Project 7: UGV Guidance, Navigation, and Control

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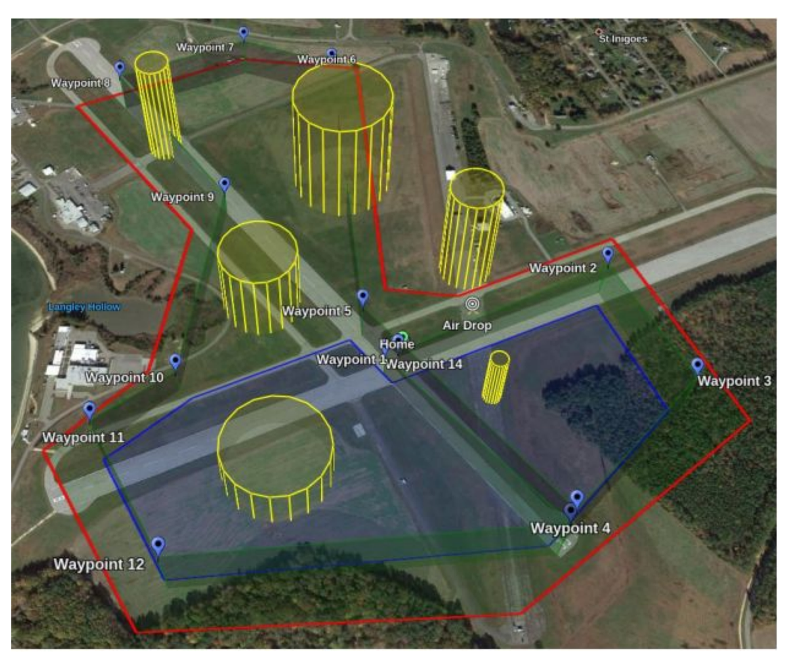
Overview: The AUVSI SUAS competition involves developing a unmanned aerial (UAV) and ground vehicles (UGV) capable of delivering a payload to a certain locations and navigate around imaginary obstacles autonomously.

Introduction: Flight path deviations are defined as changes made to the UAV's flight plan during operation, including stopping to hover, changing trajectory, changing velocity, and so on. This constraint is adverse to our flight path and flight time when completing the Air Drop task with a static descent system, i.e. a parachute or a winch system, because our UAV will not be able to maneuver to the appropriate position and hover to execute the air drop during the waypoint navigation phase regardless of the location of the drop zone relative to our UAV's current position.

Objective: Design a system that will allow our UAV and UGV to execute the Air Drop task.

Challenge: When the UAV position is first passing the Air Drop location during the waypoint navigation task that will not require our UAV to (1) deviate from our flight path between waypoints and (2) navigate to the Air Drop location a second time.



UGV Ground Navigation

- Once landed the UGV must automatically path through given waypoints while staying in boundaries.

To prevent disqualification, we use the onboard microcontroller to communicate with our Ground Station laptop intermittently using a radio. This allows us to:

- Send pathing scripts through messaging protocols
- Allows for path correction if detected through GPS
- Gives us a way to monitor our 30 second communication loss restriction

References

Pazmiño, Angelo A. Fonseca, "A Computational Fluid Dynamics Study on the Aerodynamic. Performance of Ram-Air Parachutes" (2018). Dissertations and Theses. 405.

ANSYS Simulation Tutorial https://www.youtube.com/watch?v=9bdAfGqFzJo&t=762s

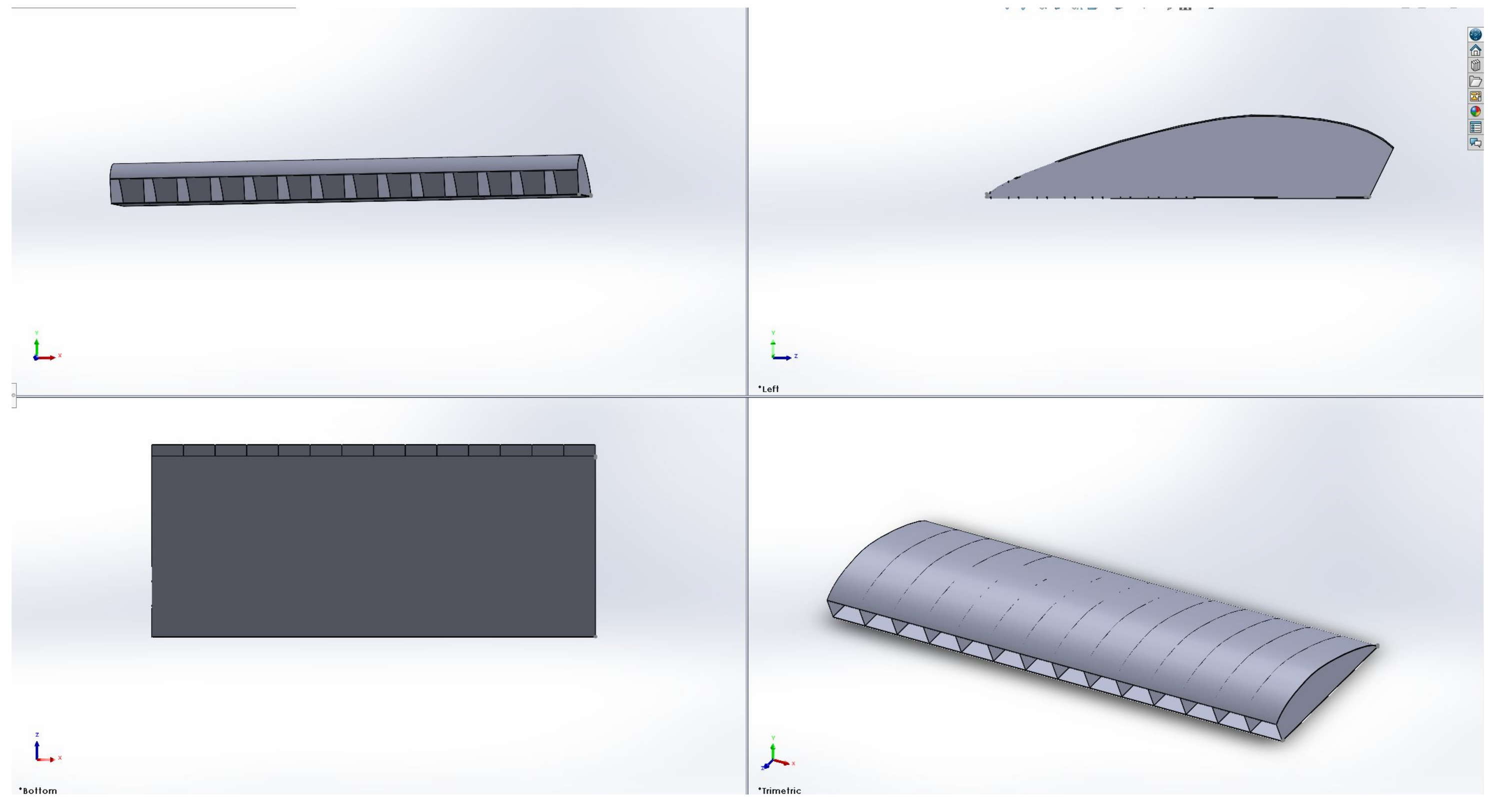


Figure 1.1: *Preliminary CAD model of the parachute (flat)*

Design chosen:

- Ram-air parachute
  - type used for skydiving, base jumping, paragliding, and for military purposes
- Servo motors
  - rotates and acts like arms pulling to steer a parachute

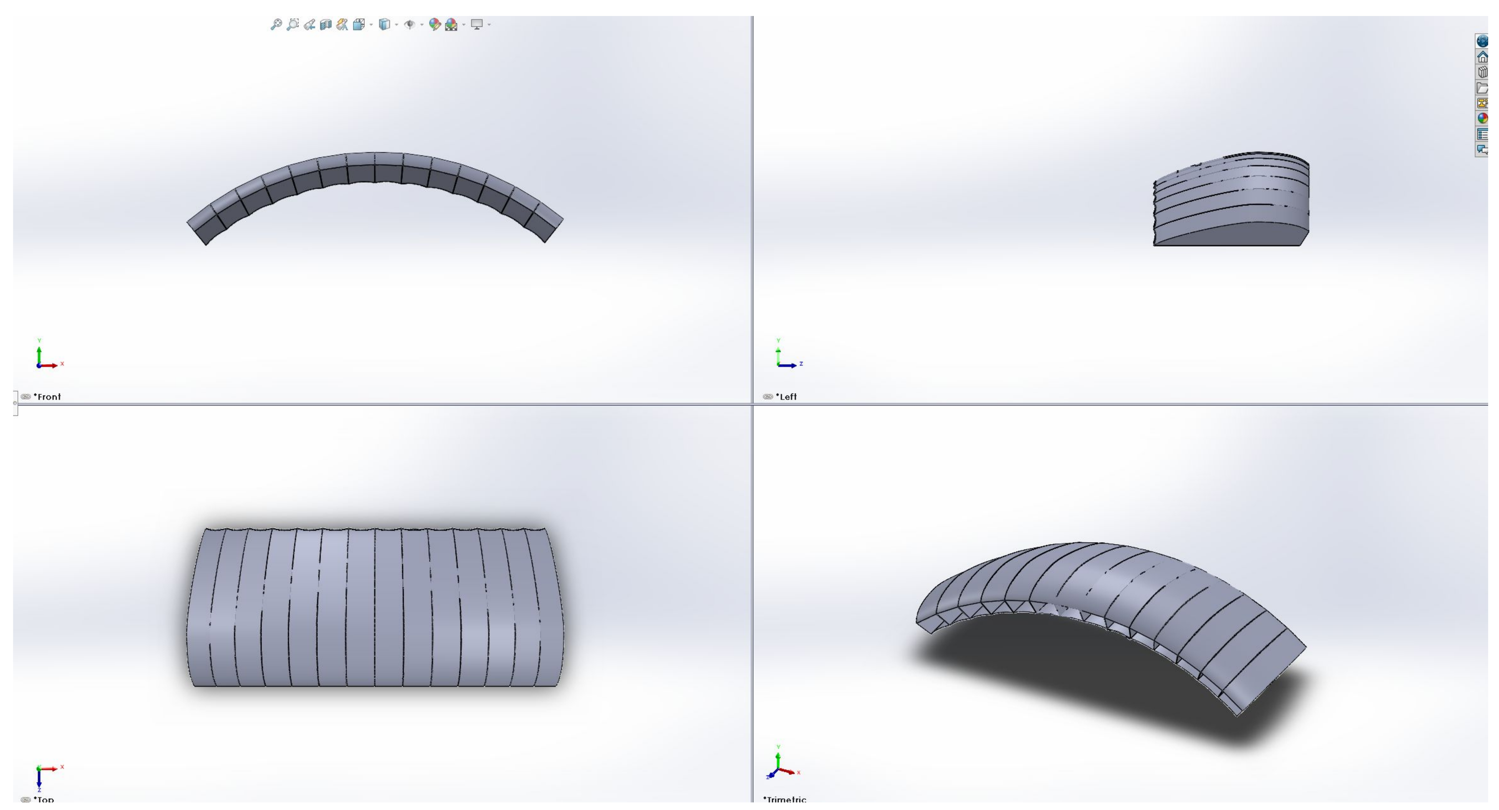


Figure 1.2: *Preliminary CAD model of the parachute (curved)*

To drop a 4lb payload:

- must have a minimum surface area of 1.85806 m^2 (20 ft^2)

Figure 1.1 and **Figure 1.2** are both the same model of a 7 ft. x 3 ft. ram-air parachute.

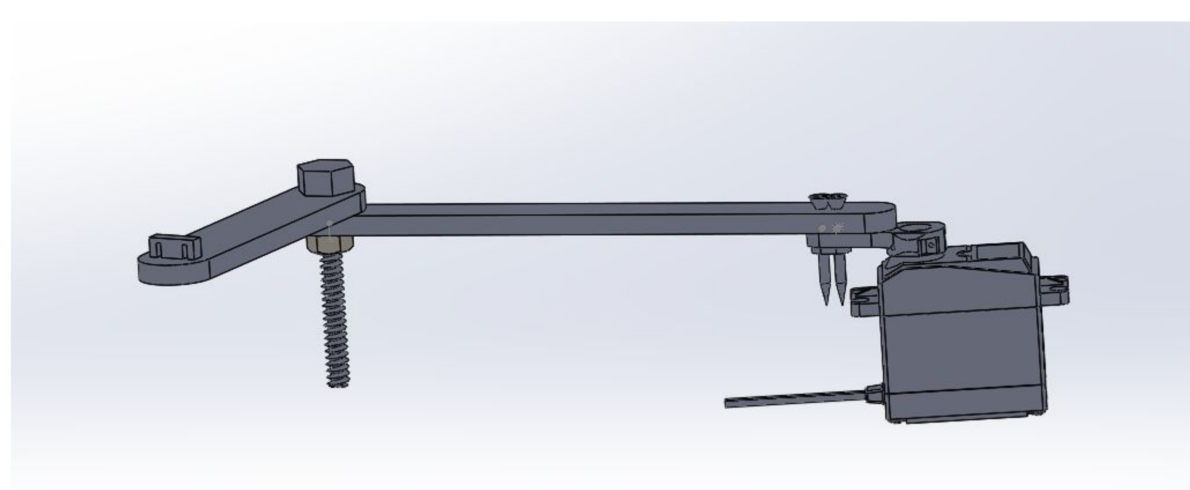


Figure 2.1: *Preliminary CAD model of the servo "arm"*

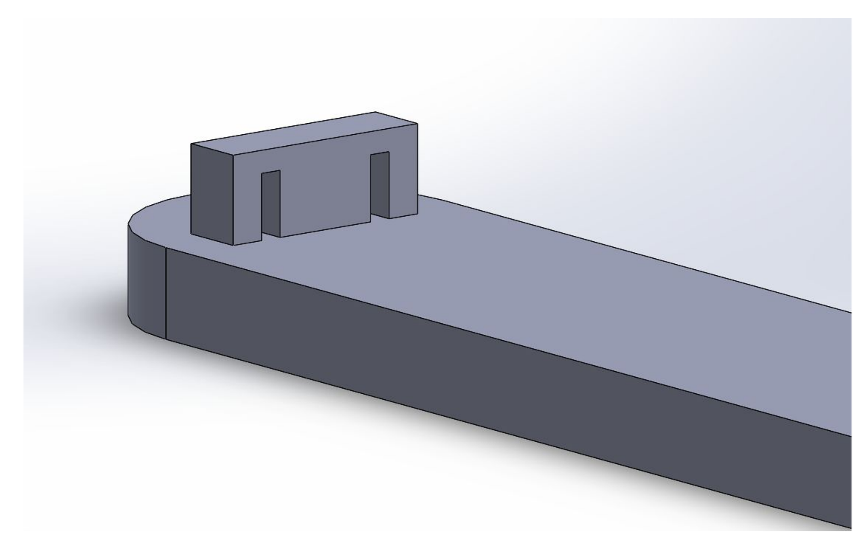


Figure 2.2: *Close up of line attachment on the preliminary CAD model of the servo "arm"*

Figure 2.1 consist of the servo motor and "arm" used to steer the parachute. **Figure 2.2** is a zoom in of where the parachute line connects to the "arm"

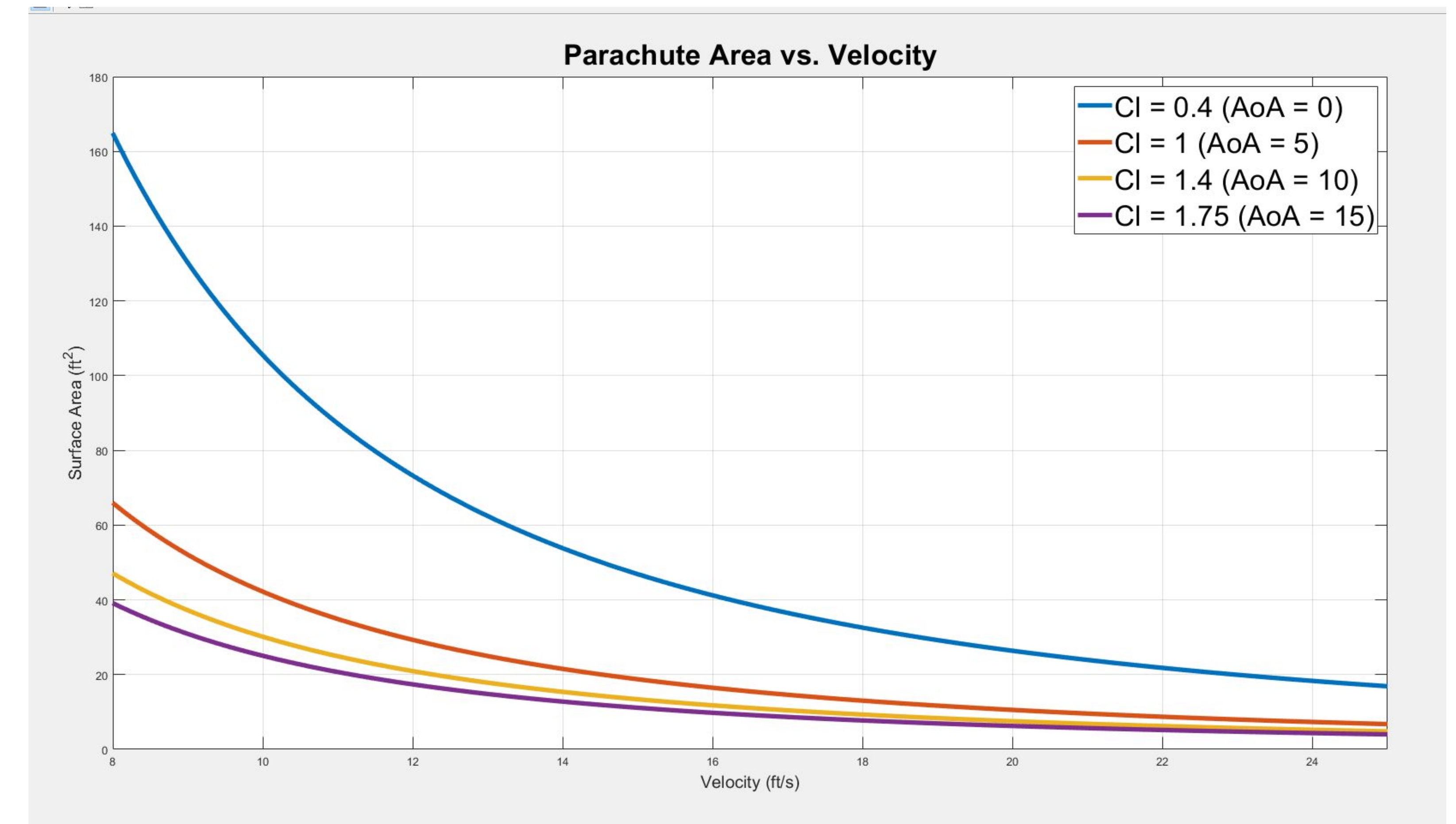


Table 1.1: *Area (ft^2) vs Velocity (ft/s) by varying coefficients of lift*

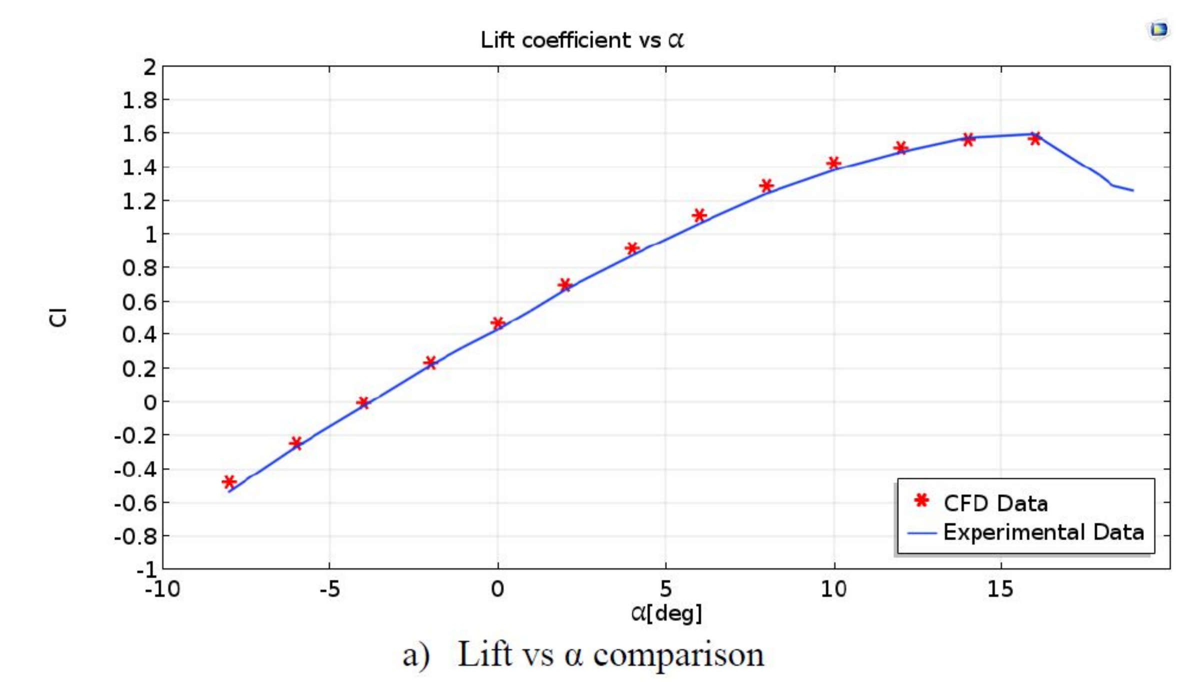


Table 1.2: *Coefficient of Lift vs AoA of RAM-Air Parachute from Embry-Riddle Experiment*

Analysis applied to design

One area where analysis is applied in the design process is the angle of attack of the parachute. The purchased parachutes are usually manufactured with strings equal in length. As a result, the parachute has a value of 0 for its angle of attack, meaning we don't get the maximum amount of efficiency from our descent. The figure above demonstrates that increasing our angle of attack to a range of 10-15 degrees decreased the required area to generate a lift force of 5lb.

Recommended Future Improvements

Some improvements that are suggested are finding the maximum impact velocity possible, In other words, determine at which velocity it will be possible to determine when the UGV will experience any damages if dropped from a certain altitude. The only factor we can determine is when the impact is high enough to cause any structural damage. A more efficient analysis can be conducted if we perform a test drop on a different RC car to analyze what type of damages can occur or when electrical components loosen off or fall off.