

Introduction:

This executive summary presents an overview of the racquetball launcher, electrical system, and computer vision software designed for an autonomous surface vessel (ASV) competing in the RoboBoat competition hosted by the Office of Naval Research. The project aimed to improve the ASV's capabilities through the design, testing, and implementation of an integrated racquetball launcher system paired with computer vision for autonomous targeting.

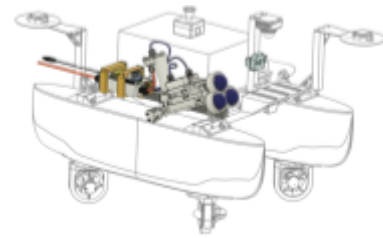


Figure 1: ASV with integrated racquetball launcher and electronic box.

Project Objectives and Requirements:

Mechanical Requirements:

- Weight less than 6.8kg
- Fit within a 15.24 cm by 15.24 cm by 15.24 cm volume
- Hold 3 racquet balls
- Maintain racquet balls during pitch, roll, yaw maneuvers ± 30 degrees
- Launch racquet balls
- Water resistant to splash IPx4
- Minimum launch distance (~ 50.8 cm)
- Ease of reloading racquet balls, from the dock when one side of the boat is accessible.
- Not negatively affect the boat handling operating characteristics
- Precision requirement circle of diameter 30.48 cm

Electrical Requirements:

- Operate on 12 V with voltage regulation.
- Interface with auxiliary payloads (e.g., water pump pinout).
- Use a waterproof electrical enclosure with simplified cable management.

Software Requirements:

- Interface with Jetson Nano NX (Linux OS).
- Detect and localize a target vessel experiencing up to $\pm 30^\circ$ roll.
- Integrate with camera-based targeting and mission control.

Design Overview:

The final launcher system consists of three integrated components:

1. **Mechanical Launcher:** Uses a compound gear mechanism to retract a spring-loaded puncher, locked by a fang and sear plate system, released via a servo-triggered gate. The mechanism includes an indexing drum to rotate the magazine and fire sequentially.
2. **Electronics Box:** Houses an Arduino microcontroller, a voltage regulator, and a water-resistant enclosure for reliable operation in marine environments. The electrical system features Hall effect sensors and magnetic encoders to synchronize mechanical actions with control signals.
3. **Computer Vision System:** Utilizes an OAK-D LR camera interfaced with a Jetson Nano Nx running OpenCV and RoboFlow-trained YOLOv8 models for object detection. The vision pipeline filters and detects the black target vessel, calculates centroids, and communicates launch commands to the Arduino.

Testing and Performance:

- Closed Loop Launcher Test: Achieved extended range but suffered from precision loss due to ball deformation during misfire.
- Non-Magazine Launcher: Provided maximum range but lacked multi-shot capability.
- Initial Rotating Magazine Launcher: Encountered range and precision limitations.
- Revised Rotating Magazine Launcher: Upgraded gear system, regulated servo voltage, and integrated safety fuses improved range, reliability, and safety.
- Computer Vision Testing: Ground tests simulated water-level conditions with the black target vessel mounted on risers. The system achieved consistent detection at ~7 meters using HSV filtering and contour detection, with centroid localization successfully driving autonomous launch commands.

The final 3-barrel reclaimed range configuration met or exceeded all design requirements, achieving $\Delta(x) = 0.0312$ m and $\Delta(y) = 0.0338$ m precision. Separate components, such as the hall effect sensor, motor, and servo motor, have been tested for water resistance using cobalt test strips, placed inside their respective casings, and have passed. The integrated computer vision software also successfully identified the target vessel.

Conclusions and Future Work:

The final design achieves project objectives by combining reliable mechanical launching, robust electrical systems, and functional computer vision-based targeting. Future improvements recommended include:

- Upgrading from bearings to bushings for enhanced water resistance.
- Using corrosion-resistant shafts.
- Adding humidity sensors for enclosure monitoring.
- Continuing software refinement to reduce false positives in detection and improve robustness in varying lighting conditions.

This project advances ASV capabilities and serves as a valuable educational platform for hands-on learning in robotics, electrical systems, and computer vision applications.