

Executive Summary

Raytheon's Annual Autonomous Vehicle Competition-"Operation Touchdown" introduces the challenge to design, manufacture, test, and validate an unmanned aerial vehicle and an unmanned ground vehicle that can achieve full autonomous specified maneuvers. Within Operation Touchdown, the UGV serves as a mobile landing pad, enabling precise navigation through the UAV's guidance. However, what makes this competition unique is that the UAV must have the ability to land securely onto the UGV. Within this year's team of Mechanical, Electrical, and Computer Science Engineers, we have designed a quadcopter-style UAV, intending to reduce weight and size to maximize flight time and ensure smooth and soft landing onto the UGV. The UGV is an RC car that is modified to house the necessary components to achieve autonomous movement but also provide a landing system for the UAV. With the use of electromagnetics equipped within the UAV, we can ensure the security of the UAV on the UGV during landing and maneuvers as they travel to the designated location simultaneously.

Background

Raytheon Technologies hosts an Autonomous Vehicle Competition (AVC) every year to bring students together to design, manufacture, and program autonomous vehicles. This year's competition involves three challenges with a UAV and a UGV working together to complete the challenges listed:

Challenge 1: Launch and landing on moving UGV

- The UAV will take off from the UGV and land back on the UGV while it is moving along a predetermined path.

Challenge 2: Destination Search and Delivery

- The UAV will take off from the UGV, locate an Aruco marker in the area, and relay the location to the UGV and land securely onto the UGV before reaching the location.

Challenge 3: Obstacle Navigation

- This combines challenges 1 and 2 with added obstacles throughout the area, as represented below.

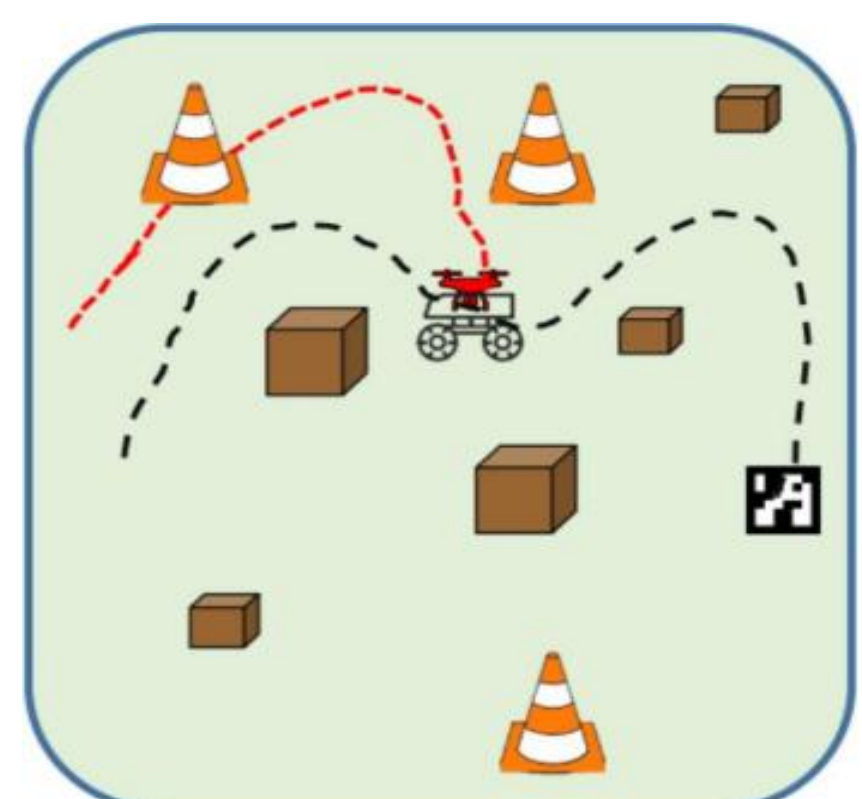


Figure 1. Challenge 3 Diagram

Current Ground Vehicle

The UGV consists of a modified Traxxas RC car, which can house the necessary components to achieve autonomous maneuvers while acting as a mobile landing pad capable of securing the UAV.

- The chassis was widened and redesigned to integrate various sensors and electronics while still incorporating the pre-existing powertrain components.
- All parts were 3D printed with either Carbon Nylon or Carbon-infused PLA to ensure stiffness, strength, and accessibility.
- To effectively secure the UAV while landing, electromagnets are used within the landing feet of the UAV to which will activate when at a predetermined distance from the UGV's steel landing pad.



Figure 2. Current UGV (without platform)



Figure 3. Current UGV with platform

Current Aerial Vehicle

The UAV is a quad-copter designed to maximize stabilization and have a lightweight structure. This was prioritized so the UAV can accurately land on the UGV and not add too much strain to the UGV chassis.

- Square tubing was chosen for the arms to create simpler mounts and a plug-and-play design for easier serviceability.
- The propulsion target was set to a 4:1 thrust-to-weight ratio
- The current design features a magnetic landing system through electro-magnets placed in the feet of the drone to lock onto the steel platform on the UGV.
- Truss supports were added to provide added stiffness while remaining out of view of the cameras.



Figure 4. Front View of Current UAV



Figure 5. Isometric View of Current UAV

Detailed Design

UGV Custom parts:

- To ensure structural integrity to support the landing platform and UAV, the team decided to replace the original suspension shock towers with a design to allow the landing platform to be mounted so attachable mounts to the existing shock towers were designed.
- The chosen landing platform was a 20-gauge steel 24" diameter circular platform to allow for an electromagnetic landing mechanism. To prioritize stiffness and strength within the steel plate, a bead was pressed along the circumference.

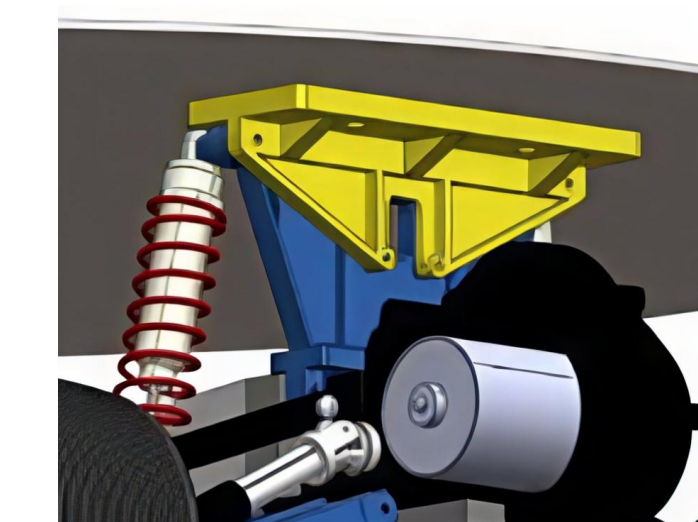


Figure 6. Rear platform mount



Figure 7. Front Platform mount

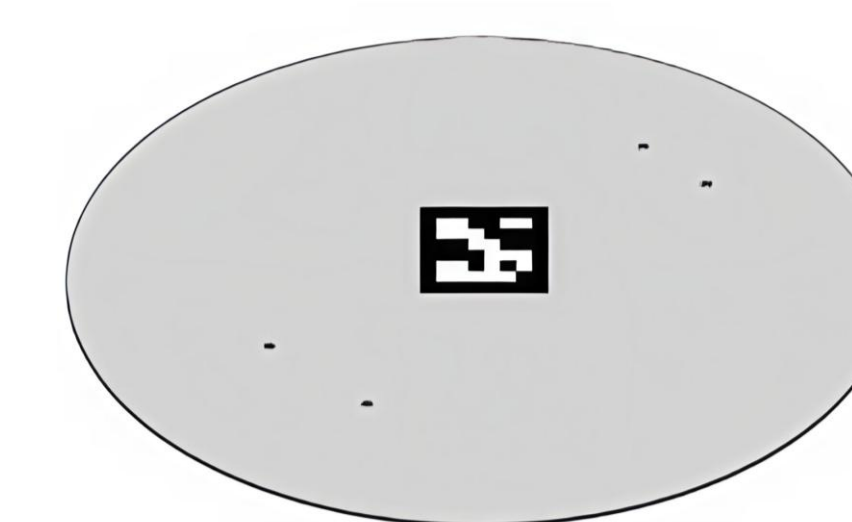


Figure 8. Landing Platform

UAV Custom Parts:

- Camera mounts were designed to hold the cameras to direct and locate the UGV and field markers.
- Two mounts were placed on the underside of the chassis 27.8 degrees from the negative z-axis and 5.2 inches apart. The coordination of the mounts allows the cameras to mesh for a more accurate reading.
- A third Camera mount was designed and placed in the center under the battery for docking and pairs with the altimeter to measure height.

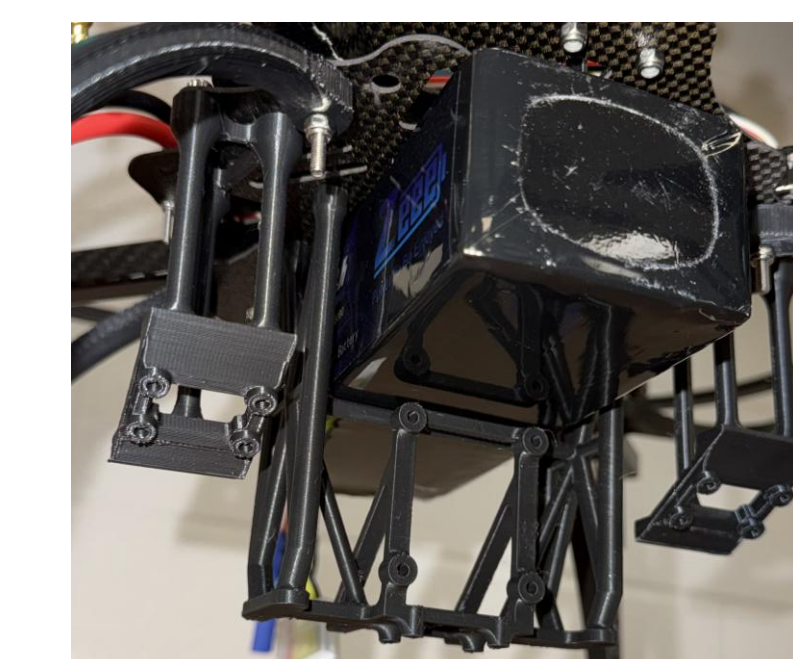


Figure 9. Camera Mounts

Conclusions

Getting all of our parts and hardware finalized and ordered is important, as there were large gaps of waiting for parts for assembly and programming. Another large takeaway from this project is that inter departmental communication is very important, and was something that caused redundancies and confusion at times. Working together as a large team can be beneficial but also has its drawbacks and working together across the departments is crucial for a efficient design and process.

Acknowledgements

Dr. Robert Woods	MAE Faculty Advisor
Dr. David Wetz	Project Advisor
Dr. Chenxi Wang	CSE Faculty Advisor
Dr. Chris McMurrough	CSE Faculty Advisor
Dr. Raghav Vadhera	Raytheon Mentor