Team SAR
Some Assembly Required
Explorer Post 1010

Flight Readiness Review Briefing

Introductions and Flight Mission Roles

Visesh	Safety Pilot/Pilot in Command
David	Air Boss/Back-up Pilot
Jasmine	Mission Planner Specialist
Nathan	Safety Tech/Scoring Captain
Muhammad	Strategic Technician

System Overview - Flight Method Strategy and Tasks

1. Accomplish autonomous objectives
    - Map locations of scoring items while completing autonomous objectives
2. Fly to drop-off targets
    - Record coordinates of drop-off targets
3. Semi-autonomous pick-up (waypoint navigation/manual pick-up)
4. Fully autonomous drop-off (waypoint navigation/auto drop-off)
5. Hybrid search for further scoring items
6. Autonomous takeoff and landing

System Overview - Expected Performance

- All 6 waypoints captured
- 3 water bottles transferred
- Autonomy-assisted pick-up
- Autonomous drop-off
- Mission completed within <25 minutes flight time
- Autonomous takeoff and landing

System Overview - Risk Evaluation

Risk	Risk Type	Mitigation
Flight Beyond Visual Line Of Sight (BVLOS)	Safety	Confirmed with flight directors that a visual observer will monitor the drone and communicate w/ PIC
Quadcopter flips after landing	Safety	Land in stabilized mode - not LOITER
Autonomous bottle release procedure: • GPS coordinate margin of error → unsafe landing location	Safety / Scoring	Release points: Air - Water bottle could bounce Ground - More control over end bottle location, but risk of breaking landing legs or vehicle
Bottle falls unexpectedly during flight	Scoring	Pick-up immediately or return later (may be worthwhile to complete other mission objectives first)
GPS navigational system inaccuracy	Scoring	Switch to manual flying

System Overview - Risk Evaluation – A.I.

Algorithms	Pros	Cons
Template Matching	- Easy to implement given reference image of target	- Has difficulty with transformations
Feature Matching	- Higher accuracy - Can handle variations in size and rotation	- More complicated than Template matching - Single-core CPU bound algorithm
Convolutional Neural Network Matching	- Highest accuracy - Lowest inference time (GPU acceleration)	- Most difficult to implement (training)

System Overview - Mission Planner Usage

- Monitor aircraft telemetry data
- Safety dashboard (arm/disarm, GPS status, flight mode)
- Program autonomous missions
- Control water bottle grabber servo
- Simulate missions
- Use flight log to diagnose problems

System Overview - Monitor Usage

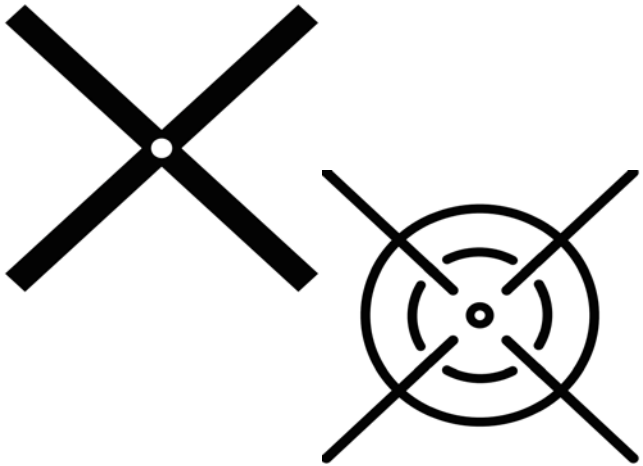
Flight decisions made based on:

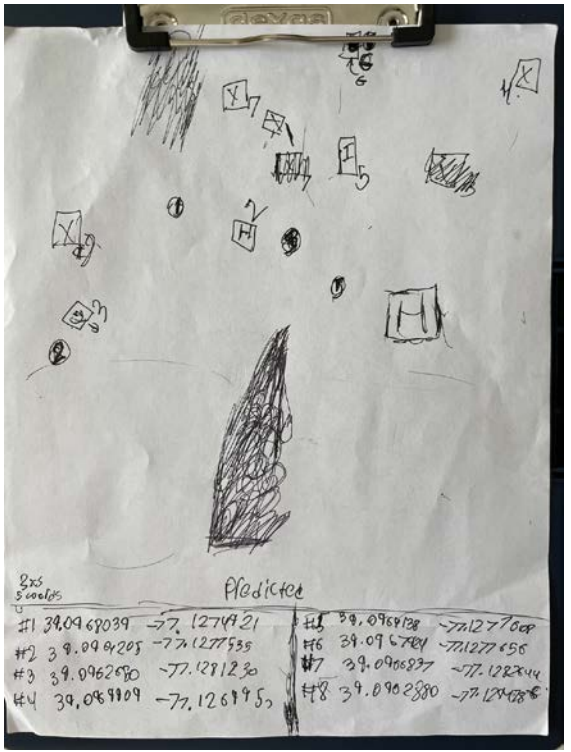
- Latitude/Longitude
- Altitude
- Throttle Percentage
- Battery Voltage
- GPS Lock
- GPS Satellite Count
- Flight Mode

System Overview - Maps

Consolidation of Data:

- Target location relative to surface features
- Type of Target
- Latitude/Longitude
- Landmarks/Obstacles
- Review after flight





System Safety - Operational Strategies

ALL flights conducted:

- With supervising adult
- In visual line of sight or Visual Observer
- BELOW 400 feet and within FAA regulations

NO flights conducted:

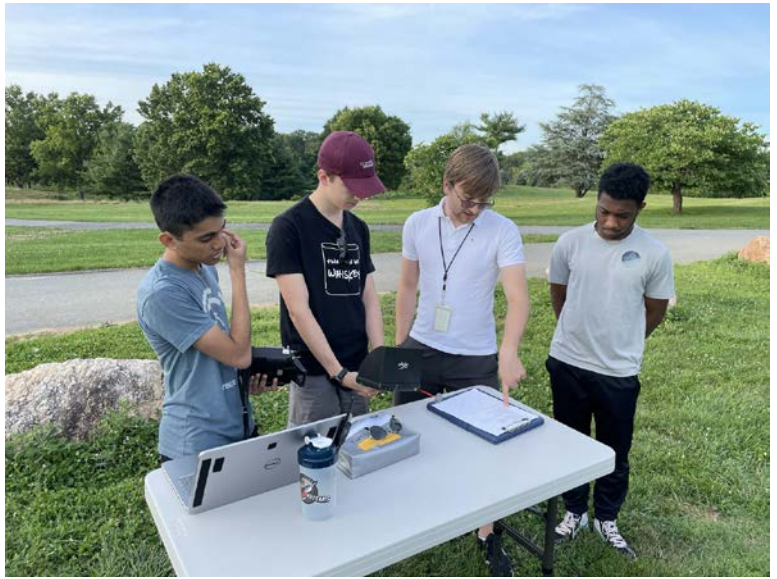
- Without performing pre-flight inspection
- In bad weather or bad visibility
- Over people or buildings

System Safety - Design and Operational Strategies

- Grabber string locks
- Break-away legs
- Appropriate servo limit calibration
- Verified failsafe RTL action
- Maintain safe altitude when crossing over obstacles

System Safety - Maintenance and Checklists

- We use checklists to enforce safety
  - Pre-flight
  - Post-flight
- We inspect all aircraft parts before each flight
- Repairs are made with consent from all team members



Developmental Test - Test Planning

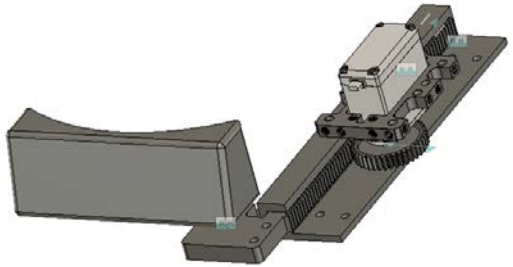
1. Prototype Completion
2. Independent System Test (off quad)
3. Integrated Ground Test (on quad)
4. Basic Flight Test (airworthiness)
5. Aerial System Test in open field
6. Mission Performance Test

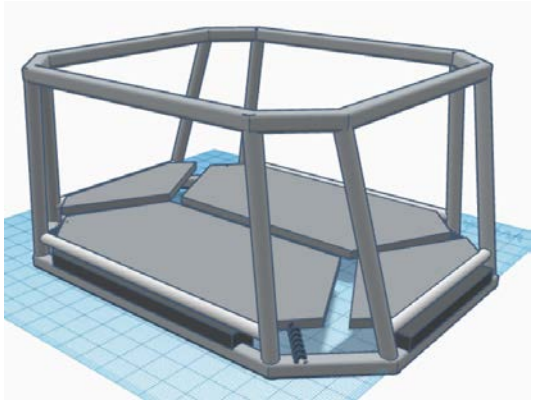
Developmental Test - Ground and Mission Performance

- Plan to simulate competition flight experience:
  - Find scoring items (autonomous map method followed by manual search)
  - Transfer water bottles
  - Complete autonomous objectives

Developmental Test - Design Framework

- Competitive selection framework
- Concept → CAD Model → Low cost prototype
- Cost benefit analysis of functional prototype: Reverse trapdoor won
- Initial flight testing of prototype w/ minimal integration effort



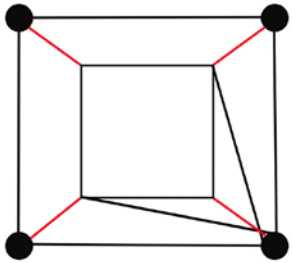


Developmental Test - Initial Results

- Goal: Expand the “flight envelope” to address all aspects of the competition flight tasks
- Discoveries:
  - High amp draw (>20 A)
  - Pickup Attempts knocked over bottle
  - Inexact landing due to offset camera position
- Developed criteria for new design

Developmental Test - Mods to Improve Mission Effectiveness

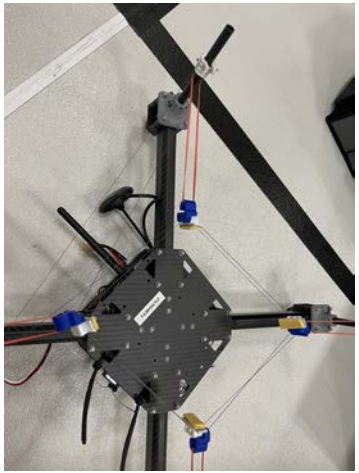
- MEAW Acquisition System:
  - New string-based web design
  - Multiple individually optimizable components
  - Leveraged team experience in other robotics activities
- New string path crosses over once and encircles landing legs
  - Uses low-friction carbon fiber tubes as “pulleys”
- Strategically placed capture location
  - Bottle captures on opposite arm of servo
  - CG maintained within ½” of frame center
  - Constant view of payload from camera



MEAW

Motorized Elastic Assisted Web

Developmental Test - Design Progression



• Different string types
  ○ Warp thread
  ○ Fishing line
• Rubber band types
	• Servo mounts
	• Extended legs
	• Guiding clamp designs and features
	• Rubber pads = less compression

Evidence of Mission Accomplishments

- Consecutive successful bottle pickup and drops
- Accurately identified coordinates (<15 ft) and content of target objects
- Safety protocols effectively ensured no damage to persons or property
- Team members effectively executed assigned roles

Pre-Mission Briefing - Personnel Resourcing

- Defined responsibilities based on roles
- Roles assigned based on skills and interests
- Defined personnel positioning and tasks based on flight status
  - Grounded-preflight
  - Flying
  - Grounded-post flight

Pre-Mission Briefing - Team Comms

Maintaining communication with team roles:

- All non-essential activities are forbidden (sterile cockpit)
- Share essential information
- Each role has specific call outs
- Maintain records of each flight

Pre-Mission Briefing - Go/No-Go Criteria

Discussions and briefings include:

Before Flight

- Weather
- Airspace Activity
- Presence of people
- Condition of Quad

During Flight

- Aircraft Performance
- Wind Speed
- Battery Condition
- Airspace Activity

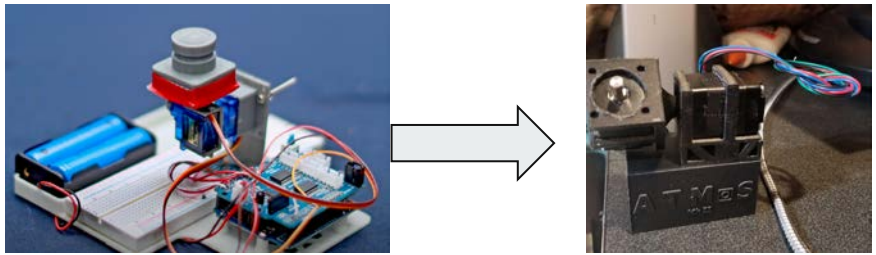
Pre-Mission Briefing - Fall Back Plans

If any risk to safety is present:

- Return to launch (RTL) immediately
- Adjust altitude to avoid obstacle
- Reschedule flight or travel to other fields
- Inspect/repair/inspect quad thoroughly

Social Outreach

- Local science day presentation
  - Introduce community to drones/explorer post
- Personal projects
  - E.g., “ATMoS” camera gimbal



Mk I

Mk II

ATMoS

Thank you for your time!

Questions?