# ROV HORNET

# TECHNICAL DOCUMENTATION
# 2023-2024 MATEROV


**sfrobotics**

MORE THAN JUST ROBOTS

## ST. FRANCIS PUBLIC SCHOOLS
## ST. FRANCIS, WI

**Andre Moreno - 7th Year - Senior (2024)**
Team Role: Software/ ROV Pilot
**Desiree Halsey - 3rd Year - Senior (2024)**
Team Role: CFO /Technical Writer
**Emmitt Esselstrom - 5th Year - Junior (2025)**
Team Role: CEO/ Mechanical Engineer/ CAD/ Build
**Brady Thorne - 1st Year - 8th Grade (2028)**
Team Role: Build/ Team Support / CAD
**Cole Cushing - 1st Year - 8th Grade (2028)**
Team Role: Build / Team Support / CAD

**Mentor:** Peter Graven
**Mentor:** Luther Esselstrom

MATE ROV COMPETITION

**Photo credit:** Team Image Collection and MATE ROV COMPETITION MARKETING KIT.
Document made publicly available through the St. Francis Public School District.
**Top Image:** ROV Hornet.

# Introduction

## Table of Contents

### MATE 2024 TECHNICAL DOCUMENATION

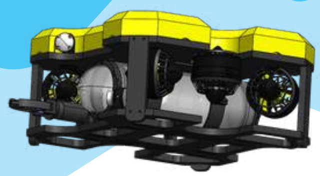






**photo credits:** Team Photo Collection

# Introduction



## Team Profile

Our team consists of five members, with one member being full-time, Emmitt Esselstrom, and the remaining four having part-time or very limited availability due to their involvement in sports and other activities. Despite the challenges posed by differing schedules and commitments, the team worked together to overcome obstacles and build an ROV. Our full-time member played a crucial role in keeping the team organized and on track, while the part-time members brought fresh perspectives and energy to the team when they were able to participate. In the end, the team's collaborative spirit proved to be their greatest strength.

**Andre Moreno**
7th Year - Senior (2024)
2024 Career Goal: Computer Science
Team Role: Software/ ROV Co-Pilot

**Brady Thorne**
2nd Year - 8th Grade (2028)
2024 Career Goal: Mechanical Engineer
Team Role: Build/ Team Support

**Desiree Halsey**
3rd Year - Senior (2024)
2024 Career Goal: Physical Therapist
Team Role: CFO/ Technical Writer

**Cole Cushing**
2nd Year - 8th Grade (2028)
2024 Career Goal: Mechanical Engineer
Team Role: Build/ Team Support/ CAD

**Emmitt Esselstrom**
5th Year - Junior (2025)
2024 Career Goal: Robotics Engineer
Team Role: CEO/ Pilot/ Mechanical Engineer

## Corporate Profile

SFROBOTICS operates with multiple specialized teams across four competition seasons and includes an outreach division developing STEM Kits for commercial use, all unified under the SFROBOTICS umbrella. While teams pursue distinct goals, some members are season-specific while others, notably in the MATEROV group, operate across various teams. The MATEROV team divides into Hardware and Software factions, with the former helmed by a CAD Designer constructing the ROV's physical components and frame, while the latter oversees control software managing ROV movement, gripper operations, and data gathering. During rapid prototyping phases, these teams collaborate closely to bring the ROV to life, reflecting daily on tasks to enhance performance, document and prioritize tasks to foster a culture of continuous improvement. This agile teamwork allows for fluid role transition and growth support, promoting proactive engagement and maximizing efficiency through detailed communication, ultimately underpinning SFROBOTICS' success in diverse projects and competition seasons.



**photo credits:** Team Photo Collection

# Introduction

## ROV Summary

**ROV NAME:** ROV HORNET
**Team Name:** Mariner Mayhem
**Headquarters:** St. Francis, WI
**Size:** 43.8cm x 43.8cm x 21.6cm
**Weight:** 11kg
**Total Estimated Cost:** $5700.50

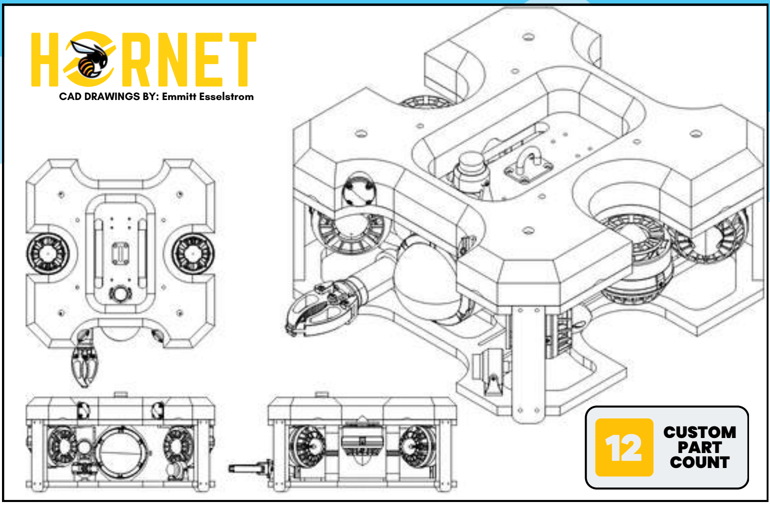



**Image:** Solidworks CAD models of the ROV Hornet.

- **Safety Features:** MATE approved thrusters (encased), 25A in-line fuse, slightly positive buoyancy, LED lights, water leakage sensor, strain relief on tether, yellow nylon tether sheathing, ROV heartbeat and safety labels.
- **Special Features:** rotating gripper, lightweight, small size, fast, connected camera system, and a servo controlled camera
- **Hours Spent on ROV:** 7 hours x 10 weeks (max involvement hours)

## ROV Abstraction

SFROBOTICS, an experienced participant in the MATE ROV Competitions, is focused on creating and utilizing Remotely-Operated Vehicles (ROVs). Their latest ROV, named HORNET, is their entry for the 2024 MATE ROV Ranger competition. It's designed to be compact yet equipped with essential gear like cameras, a gripper arm, and plans for adding a laser scaler.

The ROV HORNET is built to be adaptable for different underwater missions. It features an adjustable slider system that allows for easy swapping of underwater tools and even supports non-ROV devices. It's categorized as a light-work class ROV, suitable for maneuvering through narrow underwater spaces.

When developing the HORNET, size and weight were key considerations. The chassis is designed to be less than 45cm in diameter, using lightweight materials such as HDPE and 3D printed parts.

SFROBOTICS aims to lead the underwater robotics field and follows a democratic team structure. Decisions are made through voting, with CEOs providing motivation and leadership. The company is committed to making robotics more accessible to the wider community through dedication and hard work.

# Our Engineering Design Process

## Innovation

### Overview

Over the past few years, SFROBOTICS has been developing ROVs equipped with a fixed gripper system. This meant that whenever we needed to switch the gripper from a vertical to a horizontal grabbing position, the ROV had to be taken out of the water for manual adjustment. But this year, we took a big step forward by designing and adding a servo attachment to the primary gripper. With this new addition, our ROV pilots can now smoothly transition the gripper's position without the hassle of removing the ROV from the water.

At SFROBOTICS, we're all about customization. This year, we've gone the extra mile by crafting custom parts for almost every aspect of our ROVs. From the frame to the float cover, and even down to the claw and servo mount, we've tailored every detail to fit our needs perfectly.

### Manufacturing Specifications

**Manufactured:**

**Standard team settings unless noted:**
- 6mm HDPE plastic
- Waterjet Cut

**Parts manufactured:**
- **Number of Parts:** 3 unique parts (7 total parts)
- **Includes:** All ROV Chassis Parts

**Manufacturing Partner:** JetCuts

**3D Printed:**

**Standard team settings unless noted:**
- PLA Plastic
- ~2.8mm layer height + 25% infill
- 2 Perimeter Walls

**Parts 3D printed:**
- **Number of Parts:** 9
- **Includes:** Float Cover, Camera Mounts, Gripper and Servo Mounts, and Gripper Components.

**Filament and Manufacturing Sponsors:** bigrep, COEX

**12**
**CUSTOM PART COUNT**

### ROV Development/ Problem Solving

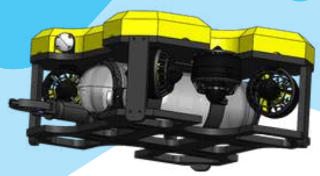
The team's strategy for developing a new ROV is straightforward. First, we thoroughly review the mission details provided by MATE to understand the specific tasks we need to accomplish. Then, we brainstorm ideas to determine the best design and features for our ROV, such as camera rotational positioning and a unique payload tray for versatile accessory placement. We also analyze our previous projects to identify areas for improvement and seek opportunities to innovate. To enhance our ROV's uniqueness and functionality, we establish partnerships with various manufacturing industries, leveraging their expertise and resources.





photo credits: Team Photo Collection

# Mission Breakdowns



## Parameters

The HORNET Chassis and Payload were designed to be versatile and suitable for various applications, including river, lake, and dam operations, as well as recreational research dives. To simulate potential scenarios that the HORNET chassis might encounter, we created a mission list. Our goal was to create a compact ROV that is sturdy and functional to meet a number of UN Sustainable Development Goals.

## Mission #1

ROV HORNET can assist in the **relocation and installation process of the Coastal Pioneer Array** along the Southern Mid-Atlantic Bight. With its maneuverability and ability to navigate underwater environments, HORNET can efficiently survey the area and assist in deploying the moored platforms, profiler moorings, and benthic multifunction nodes. Additionally, HORNET's capabilities can aid in the recovery of assets, such as triggering acoustic releases to free recovery floats and assisting in the retrieval process, contributing to the successful relocation of the array.

## Mission #2

ROV HORNET can play a crucial role in the **implementation and maintenance of SMART Cables**, particularly in the deployment and monitoring phases. With its precision navigation capabilities, HORNET can assist in the careful placement of SMART repeaters along the cable route, ensuring optimal data collection. Additionally, its ability to conduct detailed inspections of the cable system can help identify and address any potential issues, contributing to the reliability and effectiveness of the SMART Cable network in collecting essential oceanic and seismic data.

## Mission #3

ROV HORNET could **aid in coral reef research** efforts by providing assistance in deploying probiotics and monitoring their effects on coral health, as well as supporting photogrammetry studies to assess coral reef ecosystems. Furthermore, HORNET's capabilities could extend to assisting researchers at the Tennessee Aquarium in their conservation efforts for Lake Sturgeon, such as tracking their movements using implanted sonic tags and deploying acoustic receivers to identify potential spawning locations, highlighting the importance of observing technologies in understanding and mitigating environmental impacts across diverse aquatic environments.

# Our Engineering Design Process

## Innovation

### Our Process

Our team follows the engineering design process, beginning with prototyping various ROV components to experiment with ideas and ensure the final product meets the completing the necessary tasks. CAD facilitates the optimization of the design for performance and adaptability. Moving on to manufacturing, we employ in-house 3D printing and laser cutting for rapid prototyping, while outsourcing precision cutting for HDPE components and our larger 3D printed parts. Before integration into the final build, in-house testing using counterparts ensures that all components meet our standards when an option. This process guarantees that the ROV performs exceptionally in the water, showcasing the success of our engineering design process.

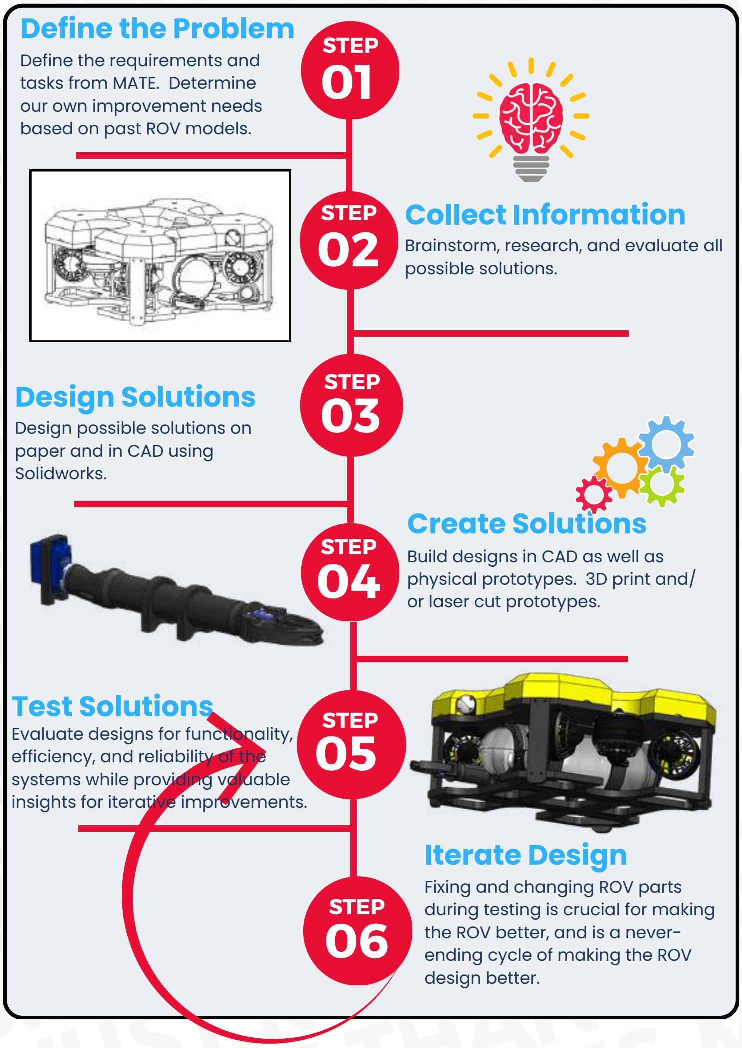
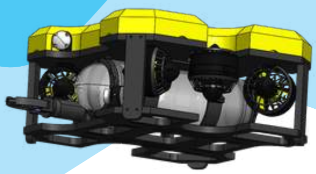







photo credits: Team Photo Collection

# Design Rational



## Engineering Design Rationale

### Overview

The team’s ROV design centered on achieving several UN Sustainable Development Goals. The engineering design for ROV HORNET focused on four key components to fulfill these goals: the "Removable Top Folding System," the "Rotational Gripper," the "Small Form Factor," and "Material Use.”

**Removable Top Folding System**: The rationale behind implementing a removable top folding system in our ROV design is rooted in **enhancing accessibility and operational efficiency**. This feature revolutionizes the way internal components are accessed and serviced. The design incorporates a removable top section that can be easily folded back, effectively opening up the middle section of the ROV. This configuration enables swift and hassle-free maintenance, repairs, and upgrades.

By eliminating the need for bolting down clamps and strategically positioning nearly every component on the top, the ROV ensures unparalleled ease of access. This thoughtful arrangement not only simplifies the process of wiring by utilizing shorter wires but also provides enhanced accessibility to both the electronics tube and payload. As a result, functionality is optimized, and operation becomes more intuitive and seamless. The removable top folding system represents a paradigm shift in ROV design, prioritizing efficiency, functionality, and ease of maintenance.

**Rotational Gripper:** The design rationale for the rotational gripper **emphasizes adaptability, simplicity, and durability**. This gripper is engineered to meet the diverse needs of underwater operations without compromising reliability or performance. Its unique design allows for vertical and horizontal opening, eliminating the need for removal from the water during use. Customized mounting ensures seamless integration into the ROV's structure, enhancing stability and functionality.

Simplicity is key in the gripper's design, featuring essential moving parts like the servo and claw jaws to minimize complexity and potential points of failure. This streamlined approach maximizes reliability while ensuring precise control over object manipulation.





photo credits: Team Photo Collection

# Design Rational

## Engineering Design Rationale

**Small Form Factor:** The design rationale behind the small form factor of the ROV **emphasizes optimal maneuverability and easy deployment**. Carefully crafted dimensions accommodate essential components, maximizing efficiency. This compact size enables the HORNET to navigate tight spaces and complex underwater terrain effectively, ideal for missions in challenging environments. Despite its small stature, this custom-designed ROV boasts advanced features, ensuring high performance and reliability even in demanding conditions.

**Material Use:** The materials chosen for the construction of ROV HORNET were carefully selected to **achieve a balance between durability, weight, and buoyancy**. High-quality, corrosion-resistant materials were prioritized to enhance the ROV's longevity and performance in diverse underwater environments. Lightweight materials were incorporated to facilitate buoyancy adjustment or maintain neutral buoyancy, ensuring effortless maneuverability. Additionally, all components were designed to be durable, capable of withstanding collisions and repeated missions without compromising the ROV's functionality. This comprehensive approach to material selection guarantees that ROV HORNET is equipped to navigate underwater obstacles effectively while maintaining optimal performance and reliability.

These four components collectively contribute to the ROV HORNET's advanced capabilities, making it a versatile and reliable tool for underwater exploration and tasks to meet several of the UN Sustainable Development Goals.

**Image:** ROV Hornet - Top View

**Image:** ROV Hornet - Open Frame

**Image:** ROV Hornet - Front View

# Design Rational

## Engineering Design Rationale

### Frame

SFROBOTICS has a history of pushing the boundaries of robot design and functionality, with a focus on application-specific tools and modular frames. This year, however, we have gone even further to design a frame that is perfectly suited to the tasks at hand. The frame is machined from a solid .5" thick HDPE plate, providing a strong foundation for the hardware we mount on it. This includes a dry housing, multiple Blue Robotics T200 thrusters for advanced movement. We have also made sure to keep the frame as lightweight and streamlined as possible by cutting away any unused space within the plate and keeping the sides as open as possible to minimize drag.

### Thrust

Over the past three years, we have made significant advancements in our ROV development, particularly with the integration of Blue Robotics' T200 thrusters. This year we were able to use T200 and keep costs down by reusing thrusters off another ROV. These thrusters offer sufficient power in a comparable form factor, and they already have thrust vectoring and propeller guards, making them a practical choice for our current undertaking.

**Image:** Blue Robotics T200 Thruster

### Movement

We have positioned four thrusters horizontally at opposing 45-degree angles, one at each corner, to enable stable control in both X and Z-axis movement. This configuration of thrusters also allows us to move sideways, similar to the horizontal movement of an aerial drone. Additionally, we have mounted two thrusters vertically on the sides of our robot, placed directly to the left and right of the center, to provide lifting force as close to the ROV's center of mass as possible without compromising other systems. With these thrusters' positioning, we can "roll" the ROV, making it easier to access certain hard-to-reach areas while deployed.

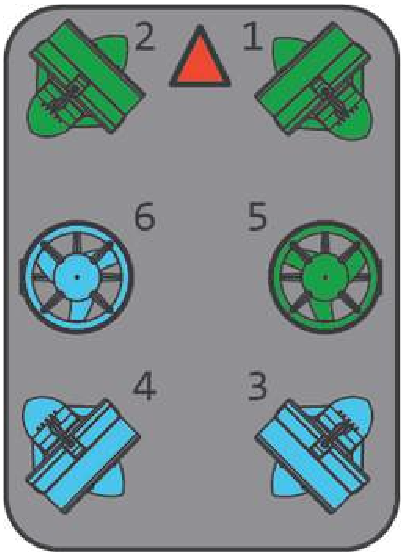



**Image:** Thruster Configuration





#WATERGAME

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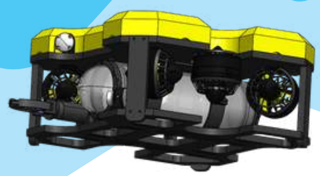
**photo credits:** Team Photo Collection and Blue Robotics (https://bluerobotics.com)

# Design Rational



## Engineering Design Rationale

### Electronics Dry Housing

SFROBOTICS has opted to utilize the rounded, cylindrical dry housing from BlueRobotics for this year's project. This particular housing offers superior pressure resistance compared to square housings, and its curved shape makes it easier to work around. The package from Blue Robotics also includes anodized aluminum bulkheads for input insertion and penetrators that thread directly into the bulkheads. Inside the housing, SFROBOTICS houses their Navigator control board and Raspberry Pi control board for the thrusters and other components.

At the front of the housing, a small camera is mounted on a servo inside a bubble and will serve as the primary visual output. While other visual sensors are mounted elsewhere on the ROV's frame, the dry housing provides additional positive buoyancy due to space not occupied by electrical components. This eliminates the need to add more buoyant materials to the ROV's frame. However, despite the buoyancy added by the electronics tube, foam is still mounted on each of the four corners of the upper motor mounting chassis to maintain slightly positive buoyancy due to the frame's lightweight design.

### Bulkhead Connectors

To ensure the safety of our ROV's electrical and control systems while underwater, all key components must be rated to withstand a depth of 100 meters. This is particularly crucial for our dry housing and its control systems. To achieve a watertight seal, the ROV bulkhead connectors are either sealed with marine-grade epoxy or use a combination of seals and o-rings. This solid seal helps prevent any leaks from compromising the integrity of our dry housing.


**Image:** WetLink Penetrators

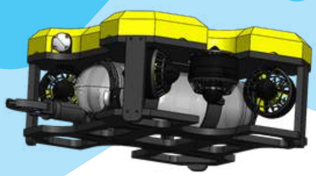






**photo credits:** Team Photo Collection and Blue Robotics (https://bluerobotics.com)

# Design Rational



## Engineering Design Rationale

### Cameras

The ROV is equipped with a camera that is controlled by a Raspberry Pi and mounted on a servo located inside the dry housing for the electronics. The camera is capable of tilting along the y-axis, which helps in piloting the ROV and using the gripper, all while utilizing just a single camera. If needed, additional cameras can be added to assist with different tasks or operations.

**Image:** Rotational Raspberry Pi Camera

One addition we kept from last year is the DeepWater Exploration camera system. Along with the Raspberry Pi controlled camera mounted inside the dry housing, we have installed four USB cameras on the ROV. These cameras are connected through a multiplexer and transmit a live video feed to the surface. The camera system can be expanded up to seven cameras. Our team can configure the placement of the cameras in various ways depending on the frame design, including the option for a vertically tilted camera.

**Image:** USB General Vision Camera

### LED Lights

SFROBOTICS implements a distinctive design feature across all its ROVs, which entails the utilization of external LED lights mounted on the frame. These lights have a dual function, as they provide illumination for the ROV's area of operation, while also serving as an early warning indicator when the battery power is running low. This feature allows for the safe removal of the ROV from the environment before power depletion becomes an issue. The lights are mounted on a top bar that can be adjusted to improve visual clarity in low or no-light conditions, providing up to 1,500 lumens of brightness. This allows for on-the-go adjustments to the brightness level for high visibility in any conditions.

**Image:** Led Light





#WATERGAME

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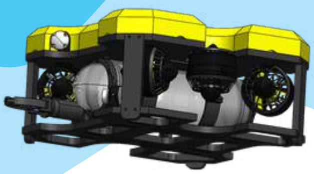
**photo credits:** Team Photo Collection, Blue Robotics (https://bluerobotics.com), and Deep Water Exploration (https://dwe.ai).

# Design Rational



## Engineering Design Rationale

### Manipulator

SFROBOTICS believes that an ROV should be capable of consistently manipulating small objects underwater to be useful in any application of underwater robotics. To achieve this, we have opted to use a servo arm due to its simplicity and proven effectiveness across SFROBOTICS divisions. The servo arm is mounted into slots that allow us to move it out of the way of other systems when needed. During the design phase of our ROV, we developed a rotation mechanism for this servo arm to allow for both vertical and horizontal manipulation.

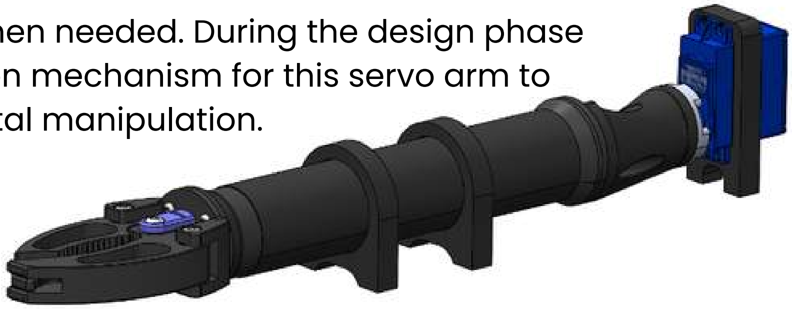


**Image:** Solidworks CAD sketch of modified gripper

### Control System

SFROBOTICS utilizes a Raspberry Pi as the intermediary for communication between the ROV HORNET and the topside controls, which consist of a laptop running the QGroundControl software application. The Raspberry Pi communicates with the Navigator Control Board, which manages the thrusters, servos, and sensor readings. The onboard sensors include an SOS leak sensor, temperature sensor, compass, and pressure gauge. The control system is designed to be easily set up and enables the pilot to modify and calibrate controls as needed. The ROV is operated using a Microsoft Xbox controller, with buttons mapped out for specific tasks.

### Tether

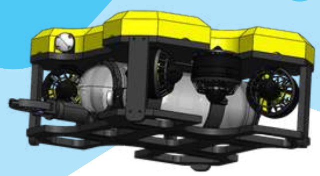
The current configuration of the ROV HORNET features a 50 ft (15.24 meters) power cable with a 14-2 AWG rating and an inline fuse with a 25 AMP capacity. Additionally, it includes a neutrally buoyant communication wire comprising of 1 pair of wires, enclosed in a protective sheath. After encountering balance issues with the previous year's tether design, we explored various tether connection options. To improve balance during underwater operations, we added a center ring mount to the ROV frame, allowing the tether to be positioned centrally. To prevent damage to the tether wiring, a rope was added for poolside members to pull on.

**Image:** Neutrally Buoyant Tether



**photo credits:** Team Photo Collection and Blue Robotics (https://bluerobotics.com)

# Design Rational



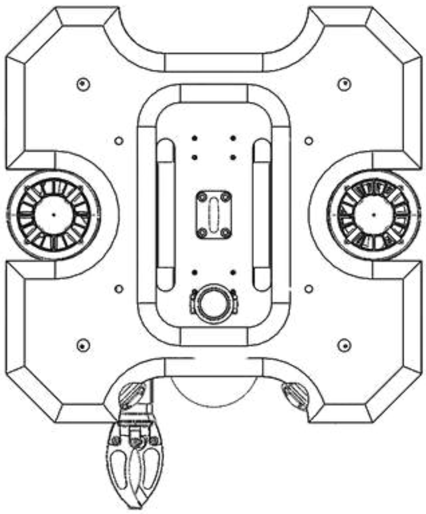
## Engineering Design Rationale

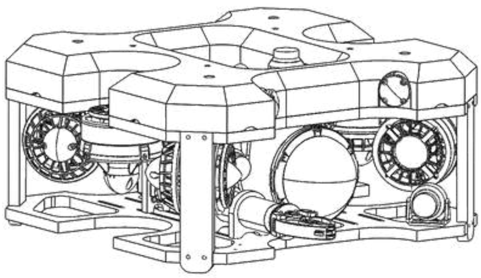
### Buoyancy

SFROBOTICS uses 0.0417 cubic meters of Polyethylene foam to achieve a slightly positively buoyant ROV. This buoyancy ensures that if the ROV loses power or encounters a critical failure, it will naturally float to the surface rather than sinking. This safety feature is crucial for recovering the ROV without needing additional retrieval equipment or risking loss in deep or inaccessible waters.

The choice of Polyethylene foam is deliberate due to its favorable buoyancy-to-weight ratio, durability, and resistance to water absorption. By carefully calculating the volume and placement of the foam within the ROV, we ensure that the positive buoyancy does not compromise the ROV's maneuverability or operational efficiency. This balance allows the ROV to maintain precise control during its missions while providing a failsafe mechanism that enhances the reliability and safety of our underwater operations.

**Images:** Different Views of ROV Hornet





**Images:** Solidworks CAD sketches of ROV Hornet

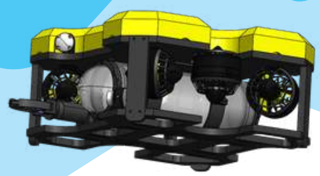






**photo credits:** Team Photo Collection

# Critical Analysis



## Testing

During the rapid prototyping phase of our ROV development, we identified and addressed several design issues. By utilizing CAD software and manufacturing parts in-house, we effectively troubleshooted various challenges.

For instance, the team initially planned to screw into the HDPE frame to secure the panels. After further discussion and trials, we opted for heat sink threaded inserts, which provided greater flexibility for removing the thruster plate without damaging the threads from constant wear.

Another example involved designing the frame to open easily without the hassle of moving wires or struggling with the frame's position. We carefully conceptualized and produced the frame in CAD, allowing for straightforward access to the electronics tube and ROV accessories.

By using Solidworks CAD software, we were able to design the ROV to our specifications before sending the frame out for manufacturing.

## Troubleshooting

Our troubleshooting strategy emphasizes addressing small variable changes first to correct issues before making significant modifications to the ROV design or electronics. This method isolates minor problems without unnecessary overhauls, saving time and resources while preserving the overall design integrity. If minor adjustments fail, larger changes are considered. This step-by-step approach ensures methodical and effective problem-solving in our ROV projects.

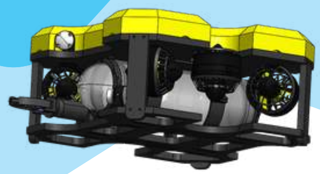
For example, when implementing updated ROV software, a new computer, and a camera application, the team faced an unexpected boot-up issue with the Blue Robotics Navigator, replacing the previous Pixhawk system. By comparing setups and testing configurations, the team discovered the need for a specific boot order for the Raspberry Pi and accessories. After troubleshooting, the ROV was restored to full functionality.





**photo credits:** Team Photo Collection

# Design Rational



## Build vs. Buy

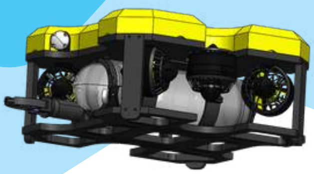
At SFROBOTICS, our mission revolves around delivering cutting-edge ROVs to the market, with an emphasis on both design and functionality. We carefully navigate the decision between building components internally or procuring them externally, considering factors like time constraints, team capabilities, and component availability to ensure the most efficient development process. Our flagship ROV, the HORNET, exemplifies this strategy by integrating trusted components, thus streamlining development while maintaining performance confidence.

While we prioritize existing components, we also invest strategically in enhancements like advanced camera systems, ensuring our ROVs remain innovative and aligned with evolving customer needs. Furthermore, our commitment to innovation extends to customization through in-house initiatives, such as the design of the rotating gripper and versatile frame, showcasing our dedication to optimizing functionality and adaptability. Ultimately, our approach at SFROBOTICS combines strategic procurement with meticulous customization, driven by our unwavering pursuit of excellence and innovation in ROV development.

## New vs. Used

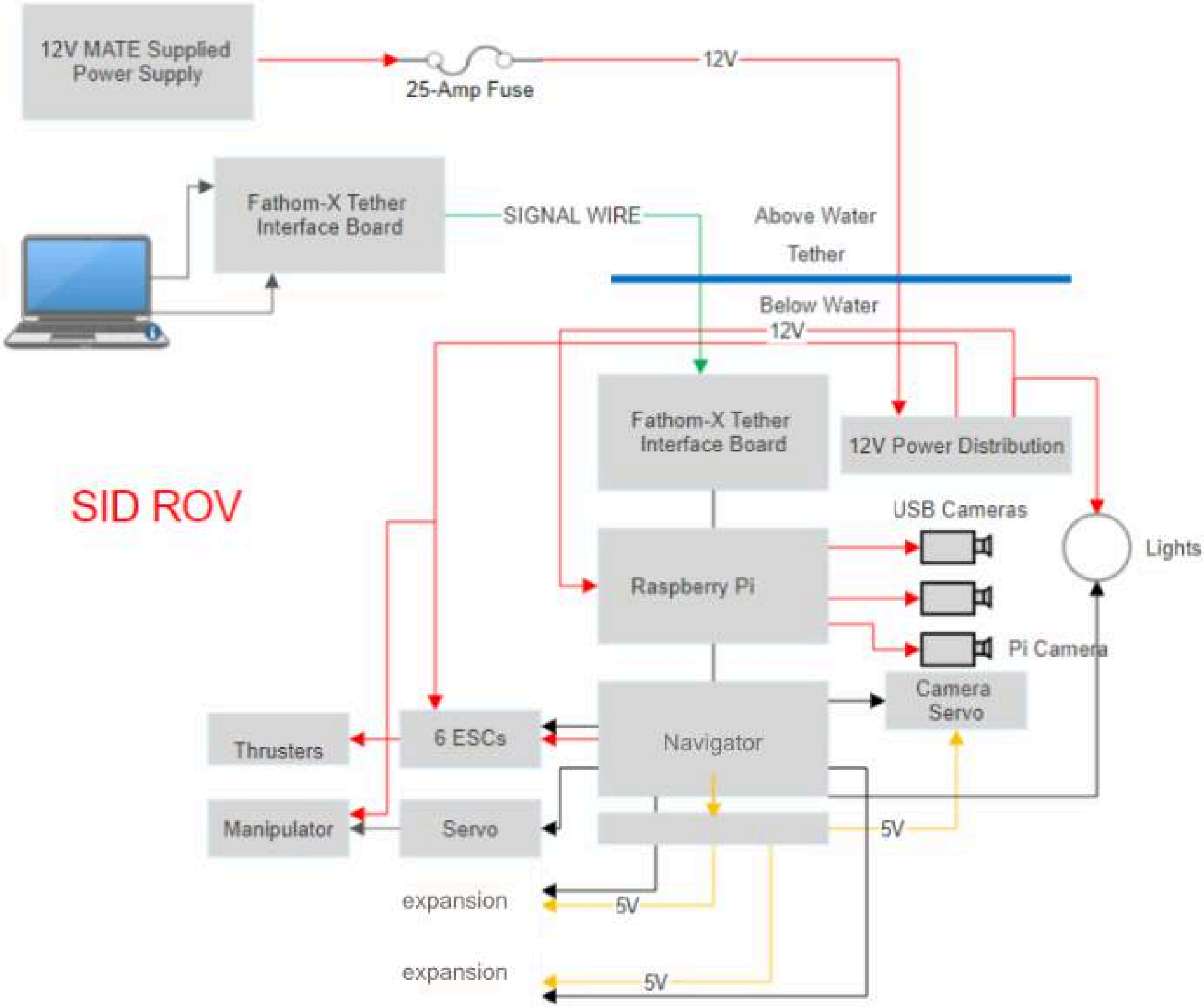
At SFROBOTICS, our core values are rooted in continuous innovation and the pursuit of excellence in our ROV designs, all while adhering to budgetary constraints. During the creation of ROV HORNET, we faced the strategic decision to retire our previous model, the 2022 ROV DRAGONFLY. This decision proved beneficial as it allowed us to salvage components such as electronics, thrusters, and lights from the DRAGONFLY, integrating them into our newest build.

Retiring DRAGONFLY enabled us to reallocate funds towards enhancing our capabilities.  We could invest in additional camera systems and upgraded control mechanisms for the HORNET. Our approach prioritizes resource optimization, often leading us to repurpose existing parts to facilitate advancements in other aspects of ROV development. At SFROBOTICS, our commitment to pushing the boundaries of ROV technology while maintaining fiscal responsibility remains steadfast, ensuring that every decision propels us closer to our goal of engineering the most advanced underwater vehicles possible.



# System Integration Diagram

## System Integration Diagrams



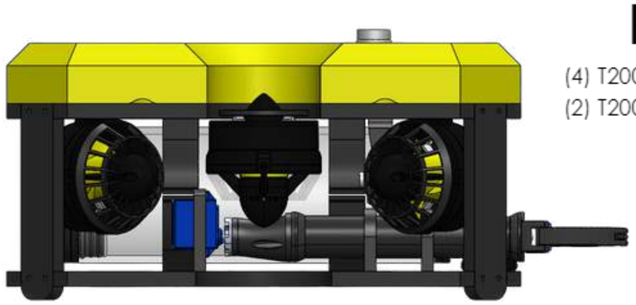
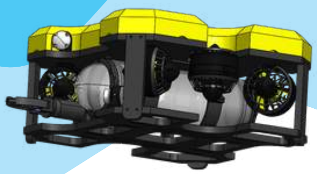



**Image:** Solidworks CAD Sketch of ROV Hornet

## ROV Fuse Calculations

(4) T200 Thrusters, .835A * 6 = 3.34A (25% gain/ 4 thrusters)
(2) T200 Thrusters, 1.67A * 6 = 3.34A (50% gain/ 2 thrusters)
Raspberry Pi: 2A
Navigator: .5A
Camera: .2A
Camera Tilt Servo: .12A
Gripper Servo: .33A
Newton Gripper: 6A (peak)
**Total Amps: 15.83 amps x 150% = 23.745 amps**
**ROV uses a 25 amp fuse**

# Safety



## Safety Protocols

At SFROBOTICS, we prioritize safety and take extensive measures to prevent any potential danger or injury. Safety is defined as the state of being protected from harm, risk, or injury. As a team, we take safety very seriously and approach all tasks with a careful and thoughtful mindset. To ensure maximum safety, we strictly adhere to the following rules:

- ANSI approved safety glasses must be worn during any repair or expansion of the ROV.
- The ROV must have no power being supplied to any electronics or motors during any repair or expansion.
- People must be warned to keep body parts away from moving parts of the robot during power-on or code initialization.
- Proper protective clothing covering hands and arms must be worn when working with heat, chemicals, electrical or mechanical hazards.
- Power tools must always be unplugged when not in use.
- Sharp or dangerous tools must always be safely stored when not in use.
- Electronics and batteries with a charge must only be worked on when away from any water to prevent shock.

Keeping the workstation clean and organized is important for ensuring a safe and productive work environment. Whenever tools and parts are not in use, we make sure to store them in a safe location.

If someone has a question or concern regarding safety, we always refer to the most up-to-date safety documents that are relevant to our work environment.

- https://20693798.fs1.hubspotusercontent-na1.net/hubfs/20693798/2024%20Safety%20Inspection%20Tutorial%20EX%20PIO%20RNG.pdf
- https://vimeo.com/811056721

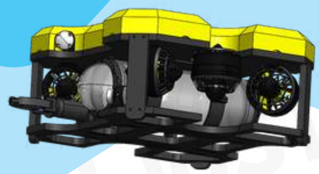
**SAFETY FIRST**





**photo credits:** Team Photo Collection

# Safety



## General Safety Checklist:

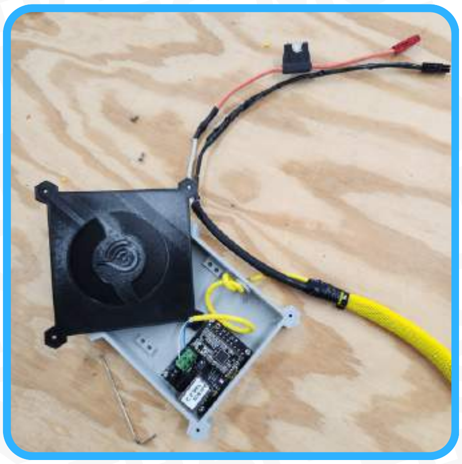
**SAFETY FIRST**

- Ensure that all items attached to the ROV are securely fastened.
- Verify that there are no sharp edges, exposed wires, or exposed propellers.
- Ensure that wiring is properly secured and protected.
- Verify that the tether is securely attached to the ROV.
- Confirm that the surface tether point, wiring, and devices are all securely fastened.
- The operations team must wear appropriate safety glasses and clothing.
- Power on the ROV and perform all necessary checks associated with its operation.

## ROV Safety Features:

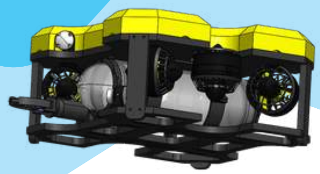
- MATE approved thrusters (encased)
- 25A in-line fuse
- slightly positive buoyancy
- LED lights
- water leakage sensor
- strain relief on tether
- yellow nylon tether sheathing
- ROV heartbeat
- safety labels.

**Warning stickers are placed around our all 6 of our thrusters.**


**Images:** Different Safety Views of ROV Hornet

# Accounting



## Budget

**2024 ROV HORNET EXPENDITURES:**

| Item Description | Purchased/ Donated Cost | Cost | Quantity | Total Cost | Company |
|---|---|---|---|---|---|
| 1/2" HDPE (24"x24") panels | Purchased | $59.99 | 2 | $119.98 | Amazon |
| BlueROV2 Electronics Enclosure | Reused | $2000.00 | 1 | $2000.00 | BlueRobotics |
| 4" Enclosure Clamps | Reused | $50.00 | 2 | $50.00 | BlueRobotics |
| Newton Subsea Gripper | Reused | $640.00 | 1 | $640.00 | BlueRobotics |
| Lumen Subsea Light | Reused | $350.00 | 1 | $350.00 | BlueRobotics |
| Misc. Screws/ Bolts | Reused | $30.00 | 1 | $30.00 | IN HOUSE |
| Misc. Plugs/ Penetrators | Reused | $80.00 | 1 | $80.00 | IN HOUSE |
| Misc. Plugs/ Penetrators | Purchased | $8.00 | 5 | $40.00 | BlueRobotics |
| PLA Filament | Purchased | $24.00 | 1 | $24.00 | COEX |
| PLA Filament | Donated | $24.00 | 1 | $24.00 | COEX |
| (3 CCW) T200 Thrusters w/ Basic ESC | Reused | $567.00 | 1 | $567.00 | BlueRobotics |
| (3 CW) T200 Thrusters w/ Basic ESC | Reused | $567.00 | 1 | $567.00 | BlueRobotics |
| Tools | Purchased | $15.00 | 1 | $15.00 | BlueRobotics |
| Manufacturing Frame | Donated | $200.00 | 1 | $200.00 | JetCuts |
| Manufacturing Float Cover | Purchased | $63.52 | 1 | $63.52 | BigRep |
| DeepWater Camera System | Purchased | $900.00 | 1 | $900.00 | DeepWater |
| Manufacturing Mounts | Purchased | $30.00 | 1 | $30.00 | COEX |
| | **ROV TOTAL** | | | **$5700.50** | |

**Purchased/ReUsed/Donated Breakdown**

| | | | |
|---|---|---|---|
| Purchased: | $1192.50 | Donated: | $224.00 |
| ReUsed: | $4851.00 | Total: | $5700.50 |

**2024 ROV HORNET Income**

| | | |
|---|---|---|
| SFSD | $2000 | Funding Grant |

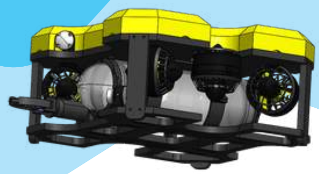
**2024 World Championship Budget**

| | | |
|---|---|---|
| Transporation | Budgeted | $500.00 |
| Lodging Costs | Budgeted | $2500.00 |
| Meal Costs | Budgeted | $1500.00 |
| Team Entry | Budgeted | $250.00 |
| Team Gear | Budgeted | $250.00 |
| | Total: | $5000.00 |





**photo credits:** Team Photo Collection



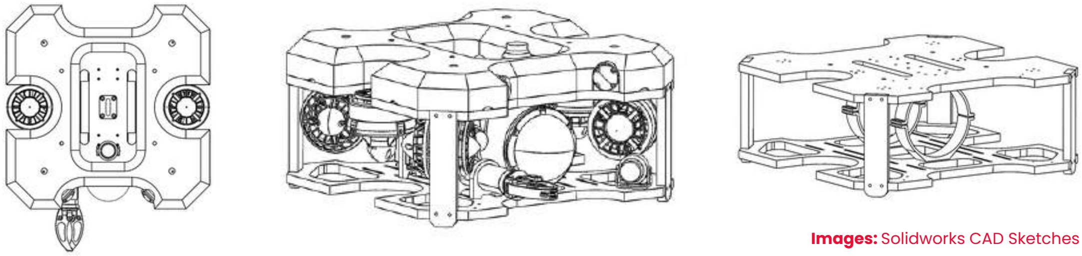
# Challenges Faced

## Technical/Non-Technical

Speed to market poses a significant obstacle for our company in the '24 HORNET ROV development journey. Engaging in diverse competitions and outreach endeavors, such as the First Tech Challenge (FTC), prolonged our involvement well into the MATEROV season. This extension necessitated an expedited development and testing phase for our ROV, placing us under heightened pressure compared to competitors with earlier project commencements. Nevertheless, despite the stringent time constraints, we take pride in our achievement of successfully launching the ROV HORNET to market within a remarkably brief timeframe, encompassing the stages of design, construction, and rigorous testing.

While the utilization of CAD software proved invaluable in facilitating both the design process and troubleshooting aspects of the ROV, it concurrently presented a notable challenge for our team. The proficiency in the Solidworks CAD program was limited to only one member, exacerbating the workload distribution dynamics. To mitigate this challenge, concerted efforts were directed towards training an additional team member in Solidworks, thereby diversifying our CAD design capabilities. This strategic initiative not only addressed the immediate challenge but also bore fruit in the form of the development of our innovative FLOAT concepts, slated for market introduction in 2025.

Furthermore, another formidable challenge confronted us this year – the scarcity of manpower due to numerous team members being committed to prior obligations. Coupled with the delayed project initiation attributable to our FTC involvement, the outlook appeared daunting. However, adversity served as a catalyst for fostering enhanced teamwork and adept workload management practices. Through collaborative efforts and meticulous coordination, we surmounted these hurdles and successfully delivered the ROV project within the predefined timeframe.



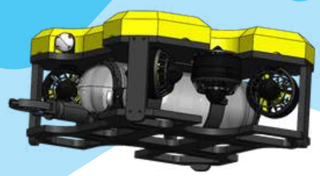
**Images:** Solidworks CAD Sketches of ROV Hornet





**photo credits:** Team Photo Collection

# Lessons



## Lessons Learned

Throughout this season, we have gained valuable insights, particularly in the area of time management. It became clear to us that attempting to teach people how to use CAD software while simultaneously building and designing the ROV and its parts was a challenging task. We also recognized that effective time management and communication are crucial when working on a robotics project. As we divided the work among various departments, we learned how to communicate effectively to make the most efficient use of our time.

## Future Improvements

Moving forward, we aim to establish an improved design process that enables us to create a more sophisticated ROV. With growing experience, we expect to enhance our skills in various areas, such as wiring, programming Arduino, and 3D CAD design. To facilitate this, we plan to train more team members ahead of time so that we can hit the ground running when the season begins.

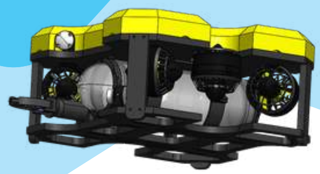
## Reflections

The completion of this project required the collaborative efforts of all team members, although the process may not have been timely or efficient. Our team's chemistry and communication skills were crucial to the successful delivery of the final product. In addition to project tasks, team members also provided mentorship to each other on new skills and trades, with the goal of developing leaders who can take on future projects. This ROV is one of our most advanced, incorporating new camera and frame designs, and will serve as a guide for future ROV developments. We aim to continue to grow and make even more efficient products, and have expanded our CAD team to improve the design process.

## Educational Connections

SFROBOTICS is a forward-thinking organization that provides opportunities for students both inside and outside the classroom to become change agents in their world. SFROBOTICS exhibits various remotely operated vehicles (ROVs) at events across Southeastern Wisconsin, spanning from Makerfaire to National Robotics Week gatherings. Our primary objective is to spotlight the advancements in robotics and ROV technology for the wider audience.

# Acknowledgements



## Team Sponors

**Our Funding Sponsors:** We extend our gratitude to our funding sponsors, the **St. Francis School District and the Wisconsin Department of Public Instruction**, whose generous support has made ROV HORNET possible. Their commitment to education and community empowerment is instrumental in advancing our goals and initiatives.

**Our Manufacturing Sponsors:** We extend our appreciation to our manufacturing sponsors for their support in providing manufacturing resources for the production of ROV parts. **BigRep, Jetcuts, and COEX3D** have played a role in enabling us to realize our project goals through their contributions and expertise in manufacturing technologies. We are grateful for their partnership and commitment, which have been instrumental in the success of this endeavor.

**Our Product Discount Sponsors:** We extend our gratitude to our sponsors who have made a significant impact on our project. Special thanks to **DeepWater Exploration, Blue Robotics, COEX3D, and goBILDA** for their invaluable support in providing discounts that facilitated the acquisition of various parts for our ROV. Their contributions have played a crucial role in advancing our efforts and enabling our exploration endeavors. We are appreciative of their partnership and commitment to our success.

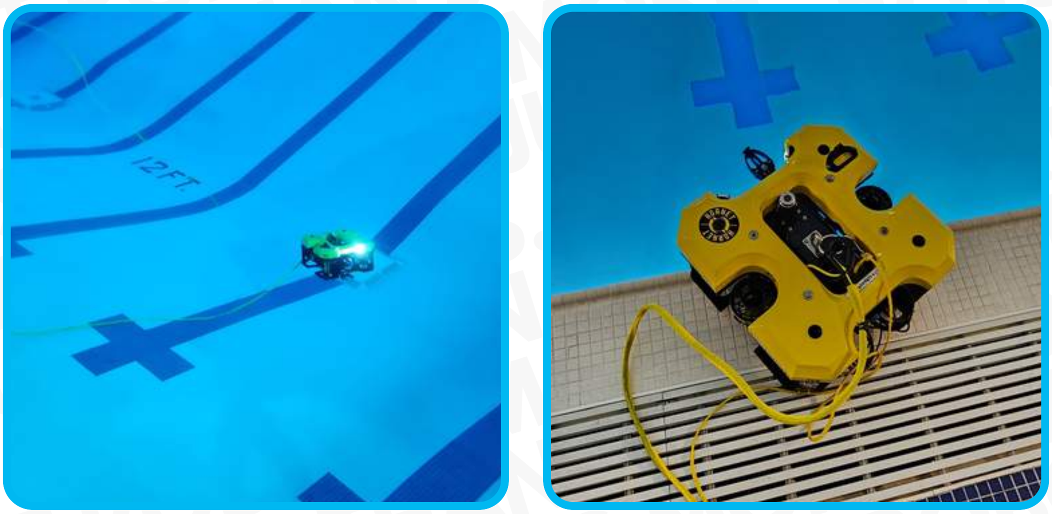
Additional Acknowledgements: We extend our gratitude to **Kingsport Aquatic Center** for graciously hosting the 2024 MATEROV World Competition. This event provides an invaluable platform for students to showcase their innovative designs in ROV development. We are deeply thankful to **MATE** for organizing this competition, fostering creativity and skill in underwater robotics. Special appreciation goes to the **St. Francis School District** for their unwavering support, enabling our team to participate and excel in this enriching experience.

ROV HORNET

# References

## Websites

- Mate ROV Competition - https://materovcompetition.org/
- Blue Robotics - https://bluerobotics.com/
- Deep Water Exploration - https://dwe.ai
- COEX - https://coex3d.com
- Jetcuts - https://jetcutsusa.com/
- GoBilda - https://gobilda.com
- BigRep - https://bigrep.com/
- QGroundControl - http://qgroundcontrol.com




**Images:** Different Views of ROV Hornet

# Contact Information

## Team Contacts

### Team Email:

All team email can be sent to:
robotics@sfsd.k12.wi.us

### Our Location:

SFROBOTICS
3680 South Kinnickinnic Ave.
St. Francis WI, 53235

### Connect with Us Online:

f) http://www.fb.me/sfrobotics
t) https://x.com/sfrobotics_wi
w) https://sfrobotics.org
e) robotics@sfsd.k12.wi.us

### Hours of Operation:

Mondays: 3:30 - 5:30pm
Tuesdays: 3:30 - 5:30pm
Saturdays: 9:00am - 12:00pm

**#WATERGAME**

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MORE THAN JUST ROBOTS

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