

## Executive Summary

The Raytheon Autonomous Vehicle Competition (AVC) is an annual event sponsored by Raytheon. It's purpose is to provide students an opportunity to solve real world problems. This year, the UAV will take off from the UGV and scout the competition field for the destination ArUco marker. The UGV must then reach the destination while avoiding obstacles, and the UAV must land back on the UGV after scouting. These challenges must be completed without using GPS for navigation.

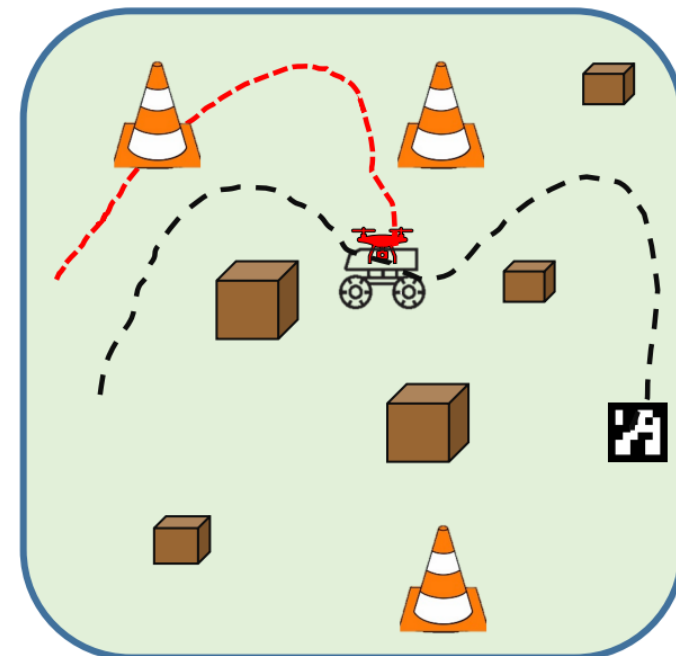


*Figure 1. Example UAV-UGV system completing Challenge 3. Adapted from Raytheon AVC Rules"*

## Background

Raytheon's *Operation Touchdown* challenges teams to develop a collaborative UAV-UGV system capable of autonomous target identification, vehicle to vehicle communication, and coordinated navigation. In this project, the UAV launches from the UGV, searches the field for a designated ArUco marker, communicates the destination directly to the ground vehicle, and then lands on the UGV while it is moving. Systems like this are relevant to real world applications such as disaster response, search and rescue, and defense, where aerial scout vehicles can improve the awareness and effectiveness of ground vehicles.

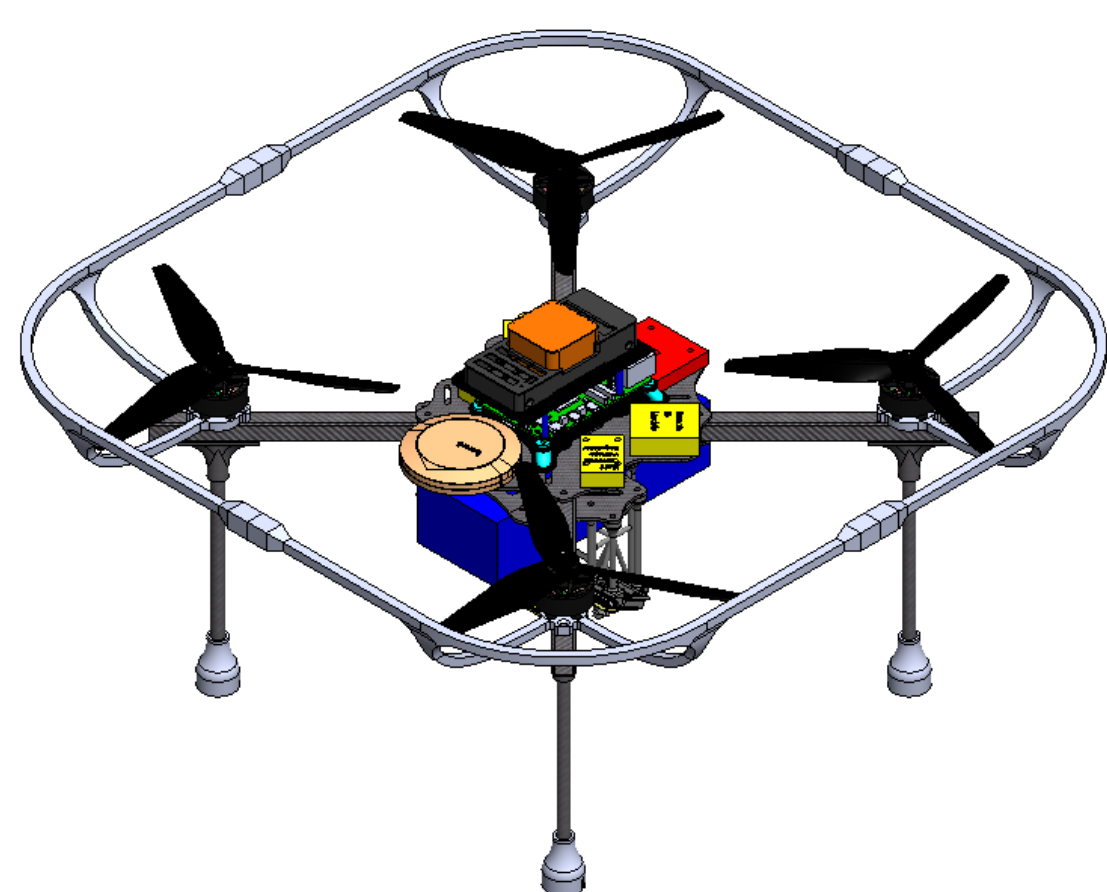


*Figure 2. Final UAV design*

## Experimental Setup

Our experimental setup uses a three-layer architecture consisting of a UAV, a UGV, and a ground station. The UAV acts as the aerial scout and is built around a Cube Orange flight controller and Raspberry Pi 5B companion computer running ArduPilot and ROS 2. It integrates a BrainChip module and stereo cameras for obstacle mapping, a downward-facing camera for landing alignment, GPS for geofence enforcement (GPS is not allowed for navigation), and telemetry hardware for command and status exchange. The UGV uses its own Cube Orange and Raspberry Pi 5B with LiDAR-based obstacle awareness, dead-reckoning state estimation, and a landing deck that supports UAV takeoff and recovery while the vehicle is moving. The ground station receives telemetry from both vehicles, logs mission events, and provides the emergency kill-switch interface. Testing is designed around the AVC mission requirements and is performed in the ERB drone cages, as well as the Maverick Stadium. The testing field contains randomly placed ArUco markers and stationary 3D obstacles such as cones and boxes. This setup is used to evaluate autonomous launch, UAV to UGV destination transfer, GPS denied navigation, and landing on the moving UGV.

## Experimental Test Plan

Testing is performed in three stages: subsystem verification, integration testing, and full mission validation. Subsystem tests evaluate core functions such as autonomous UAV takeoff and landing; ArUco detection under varying distance, angle, and lighting conditions; UGV obstacle avoidance on turf without GPS, telemetry/logging; and emergency kill-switch behavior. Integration tests then verify direct UAV to UGV communication, transfer of target coordinates, and coordinated mission state transitions between scouting, navigation, and landing. Finally, full system trials are conducted in a competition like field with stationary obstacles and a randomly placed ArUco marker to measure whether the system can complete the mission autonomously within the required seven-minute limit while complying with safety regulations. Each test is tied back to a requirements traceability matrix and documented with pass/fail.

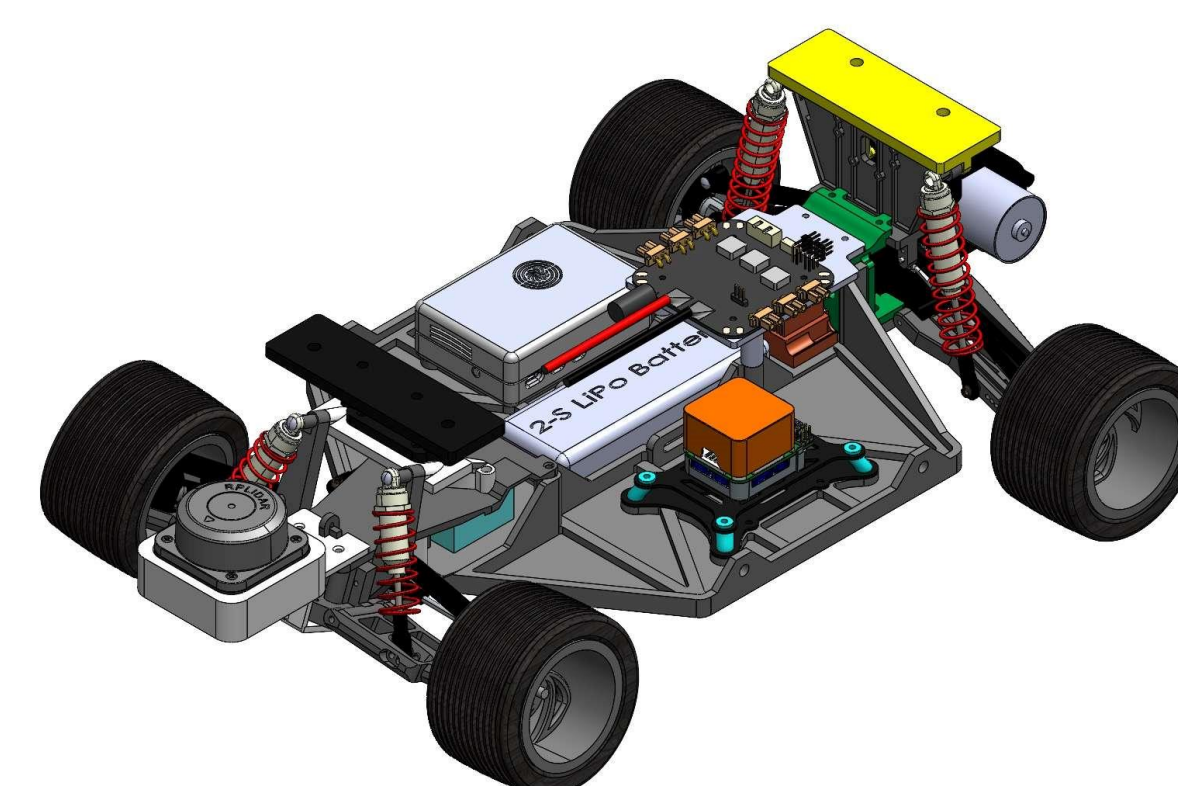


*Figure 3. Final UGV Design (without landing platform)*

## Experimental Results

Experimental results are currently being evaluated against the system's performance requirements. The primary metrics include UAV takeoff reliability, ArUco marker detection accuracy, GPS denied UGV obstacle avoidance, autonomous landing on the moving UGV, and emergency kill-switch response. The system was designed to meet target benchmarks of 95% takeoff reliability, 90% marker detection accuracy within 17 ft, landing on the moving UGV within 7 min, and full stop of both vehicles within 3 s of kill-switch activation. Ongoing subsystem and integration testing are being used to measure performance against these requirements and identify areas for further tuning in perception, navigation, and landing control.

## Conclusions

This project demonstrates a collaborative UAV-UGV system designed to meet the Raytheon AVC *Operation Touchdown* objectives of autonomous target identification, direct vehicle to vehicle communication, GPS-denied navigation, obstacle avoidance, and landing on a moving platform. By combining onboard vision, ROS 2 based autonomy, and short range vehicle communication, the system provides a platform for real world autonomy. Continued integration and field testing will focus on improving the reliability of ArUco detection, navigation, and moving platform landing so the full system can complete the mission safely and consistently in outdoor competition conditions. With the help of Raytheon, our Raytheon representative Dr. Raghav Vadhera, our CSE sponsor Dr. Chenxi Wang, and our lab manager Steven McDermott, our team was able to gain valuable experience in the fields of autonomous vehicles, computer vision, and GPS-denied navigation.

## References

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