ASNE26: Autonomous Racing Trimaran

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Introduction

In an effort to promote naval engineering across the USA, the American Society of Naval Engineers annually hosts the Promoting Electric Propulsion (PEP) competition. At this competition, over 50 teams of college engineers race electrically-powered watercraft. Our vessel, named Cerberus, placed 3rd out of 17 teams in the autonomous division.

System Requirements

- *The craft shall be able to operate for at least **2 miles.***
- *The craft shall carry a **30lb payload.***
- *The craft shall self-navigate using **GPS waypoints.***
- *The craft shall have an **emergency shutoff switch and fuse.***
- *The craft shall be **IP67 rated.***
- *The craft shall **fit in the bed of a pickup truck.***

Autonomy and Controls

Our autonomy and control system centered around the Pixhawk 6C as its flight module, combined with the M10 and F9P GPS modules:

Fig. 1 Pixhawk 6C, M10 GPS, and DroneCan F9P GPS module (left to right)

Each GPS module has a built-in compass, allowing us to obtain a precise heading with redundancy, along with centimeter-level positional accuracy.

The Pixhawk communicates with the base station via Telemetry and RC. The system contains two 6Dbi gain omni directional antennas, and an R8XM RC receiver for communication up to 800m.

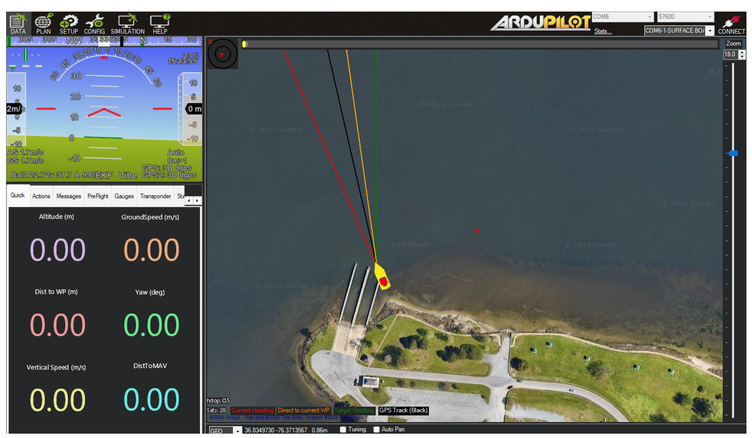
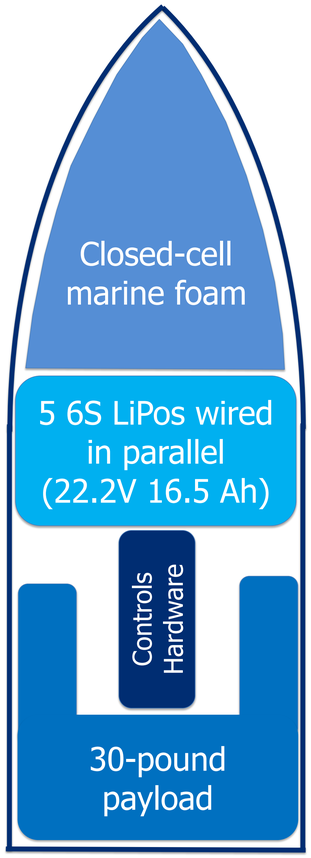


Fig. 2 Screenshot of ArduPilot Mission Planner

The system used ArduPilot as its navigation software. ArduPilot is an open-source software that offers precise drone navigation and extensive tuning capabilities. Most importantly, ArduPilot also saves telemetry logs for every mission to review race performance and generate tuning data.

Design



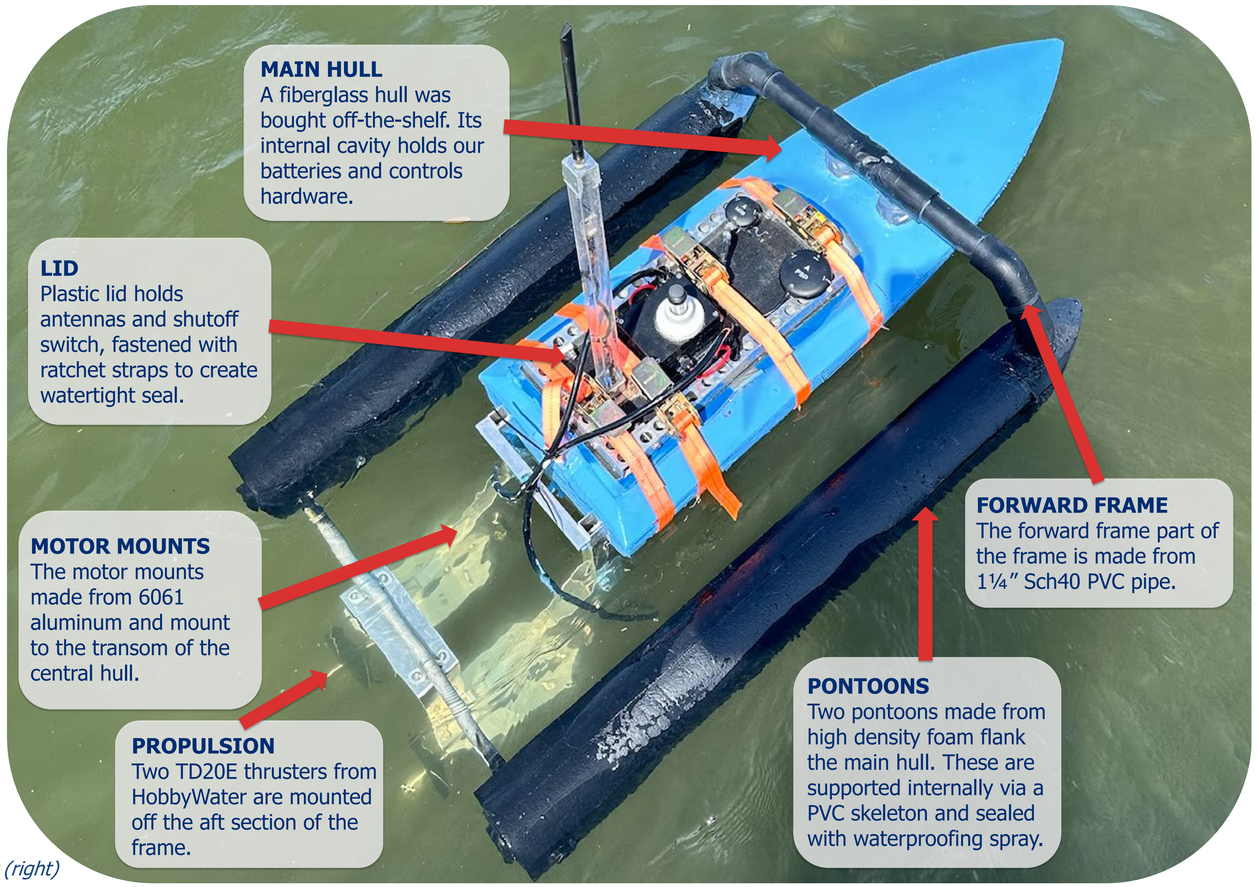


Fig. 3 Internal layout (above) and external layout (right)

Testing

Fig. 4 First open water test where we discovered issues with deployment and stability

One point that was stressed to us was the importance of testing. This led to a few new requirements. The first was to have a maximum weight of 80 pounds, including payload, to allow the craft to be single-man deployable. The second was to be able to fit our craft in the back of a sedan to allow for a more frequent and flexible testing schedule. We managed to conduct 8 full-system tests throughout the year, iteratively improving each time. This ultimately culminated in our final craft (below).

Fig. 5 Final test before race day. Our craft was one of the most reliable of the competition.

Tuning and Race Strategy

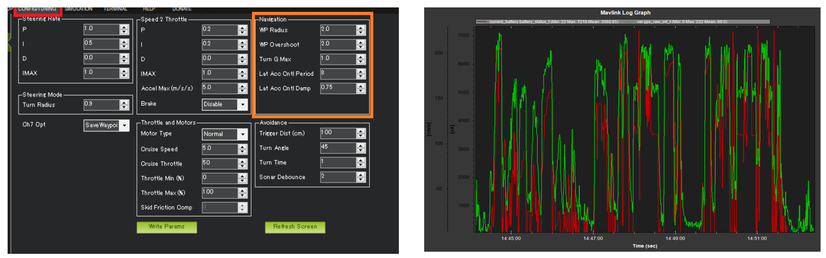


Fig. 6 Mission Planner Tuning Menu (left) and Current vs Velocity Telemetry Log (right)

ArduPilot allows us to input physical vessel parameters such as turn radius, cruise speed, and cruise throttle, along with navigation settings like target speed and PID gains. We determine these values based on telemetry logs, which provide performance data from previous missions.

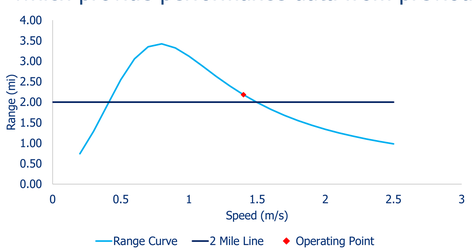


Fig. 7 Speed vs Range Optimization Curve

A primary use of our logs was determining the optimal speed to minimize time while ensuring we finish the race given our battery capacity. Using the logs we were able to reach an optimal value of 1.45 m/s.

Acknowledgements

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