ANCHOR (Autonomous Naval Control for High-Range Operations & Reliability)

SDSU College of Engineering

Department of Electrical and Computer Engineering

Team Members

Erik Carlson (EE)

Alberto Serrano (ECE)

Khalia Wells (ECE)

Nathan Trejo (EE)

Randall Hilc (EE)

Project Overview

ANCHOR (Autonomous Naval Control for High-Range Operations & Reliability) is a system that upgrades a standard RC boat with long-range communication and real-time telemetry. A Raspberry Pi Pico is used as the main controller, integrating a LoRa radio for wireless communication, GPS for position tracking, an IMU for heading, and radar for obstacle detection.

The system allows a user to control the boat through a GUI while receiving live data such as position, heading, and nearby obstacles. Commands are sent to the boat and telemetry is returned in real time.

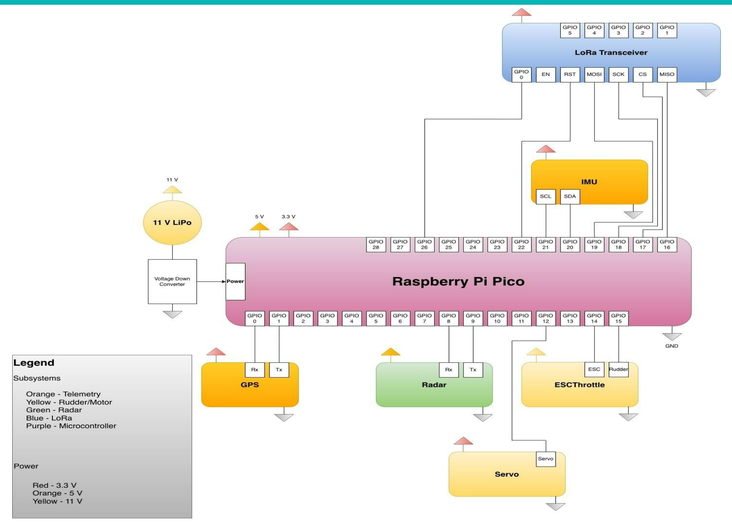
Motivation

- Standard RC boats limited to short-range line-of-sight control
- Navy requires long-range operation when human line-of-sight is difficult or unattainable
- No low-cost, modular retrofit solution exists for maritime remote operation
- Gap between consumer RC boats and expensive autonomous naval systems
- ANCHOR delivers a $5,000-budget kit that adds long-range telemetry, GPS tracking, and obstacle detection to any RC boat with minimal hull modification required.

Acknowledgements

Sponsored by NIWC Pacific (Naval Information Warfare Center Pacific)
Faculty Advisor: Dr. Christopher P. Paolini and Mark Bruno
San Diego State University — Dept. of Electrical and Computer

Final Model



System Components

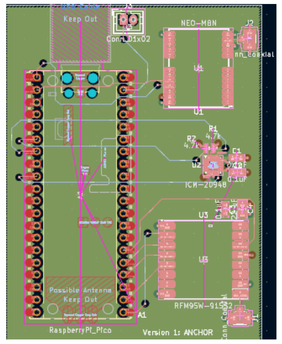


Figure 1: ANCHOR System PCB Design

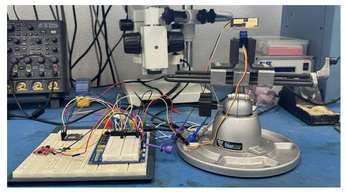


Figure 2: Electronics Integration and Bench Testing

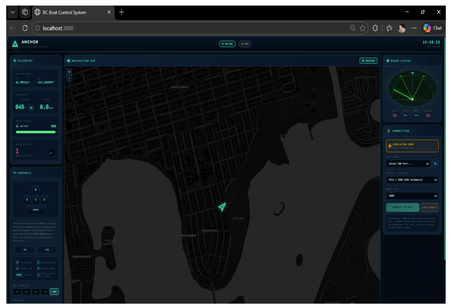


Figure 3: Real-Time Telemetry Ground Station Interface

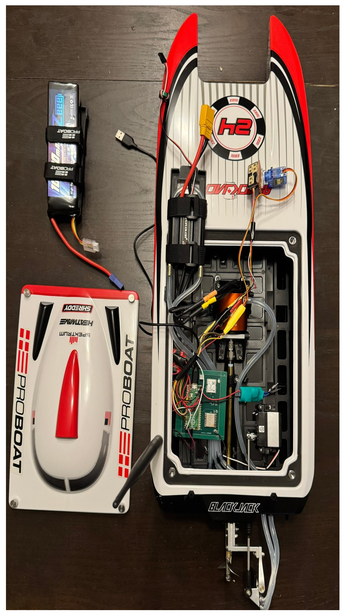


Figure 4: ANCHOR Hull Interior and Electronics Payload

- Waterproof Container
  - Raspberry Pi Pico Microcontroller
  - RFM9x 915 MHz LoRa Radio
  - NEO-M8N GPS Receiver
  - ICM-20948 IMU
  - RD-03D 24 GHz Radar
- Controller
  - Raspberry Pi Pico Microcontroller
  - RFM9x 915 MHz LoRa Radio

Key Performance Specifications Standards

- Waterproof: Sealed enclosure protecting all electronics
- Comms: LoRa 915 MHz, 2.74 Hz update, 365 ms latency, less than 5% packet loss
- GPS: 2.5 m CEP, 1 Hz update, displayed on GUI map in real time
- Heading: IMU tilt-compensated, less than or equal to 2 degree jitter target, shown on GUI
- Runtime: Greater than 15 minutes on LiPo battery
- Control: GUI throttle and rudder over LoRa connection
- ESC: 1000 to 2000 us PWM at 50 Hz, 0.6 s failsafe cutoff

Software Overview

ANCHOR uses a two-layer software architecture consisting of a React/FastAPI GUI and Raspberry Pi Pico firmware. The firmware collects GPS, IMU, and radar data, packages it into JSON telemetry, and transmits it through the LoRa link to the operator interface. On the shore side, the GUI displays live telemetry and accepts remote control inputs, allowing the user to monitor the boat and issue commands in real time. Bench testing verified successful communication, telemetry handling, and live software integration across the system.

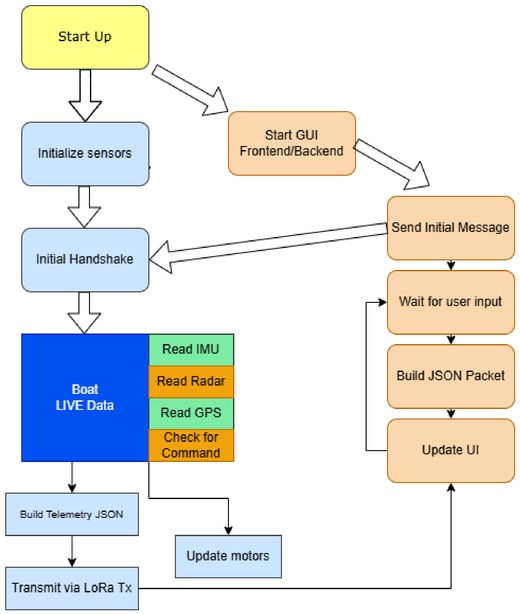


Figure 5. Flowchart for ANCHOR's Code Operation

Conclusion

ANCHOR demonstrates the feasibility of transforming a standard RC boat into a more capable remote-operation platform with long-range communication, live telemetry, and obstacle-awareness sensing. The project successfully moved beyond isolated component testing and established an integrated prototype that supports real-time sensing, telemetry transmission, and operator interaction through a GUI. Overall, the project provides a strong proof of concept for modular maritime retrofitting and creates a foundation for future work in field deployment, autonomous navigation, and expanded sensing capability.

Spring 2026