Marine and Naval Technological Advancements for Robotic AutonomY (MANTA RAY) Autonomous Surface Vehicle (ASV)

Project Advisors: Dr. May-Win Thein, Dr. Yuri Rzhanov, Dr. Elizabeth Fairchild
Graduate Advisors: Ozzy Oruc, Hannah Arnholt, Nick Custer, Igor Vladimirov, Rich Randall, Chris Van Valkenburgh, Alex Cook
Team Members: Hunter Clark, Natalie Cook, Chris Redard, Clifton Sullivan, Zachary Dicicco, Harrison Ursitti
Department of Mechanical Engineering and Center for Ocean Engineering, University of New Hampshire, Durham, NH 03824

Team MANTA RAY Mission

Team MANTA RAY is an interdisciplinary project dedicated to creating, maintaining, and expanding a network of marine robots for seafloor mapping and underwater perception. The network began as just the Autonomous Surface Vehicle (ASV) and Unpiloted Underwater Vehicle (UUV) but has expanded to include a prototype of the ASV, known as TUPPS, and two kinds of remotely operated vehicles, known as GUPPS and KRILL. With these systems, students work to improve communication between vehicles, develop autonomous behaviors and algorithms, and upgrade existing mechanical systems to improve precision and performance.

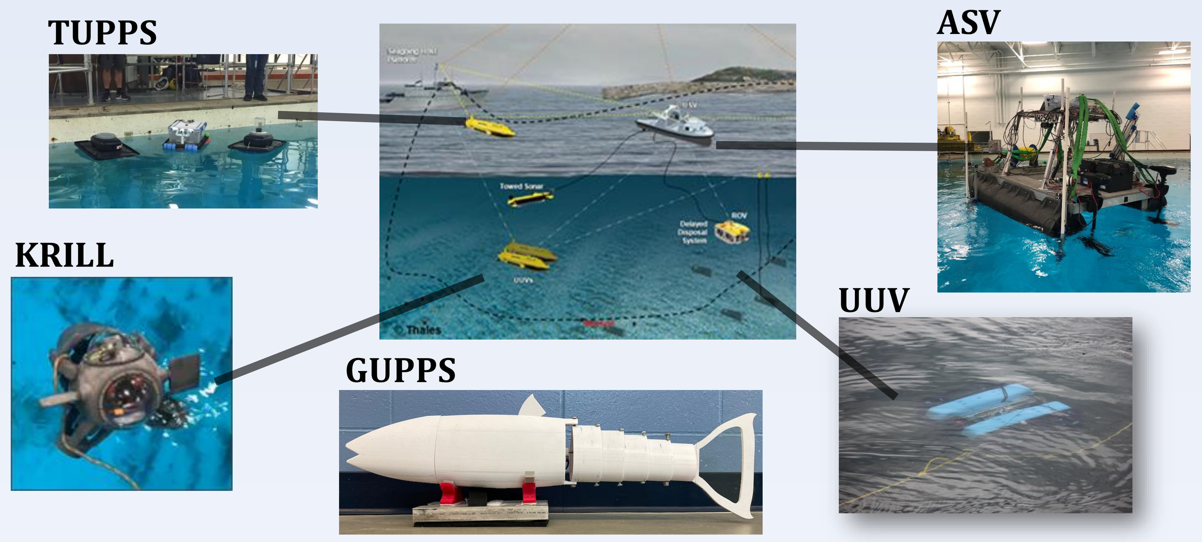


Figure 1: MANTARAY Mission

ASV Mission

The ASV mission for this year was to enact a deployment sequence to launch a UUV from the platform, perform mission functions autonomously, and to follow an autonomous path determined by pre-determined waypoints.

Mechanical Design

- Built by 2017-2018 ASV Team
- Catamaran body: 7'9" length, 5'6" beam
- Twin 55lb thrust electric trolling motors
- "Penthouse" platform with electronics box mounted on stern edge
- Tether winch for UUV tether management and deployment
- Pixhawk 4 mounted on top of tether tensioning system
- Hardware standards for open source autopilot
- Enables missions uploads and performs scripted autonomous navigation between waypoints
- Contains a robust sensor suit including a compass, internal IMU and GPS capability

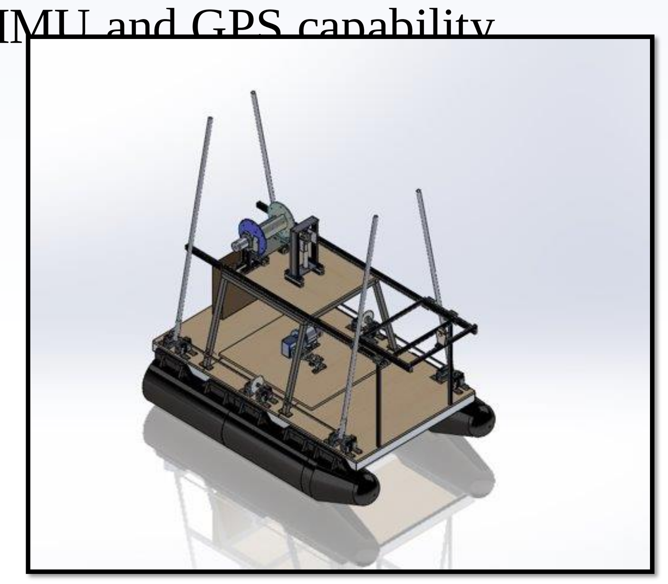


Figure 2: ASV SOLIDWORKS Model

ASV Subsystems

Underwater GPS

- Incorporates ultrasonic nodes that triangulate precise location of UUV
- Allows for real time location tracking of UUV with respect to shore station with the ASV acting as a jump between the two
- Rotates into position as part of deployment sequence

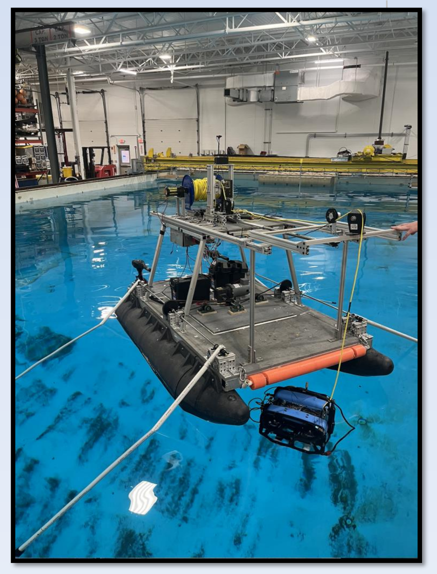


Figure 3: UGPS system deployed

Tether Tensioning System

- Tracks tension on tether to enable constant tension mode for UUV
- Reads in values from linear encoder and communicates with rotary encoder
- Winches in or out depending on needs of UUV and tension on winch cable

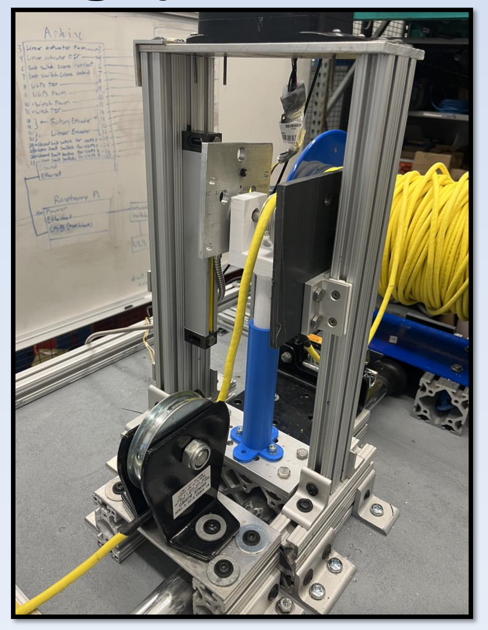


Figure 4: TTS System

Deployment Crane

- Deploys UUV from ASV
- Uses linear actuator for powerful and controlled movement
- Limit switches denote the open/closed position of the crane
- Allows for redundant use of system and a key element of our ASV/UUV automation
- Tether is used for communication between ASV and UUV and is used to lift and lower the underwater vehicle

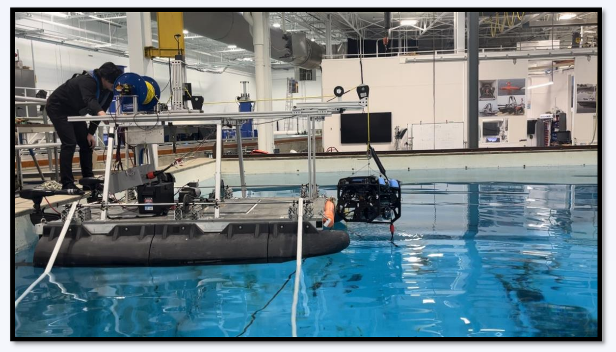
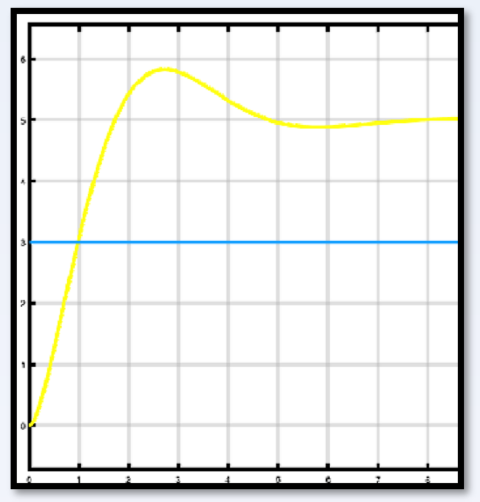
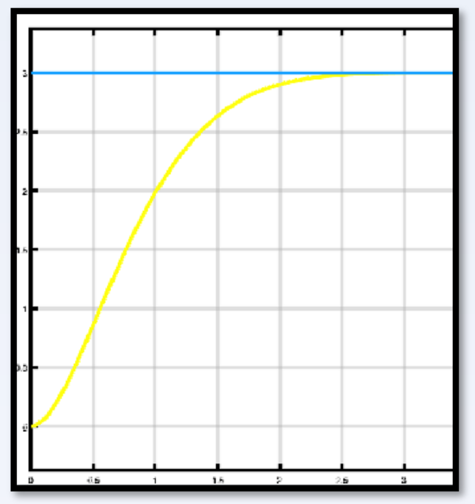


Figure 5: UUV deployment from crane

Tether Tension System PID Transfer Function



Graph 1: Response without PID Control



Graph 2: Response with PID Control

$$M\ddot{x} + B\dot{x} + kx = (K_p e + K_I \int e\,dt + K_D e) \cdot cos(\theta_1) + T_2 \cdot cos(\theta_2)$$

$$e = x_{des} - x_{actual}$$

$$M\ddot{x} + B\dot{x} + kx = T_2 \cdot cos(\theta)$$

Figure 6: Equations of motion for Multi-Input Single Output Nonlinear System

ROS Integration

Autonomous Control using Arduino + ROS Commands

- Raspberry Pi (onboard computer) sends commands over ROS to the Arduino.
- Arduino controls subsystems based on ROS command from the Pi.
- Pixhawk 4 communicates GPS data.
- All data (GPS position, operating mode, active commands, etc) published through ROS topic.
- Using a local network router, this allows for relable ROS connection bwtween devices on the same network

ASV GUI Integrated with ROS Commands

- Switched remote communication from Xbee wireless communication to executing ROS commands by calling functions in ROS Topics

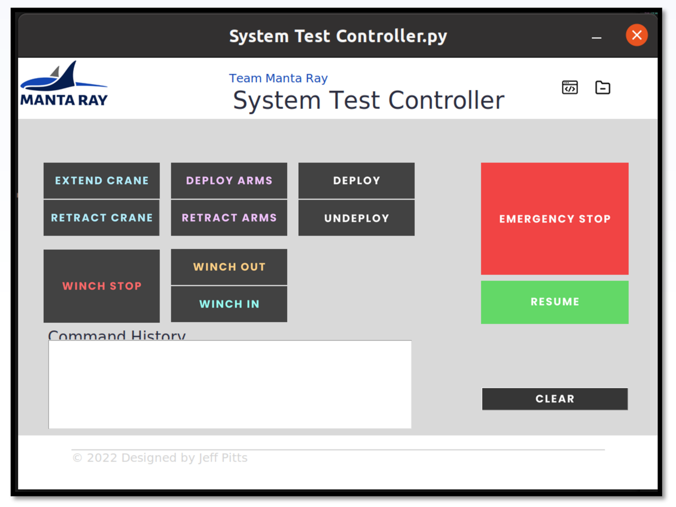


Figure 7: ROS Integrated GUI

Results

- Deployed in the Jere A. Chase Engineering Laboratory Engineering tank and enacted deployment sequence
- Utilized Mavros to communicate and send missions to UUV via ethernet cable
- Tested autonomy at Jackson Estuarine Lab
- Deployment and undeployment sequences performed with active tension mode for UUV

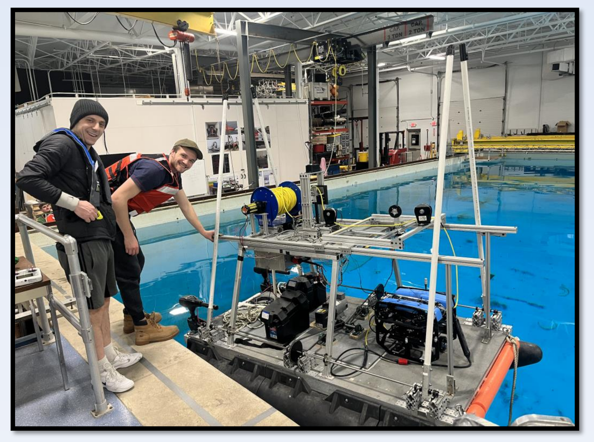


Figure 8: ASV during Chase tank testing

Future Plans

- Convert to radio wave communication to improve range
- Open ocean testing with UUV
- Switched subsystems to better suited vessel
- Redesign for multiple UUV deployment

Figure 9: UNH Pier

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