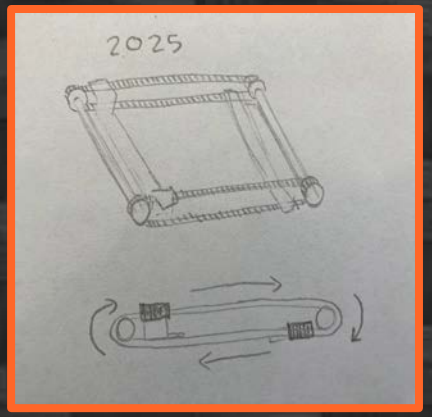
System Safety – Payload Mechanisms

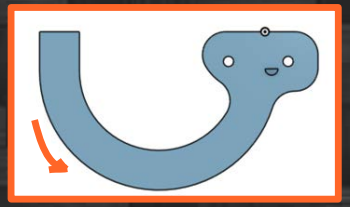
Hammer grabber

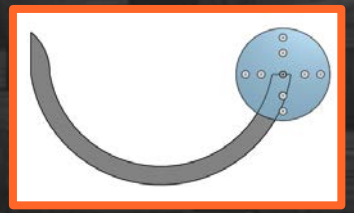
- Keeps hammer secure in the center
- Strong, lightweight parts
  - Carbon fiber rods
  - Mesh metal screen
  - PETG printed parts
- Mini servo mounted on the grabber replaced larger servo mounted on the frame of the quad

“Hat Hook”

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

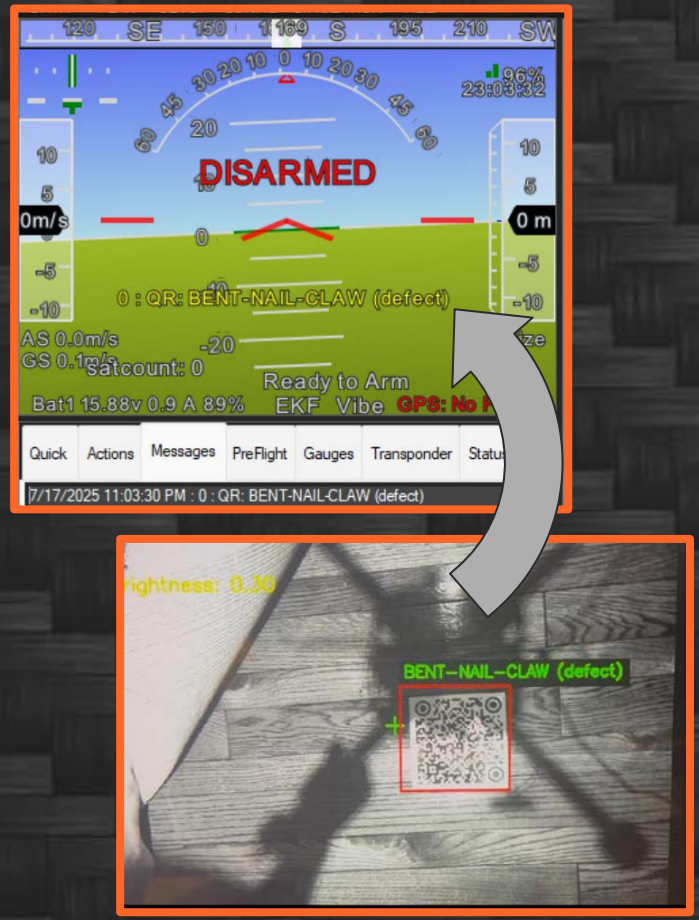






System Safety – QR Decoding

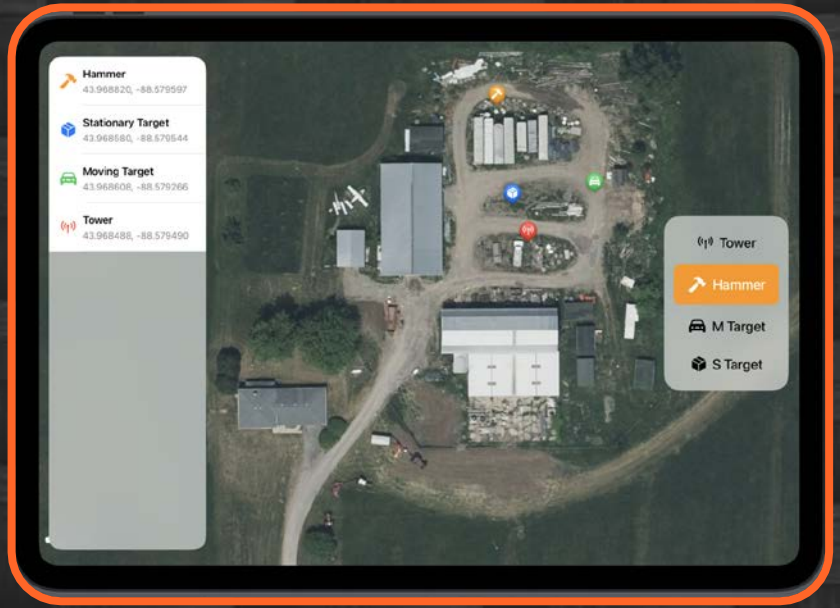
- Trained a custom model to detect QR codes with bounding boxes in real-time
- Use PyZBar library to decode the QR codes
- Send QR data to Mission Planner via MAVLink for quick communication
- Use Precision Loiter function on QR code bounding box for moving target and to help assist in decoding
- Use Precision Land to deliver the payloads autonomously
- Manual override for all autonomous operations
- Use iPhone shortcut to decode QR code as a failsafe
- Use SSH over a WiFi access point to run scripts on the Pi



System Safety – Maintaining Situational Awareness

Innovation in Mapping

- Our new custom tablet app for the competition field boosts our pilot's situational awareness
- We identify targets through a camera feed and mark them on the map
- The app returns coordinates that are then passed to the pilot
- This enables autonomous navigation to targets

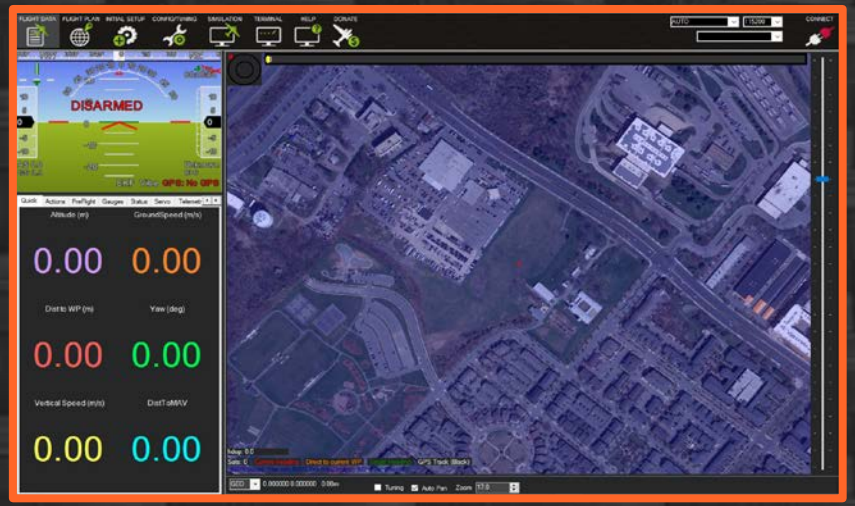


Continued emphasis on safety

- We remain in constant contact with the pilot
- We monitor the battery percentage during flight

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
- Get result of decoded QR codes from AI program



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 previous competition 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

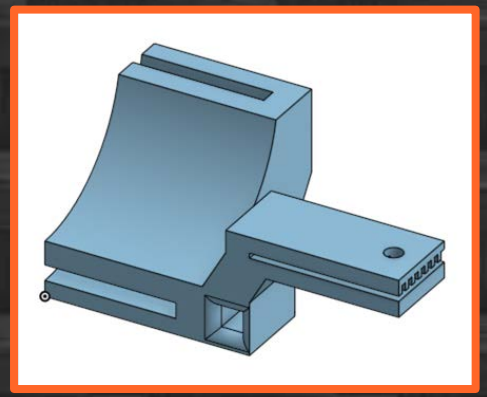
Developmental Test Results – Payload mechanisms

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

3D printed corners for grabber
- Split along layer lines
- Reprinted with different orientation + filaments

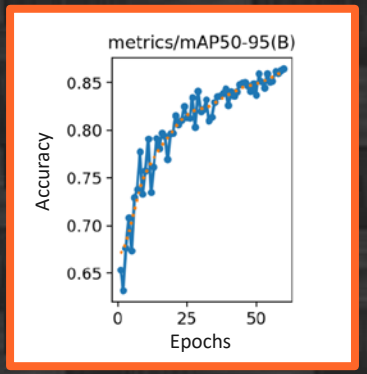
Ground tests: belts binding
- Altered slots for carbon fiber rods
- Adjusted height

Test flight
- Solid aluminum interfered with yaw
- Switched to a metal mesh material



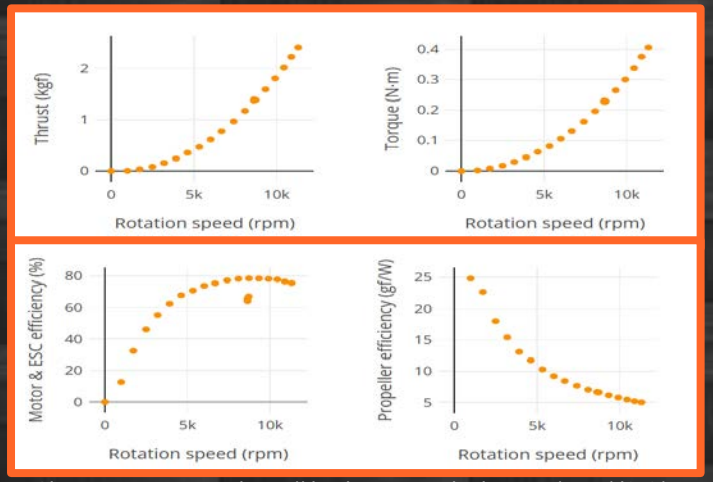
Developmental Test Results – Software

- Object detection model reached an accuracy of 86.5%
- Model successfully identified and extracted data from competition QR codes
- Initially used YOLO model on Raspberry Pi 4
  - CPU load was too great, switched to a different format to run on Raspberry Pi AI Camera's IMX500 sensor for in-camera processing
  - Performed changes in exposure within the camera easier decoding
- iPhone shortcut failsafe works on all codes
- Tested precision loiter script but didn't perform reliably enough to be used



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

- 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

Roles	
Pilot	Scoring Captain
Mission Planner Specialist	AI Specialist
Strategic Technician	Safety Specialist
Airboss	Visual Observer
Aircraft Specialist	Backups Assigned For All Roles

Pre-Mission Briefing – 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

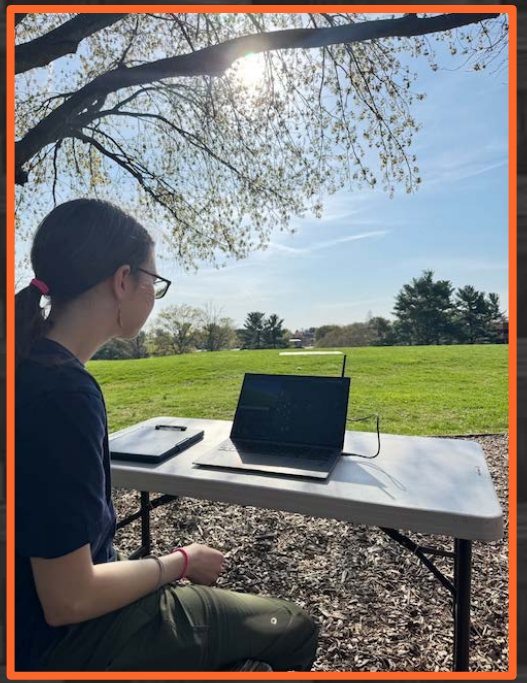
Pre-Mission Briefing – Go/No Go Criteria

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 that airspace continues to be safe



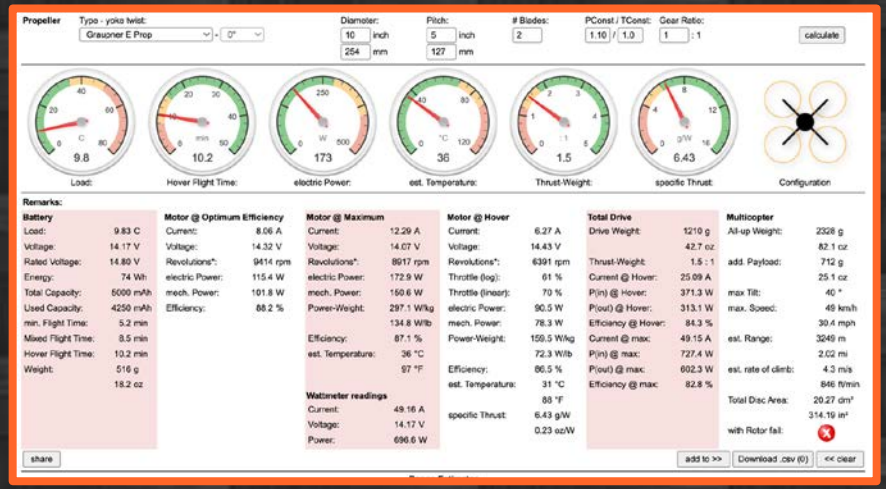
Community Outreach

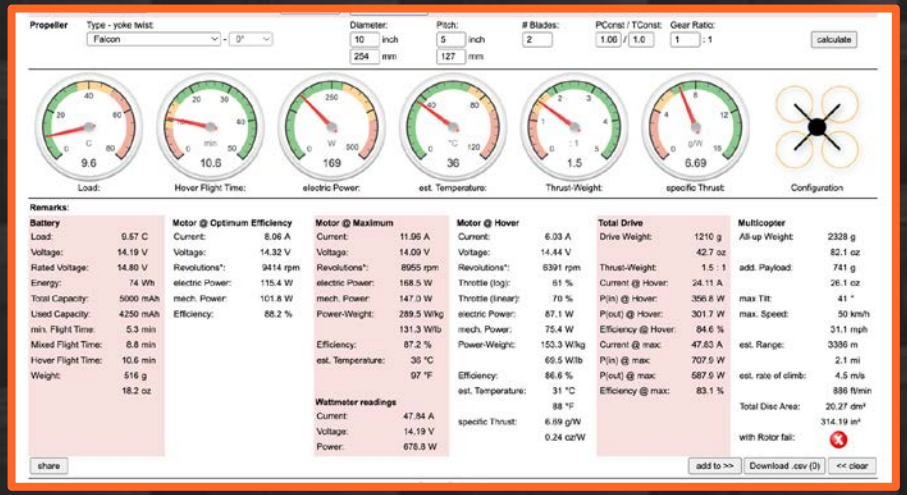
- Team SAR Open House
  - Introduce prospective team-members to SAR and the UAS4STEM competition
- Local Fundraisers
  - Gather fundraising for material and travel costs, partnered with Five Guys
- Rockville Science Day
  - Introduce community to drones/ aviation/explorer post (flight simulators & AI demonstrations)
- Public Meetings + Practices
  - Meetings are held at a publicly open makerspace, flight practices at local park
  - Community is open to ask questions and learn!

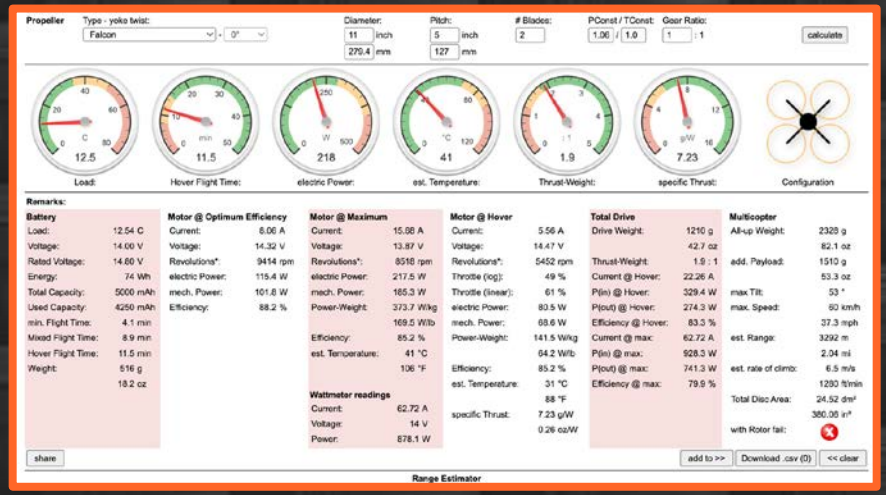
Thank you for your time!

...Any Questions?

eCalc Simulated Performance







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

Developmental test results

Hammer grabber testing

No feet, no changes to aluminum

1. Open - Tiny bit of skipping
2. Close - fully jammed

4 layers of paper, no changes to aluminum

1. Open - no skipping
2. Close - skipping (but maybe because quad slid off paper?)
3. Open - no skipping
4. Close - no skipping (held jeff in place)
5. Open - no skipping
6. Close - no skipping
7. Open - no skipping
8. Close - no skipping
9. Open - no skipping
10. Close - maybe one skip? Or some other sound

4 layers of paper, no changes to aluminum (with ballpeen hammer)

1. Close - scribble aluminum slid under round side, but higher aluminum caught on the bigger side
2. Open - no skipping
3. Close - (flipped ballpeen hammer) scribble aluminum still worked, high aluminum still caught even on round side
4. Open - skipping

Hat drop testing

June 11

Jane

1st attempt - missed (Jane thought there would be more delay)
2nd attempt - hit
3rd attempt - missed quad (low altitude?)
4th attempt- missed (too early)
5th attempt - missed
6th attempt- missed

Simon

1st attempt - missed
2nd attempt - hit the edge, just missed (waited for the groundbot to go by)
3rd attempt - missed

July 4

Jane

1st attempt- near miss
2nd attempt- hit!
3rd attempt - miss
4th attempt- miss (groundbot turned as Jane dropped hat)
5th attempt - miss
6th attempt - hit but fell off
7th attempt - hit
8th attempt - hit but fell off
9th attempt - miss (trying to follow the target for less time)
10th attempt - hit
11th attempt - miss

July 16th (quite windy)

1st attempt - hit
2nd attempt - hit but blew off
3rd attempt - miss
4th attempt - miss
5th attempt - hit but fell off
6th attempt - hit!
7th attempt - miss
8th attempt - near miss, hit edge but fell
9th attempt - miss
10th attempt - miss

YOLO Model Testing & Evaluation Metrics