MARVEL

A Modular Autonomous USV for Advanced Navigation and Sensor Fusion

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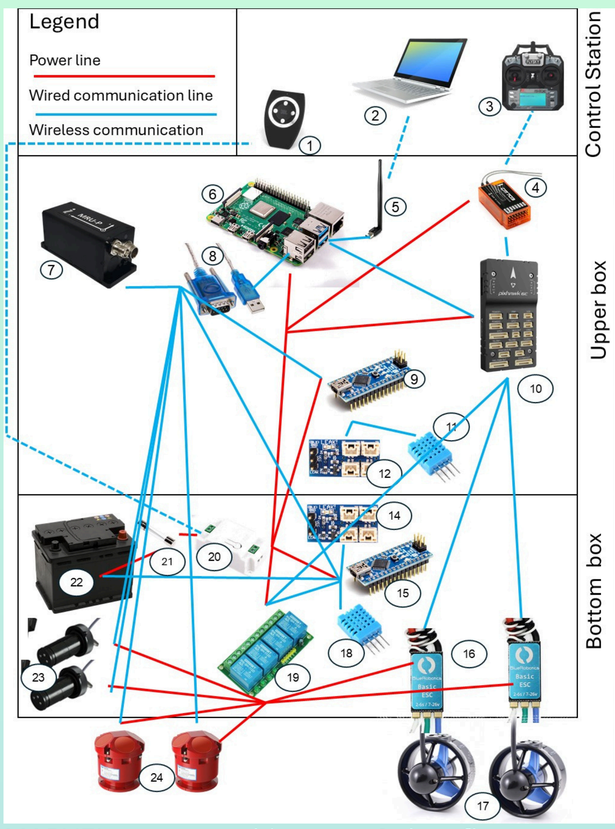
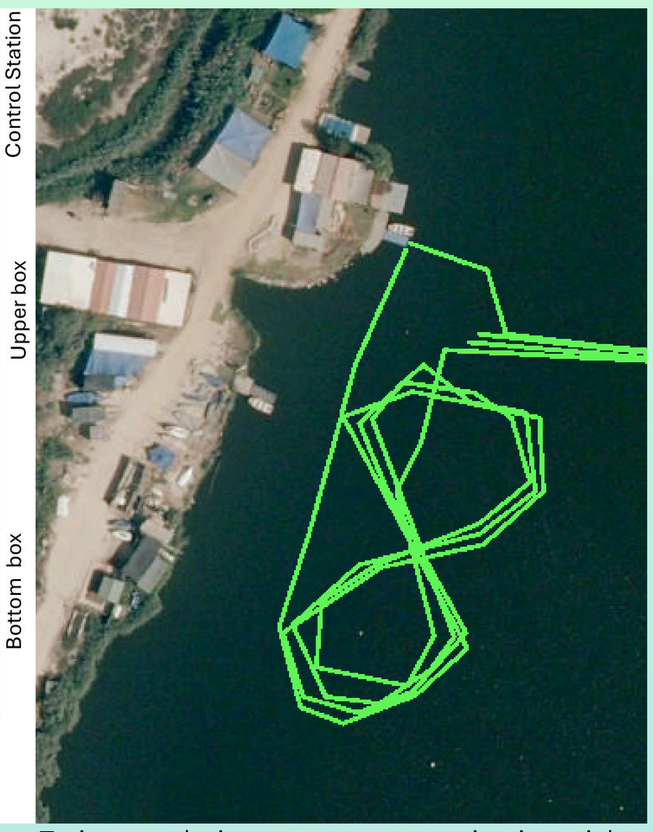
Abstract

This poster presents the design, development, and experimental validation of MARVEL, an autonomous unmanned surface vehicle (USV) built for real-world testing of sensor fusion-based navigation algorithms in challenging environments. MARVEL was developed under strict constraints of cost-efficiency, portability, and seaworthiness, with the goal of creating a modular, accessible platform for high-frequency data acquisition and experimental learning. It integrates electromagnetic logs, Doppler velocity logs, inertial sensors, and real-time kinematic GNSS positioning. MARVEL enables real-time, in-situ validation of advanced navigation and AI-driven algorithms using redundant, synchronized sensors. Field experiments demonstrate the system's stability, maneuverability, and adaptability in challenging sea conditions. The platform offers a novel, scalable approach for researchers seeking affordable, open-ended tools to evaluate sensor fusion techniques under real-world maritime constraints.

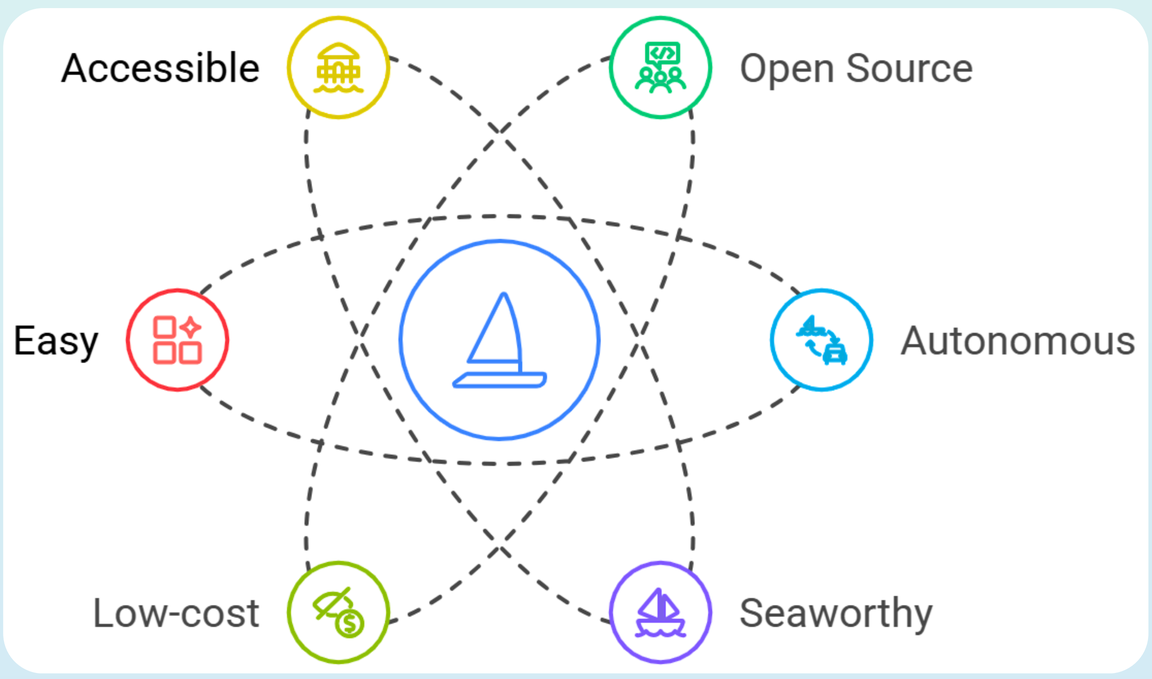


MARVEL system architecture & data flow



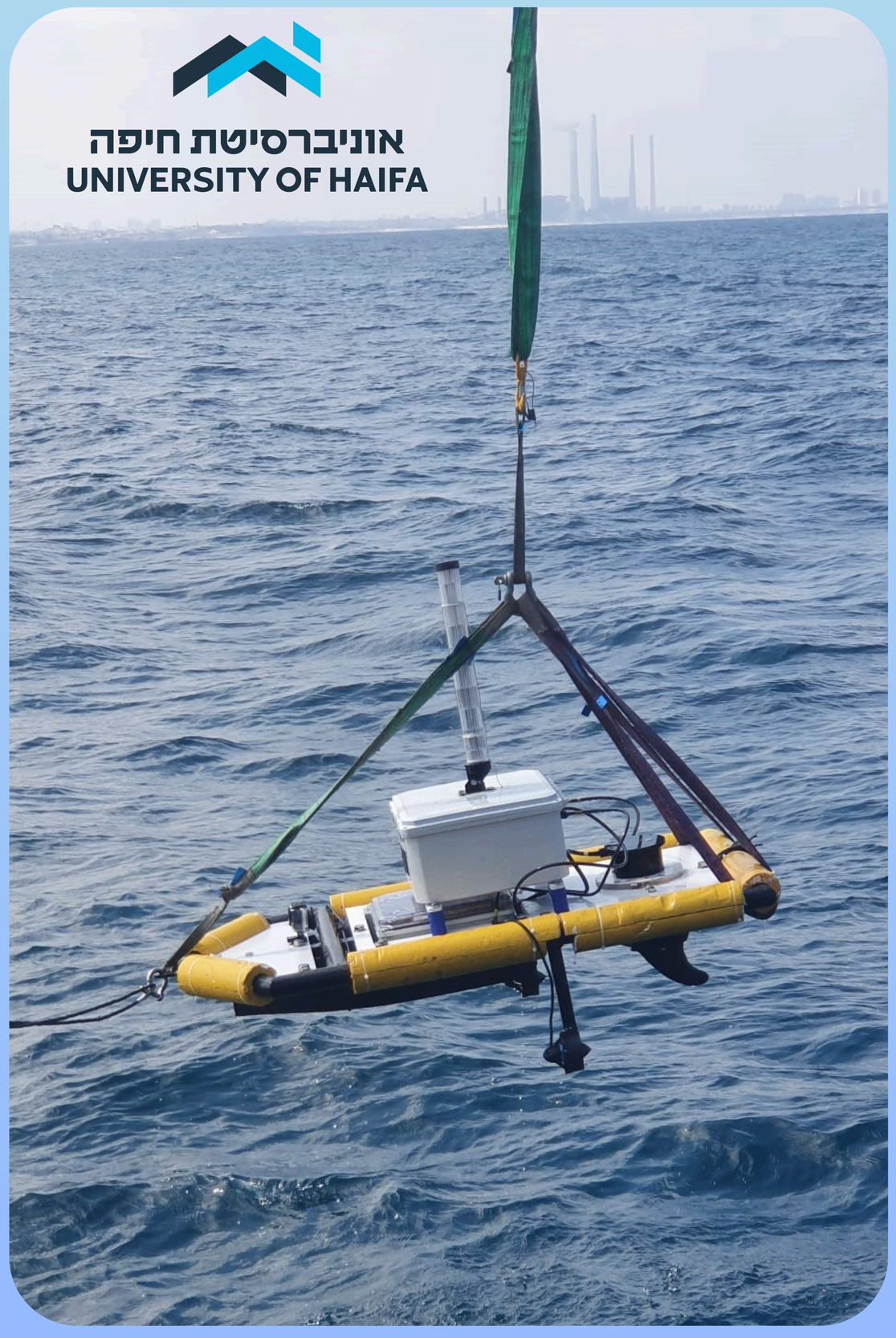
Trajectory during autonomous navigation trials

Core Design Principles



Objectives

- Develop a modular, accessible platform for testing advanced navigation and sensor fusion
- Validate sensor fusion under realistic maritime conditions
- Enable autonomous navigation and high-frequency data acquisition
- Ensure portability, affordability, and ease of use through off-the-shelf components and open-source software
- Achieve seaworthiness and stable operation in challenging sea states
- Provide scalability for future AI-driven navigation integration



Experimental Validation

- Demonstrated stable navigation and effective maneuverability
- Reliable, redundant velocity measurement confirmed by sensor comparisons
- Robust data acquisition during extensive field validation

Conclusion

MARVEL successfully provides an affordable, adaptable solution for validating advanced maritime navigation techniques and sensor fusion algorithms.

Future Directions:

- Integrate onboard AI for enhanced adaptive navigation
- Collect large-scale datasets for maritime autonomy research

References

S. Cohen-Salmon and I. Klein, "Design and Experimental Validation of an Autonomous USV for Sensor Fusion-Based Navigation in GNSS-Denied Environments," accepted to OCEANS 2025 - Brest, France, 2025, online preprint. https://arxiv.org/abs/2503.23445