A. T. L. A. S.
Carry the skies

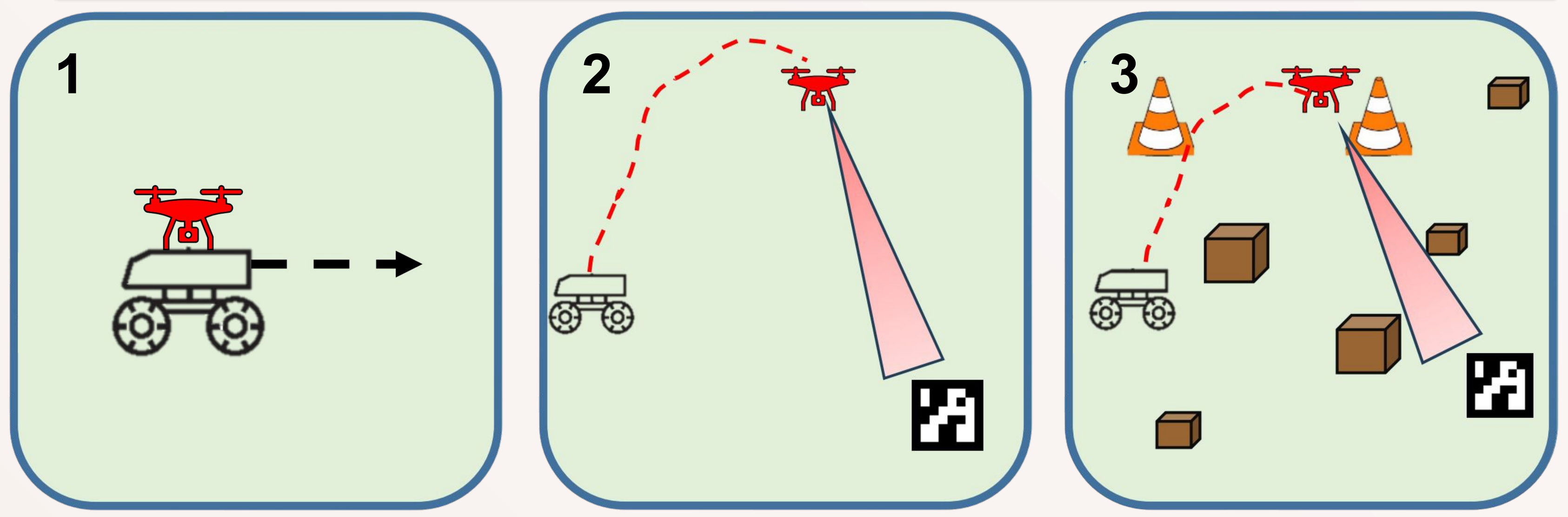
Autonomous Tactical Land-Air System

Roland Zhang | Jacob Bauman | Han Xiao-Li | Alejandro Cifuentes | Ali Yavuz Bozatli
Henry Zheng | Nathan Scheer | Aneesh Thakkar | Steven De Jesus | Maxwell Wu

Background

Developed for the Raytheon Autonomous Vehicle Competition, this project addresses the critical need for automation in modern defense and exploration in extreme environments to reduce human risk. While conventional commercial systems rely heavily on GPS to navigate, leaving them vulnerable to signal jamming. this project prototypes a collaborative reconnaissance platform, an unmanned ground vehicle (UGV) and an unmanned aerial vehicle (UAV), engineered for robust, fully autonomous operation in GPS-denied environments.

Competition Challenges



1.
- UAV hovers for 30s
- UGV drives 0.2 mph in a straight line
- UAV lands on the UGV as it moves

2.
- UAV searches for a destination tag in a 15x15yd field
- UAV commands the UGV
- UAV & UGV arrives & stops at destination

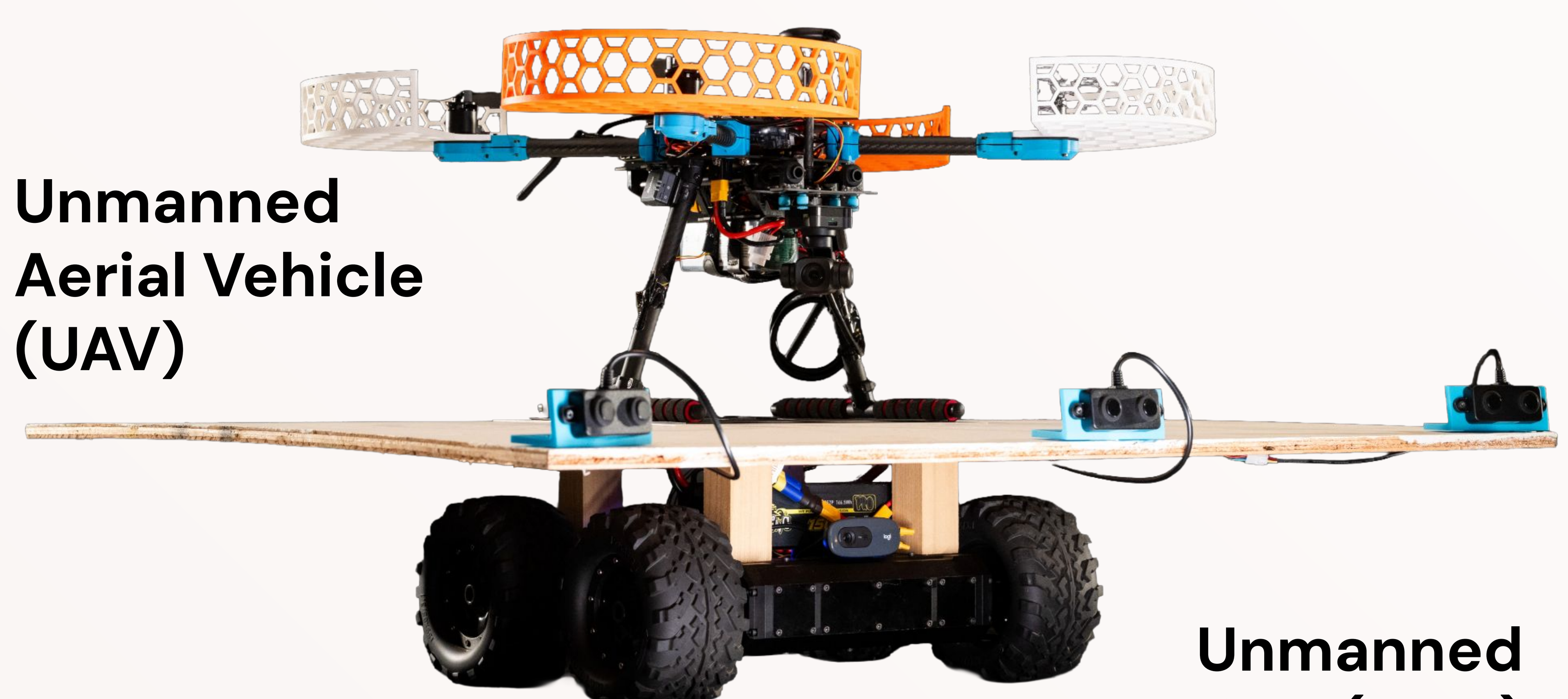
3.
- UGV must avoid obstacles, such as cardboard boxes, cones, and buckets
- UGV cannot drive over obstacles

UAV Imaging Pipeline

1. Decode H.265 image using **GStreamer**
2. Transform color image to grayscale
3. Detect ArUco tags with **OpenCV**
4. Draw a line between the UGV and destination tags
5. Calculate their relative angle and distance

System Overview

The unmanned aerial vehicle (UAV) operates as a scout. It streams and processes 4K camera images to detect ArUco tags using its onboard Raspberry Pi 5.



The unmanned ground vehicle (UGV) operates as a terrain traversal agent. It listens to the UAV for navigation commands, and uses its sensor suite to avoid obstacles.

GPS-Denied Navigation

Holybro H-Flow

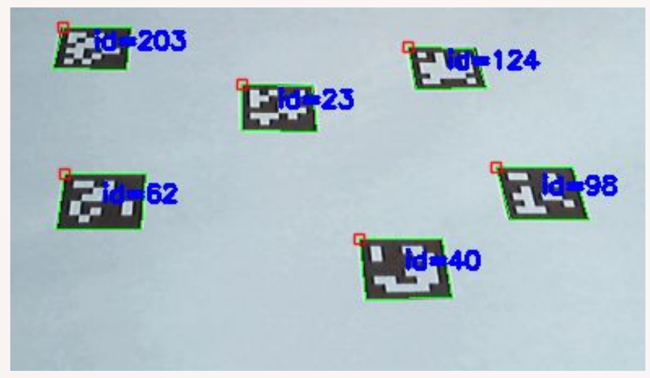
- plug-and-play, integrated sensor module
- replaces GPS with optical flow and range sensing
- configured through QGroundControl, a ground station software

Camera & ArUco Detection

SIYI A8 Mini

Specification	Target	Actual
Image pixels to tag pixels	3:1	6.9:1
Detectable imaging height	15 m	16 m
% tags detected	90%	92%

- 4K image resolution
  - full field coverage at 15m altitude while successfully reading 1x1 foot ArUco tags
- gimbal & vibration dampers
  - decreases motion blur from wind and motors



Example of Detected ArUco Markers

Vehicle Communication

The UAV and UGV communicate using telemetry radios on the. As the UGV approaches its destination, the UAV will send heading updates more often to finish the challenge smoothly.

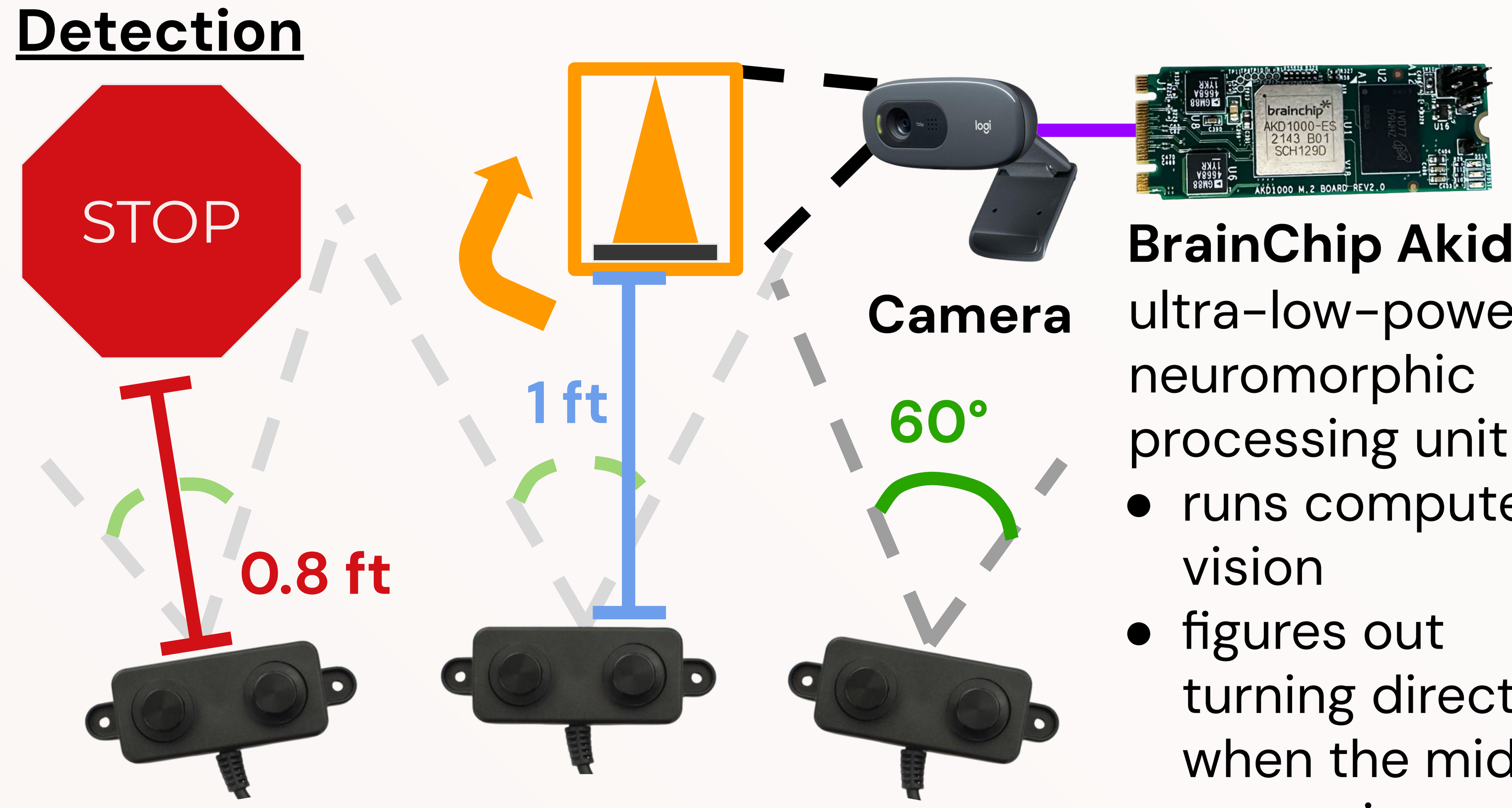
UAV:
1. Both tags detected
2. Update heading.json
3. Sends heading command

UGV:
1. Receives command
2. Turns to commanded heading
3. Drives forward

Obstacle Avoidance

Different computers are used to manage sensor data and exported to the UGV's main Raspberry Pi 5 to control movement. The UGV switches to an obstacle avoidance state where it ignores UAV commands when an obstacle is detected.

Detection

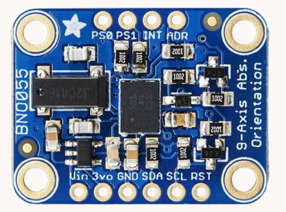


Ultrasonic Sensors
all poll simultaneously, stop within 0.8', and have 60 degrees of angular detection

BrainChip Akida
ultra-low-power neuromorphic processing unit
- runs computer vision
- figures out turning direction when the middle sensor is triggered

Navigation

1. UGV drives in a semi-circle around the obstacle
2. UGV returns back to its original heading to continue driving toward the destination marker



9-axis IMU
Heading

Encoder
Travel Distance

Raytheon
An RTX Business

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UC SANTA BARBARA
Robert Mehrabian College of Engineering