Amphibious Rescue Craft (ARC)

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Abstract

Every year at beaches across the United States, there are 100 deaths due to drowning. Approximately 80% occur during unguarded conditions – when beaches offer lifeguarding services, but lifeguards are not on duty or the victim is in an unprotected area. In addition, lifeguards in open water environments make an average of 70,000 rescues per year[1], 80% of which are due to rip currents that can make rescues especially dangerous for lifeguards[2].

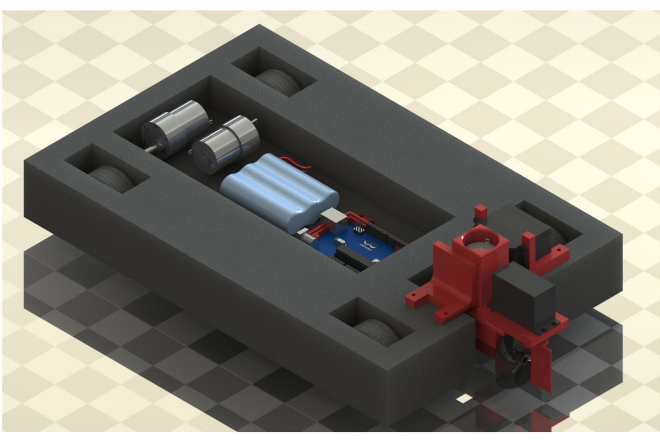
Amphibious vehicles have existed since the 19th century, but are not widely used beyond military and recreational applications. If a rescue craft can be remotely controlled and also maintain locomotive capability in rough conditions, it can reasonably be deployed from a beach as a lifesaving device.

The purpose of this project is to combine amphibious vehicle technology and beach rescue in a platform that saves more lives during unguarded conditions and reduces the risk lifeguards inherently face.

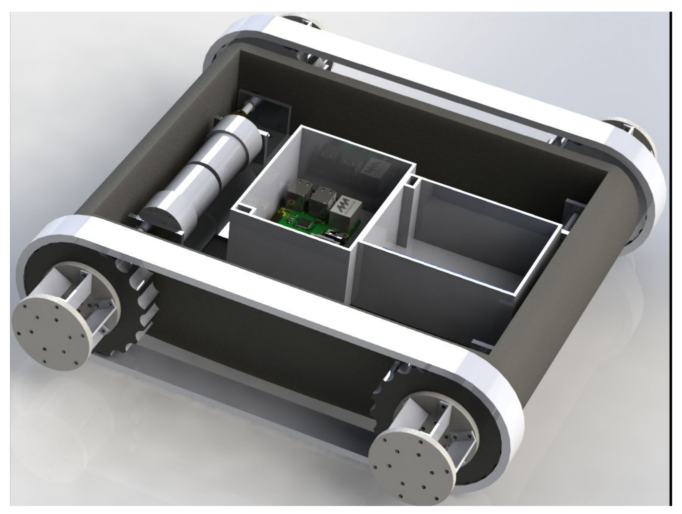
Design Specifications

Specification	Measured Value
Maximum velocity on land	0.63 m/s
Maximum velocity in water	0.14 m/s
Turning velocity on land	1.164 Rad/s
Turning velocity in water	0.7854 Rad/s
Mass	2.805 kg
Theoretical payload	0.2 kg

Design History

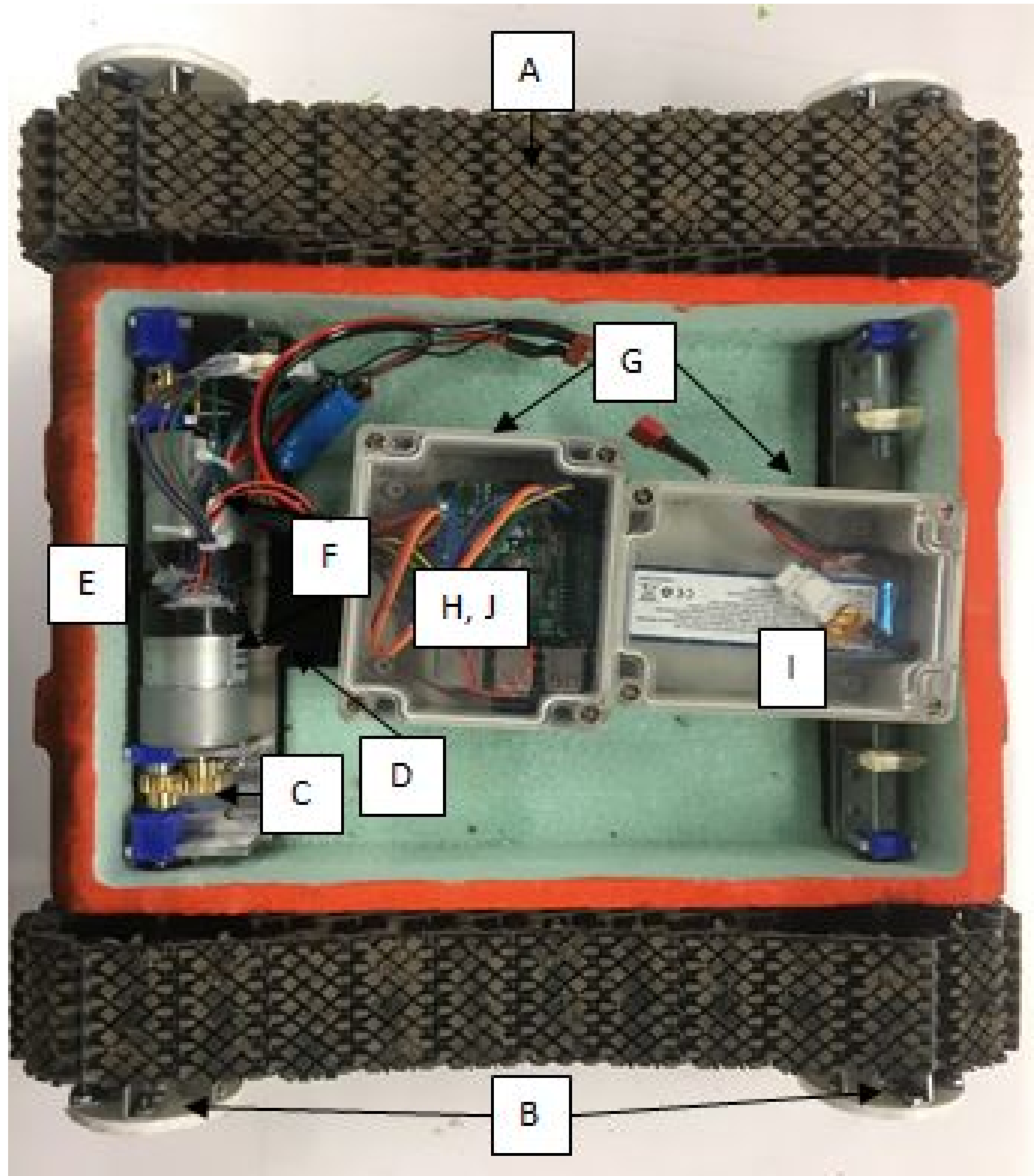


ARC Mark I
- Two DC motors for land movement
- One DC motor and two servo motors for aquatic movement
- Differential steering on land and propeller-rudder steering in water



ARC Mark II
- Two DC motors (one locomotion system) for land and water movement
- Differential steering on land and in water
- Hydrodynamic hull design
- Stable chassis to maintain coaxial alignment

Subsystem Overview



Mechanical Subsystem
A. Track drive with differential steering
B. Custom modular paddle wheels
C. Custom bearing, gear and motor housing
D. Custom H-shaped aluminum chassis
E. Custom polystyrene hull

Mechatronic Subsystem
F. High torque motors with encoder capability
G. Waterproof component boxes
H. Dual H-bridge motor drivers
I. 3s Lipo battery pack

Computational Subsystem
J. Onboard computing system with joystick control

Engineering Design

Design considerations included balancing motor size and performance, optimizing locomotion in all target domains, waterproofing the hull, isolating onboard mechatronic components, maintaining coaxial alignment, maintaining track tension, and reducing friction in moving parts.

The engineering objective is to maximize payload while packaging these considerations into a modular and scalable prototype, which required custom structural components and a unique locomotion design.

Testing

Land
- Drove on rough soil in Schenley Park and smooth concrete indoors.
- Turning velocities dependent on terrain, faster on rough soil.
- Uneven terrain poses problem for vehicle, hull may get stuck and cause tracks to lose traction.

Water
- Drove in pond in Panther Hollow and in a bathtub.
- Behavior similar in both test environments
- Lower velocity in water than on land.
- Uneven weight distribution causes vehicle to dip on the motor end
- The waterline does not reach the ideal halfway mark

Land to Water
- Tested soil to water transition in Panther Hollow. Also tested using a wooden launch ramp
- The vehicle retains most of its land velocity after entering the water.
- Achieved effective transition with constant motor power.

Conclusion

- ARC moves as desired in all three target domains
- ARC carries a payload equivalent to 7% vehicle mass
- Waterproofing techniques prevent hull leakage
- Axles hub design allow for modular attachments

Future Work

- Scale vehicle to practical size to perform actual rescue
- Install RTK GPS for localization
- Develop and test different mechanical components to expand target domain to include different kinds of terrain
- Explore advanced waterproofing techniques
- Improve maximum payload and consider payload carrying methods

Acknowledgements

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[1]http://arc.usla.org/Statistics/current.asp?Statistics=Current
[2]http://www.usla.org/?page=RIPCURRENTS