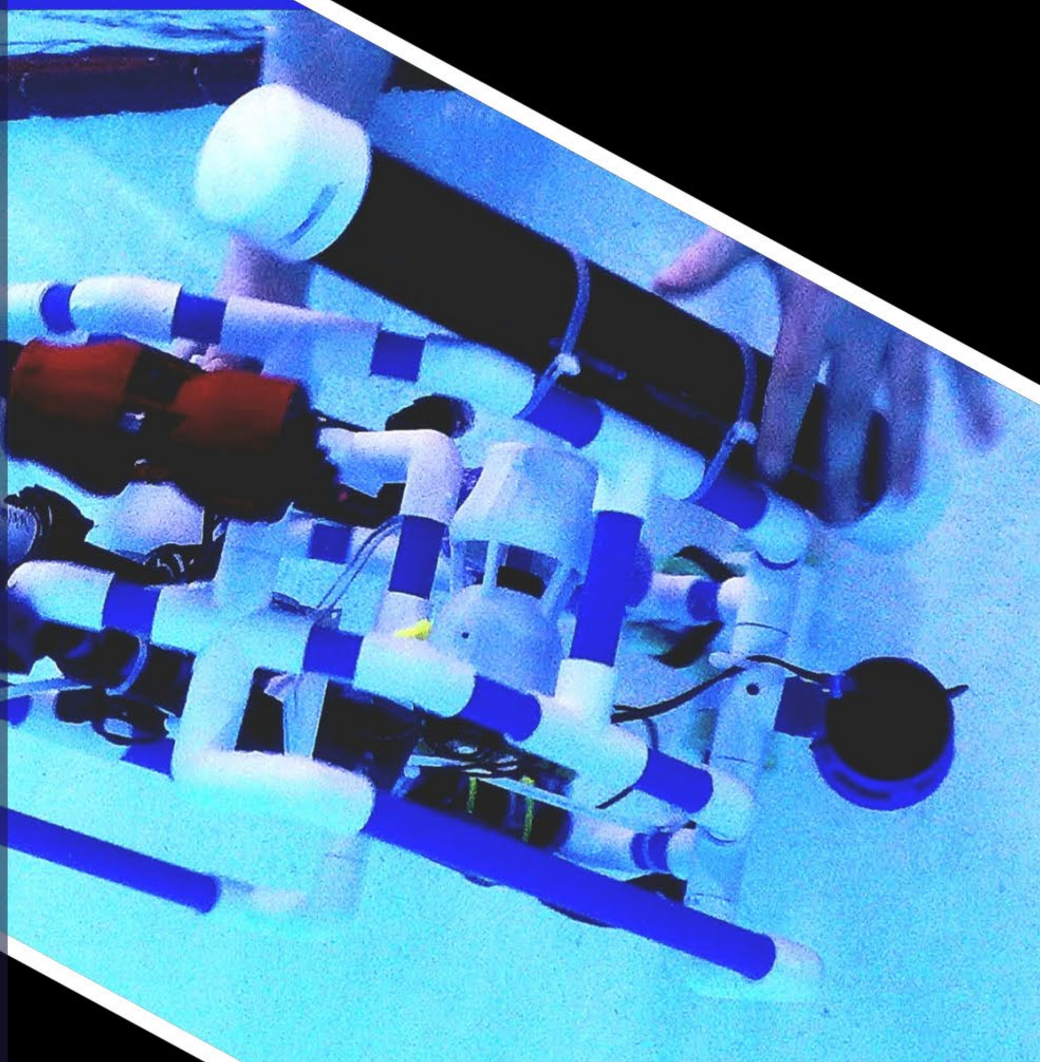
# Cyance

A Division of Atlantis S.T.E.A.M., Whidbey Island, WA
2,080 km to Longmont Colorado



**Team Members**

Caleb Arndt
(CEO, CAD Specialist)

Elliott Andrews
(Chief Electrical Engineer)

Theodore Alexander
(Payload Specialist)

Solomon Hilliard
(Coding Specialist, Safety Officer)

Nicholle Sargent
(COO)

Opheibia Neff
(CFO,
Team member in training)

Bixby
(Emotional Support Dog, Mascot)

Mentors:
Ash Bystrom, Ryan Holle

# 2023 Technical Documentation

# Table of Contents

# Abstract

Cyance, a division of Atlantis S.T.E.A.M.[1], is committed to benefiting people by improving their access to the Science, Technology, Engineering, Arts, and Math education they deserve. Our goal is to facilitate equal opportunity for S.T.E.A.M. and innovation all around the world. This goal is reflected in our ROV, “Psi”, by our use of inexpensive and easily-accessible materials such as PVC, car cameras, CAT 6 cables, bilge pump motors, and other globally-available materials.

Our chassis is built out of ½“ PVC in an elongated octagonal design, evolving from the first iteration of an abstract turtle shell shape. Mounted around the frame of our ROV, we have six bilge pump motors: our four lateral motors are mounted in an X vectored configuration and our two vertical motors are wired in parallel. The manipulator is mounted through two bearings that allow all stress put on it to be distributed into the frame. We have four cameras mounted throughout our ROV to give us many viewpoints of our surroundings.

All of these systems combined with a competent pilot can efficiently, and effectively, complete tasks such as aiding deceased coral, mooring solar power arrays, and scanning pre-existing wind turbine tethers for corrosion. ROVs become important to our island community when a seaplane plummeted into the water off of Whidbey Island, WA. The wreckage of the plane and the recovery of the victims of the plane's dive were only recoverable by a working-class ROV.

(Word Count 248)

# Teamwork: Company Structure and Communication

## Project Management

Back in May of 2022, the idea of creating an ROV company was formulated at an ROV training session by three of our current employees. Pursuing more training over the summer, we encountered two more enthusiastic current employees. All of these employees were trained by our current mentor Ash Bystrom, who taught us many of the foundational skills required to begin our company. As a result, we started our company “Cyance” in October 2022.

[1] S.T.E.A.M. stands for Science Technology Engineering Arts and Math

Our motto is “Don't get caught in the weeds,” because when building our ROV we had a goal to not get caught in distracting details. During the design process, our company's top priorities have been: 1.) Ease of use for consumers to tackle the issues of marine renewable energy, reintroducing species to nurturing habitats, and aiding in coral recovery; and 2.) Documenting the design processes throughout the modification of our product to its final iteration. These priorities have helped us along our design process by keeping our employees on task and committed to benefiting our community. Our team chose a four motor vectored configuration with two vertical motors. This setup has more maneuverability than other arrangements we considered. We have five cameras to maximize spatial awareness. In the following sections we further discuss some more of our systems. The company's number one priority is: physical, environmental, and psychological safety. We require company members to follow safety procedures in order to ensure everyone stays safe.

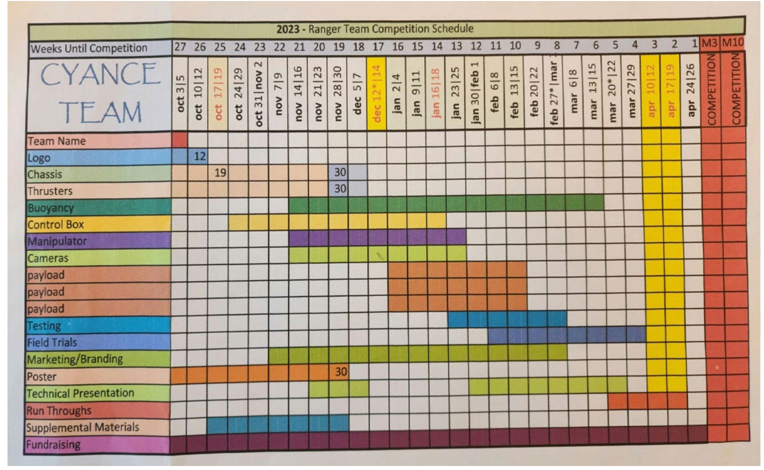



Figure 1: Original schedule, Oct 2022

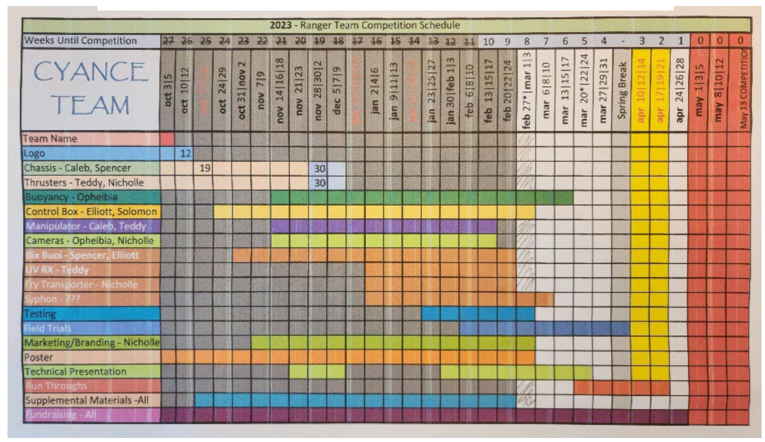
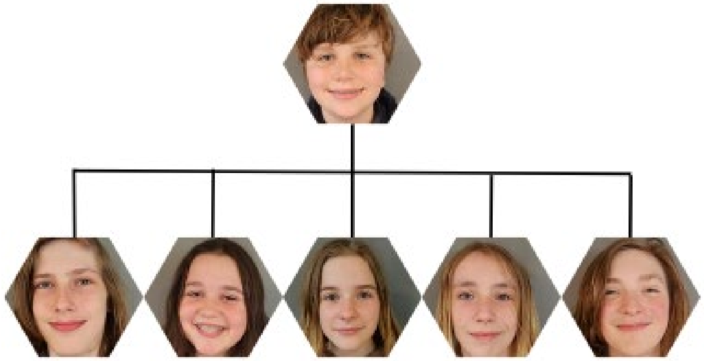



Figure 2: Adjusted schedule, Nov 2022

## Company Organization

# Cyance Corporate Workflow



Top: Caleb Arndt, Chief Executive Officer

Second Row L-R:

Figure 3: Corporate Workflow

Elliott Andrews, Chief Electrical Engineer

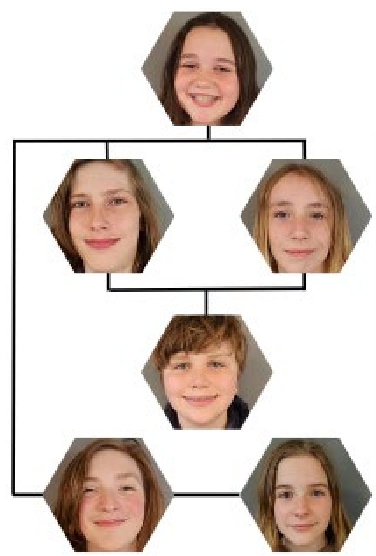
Nicholle Sargent, Chief Operating Officer

Opheibia Neff – Chief Financial Officer

Solomon Hilliard-Coding Specialist/Safety Officer

, Theodore Alexander – Payload Tool Specialist

# Cyance On-Deck Workflow



1st row: Nicholle Sargent – Mission Navigator
2nd row, l-r: Elliott Andrews – Pilot/Co-Pilot,
Solomon Hilliard - Pilot/Co-Pilot.
3rd row: Caleb Arndt - Manipulator
4th row: Theodore Alexander & Opheibia Neff – Tether/Payload Tools

# Design Rationale

Figure 4: On Deck Workflow

## Engineering Design Rationale

When designing our ROV, our first decision was the type of thrusters we would use and what motor configuration we were going to use. Then we decided on our basic chassis design, then we made the decision of where our first cameras would go. After that we chose to start soldering our six thrusters to our tether. After that we made the important decision between switches and potentiometers we decided on potentiometers

## Innovation

We have made numerous innovative changes to our bot and its systems, all changes on our bot were either made for cost efficiency, making the bot more efficient at tasks, or making the ROV safer. Some of these changes consist of, using an octagonal shape to house our vectored motor configuration, incorporating a peanut butter lid into the chassis to complete the UVRX task, or mounting a custom-made PVC strain relief mount on the back of the bot.

## Chassis

We decided to use PVC pipe to create a chassis because it is lightweight, accessible, and cost-effective. The shape of the chassis is loosely based on a turtle as one of our employees has modeled below. The PVC is arranged in an elongated octagonal shape to accommodate our vectored motor configuration, the extra space in the chassis allows us to fit two vertical thrusters. and all of the electronics required for the bot to function. Not only does this chassis design allow space to store all of our electronics.

## Control Box

The control box is what transforms signals from the controller to signals for the motors as well as supplying power to cameras and holding a monitor. Its wires are all perfectly straight to minimize electrical interference. It contains three circuit boards for controlling the motors: a k166 for vertical motors and two sabertooths for horizontal motors, all processors are suspended for cooling. The control box has quick-release connectors on it for its inputs and outputs. The tether connects into the control box allowing signal and power to our ROV. To protect our systems we have a plexiglass shield which also provides strain relief for wires coming out of the control box.

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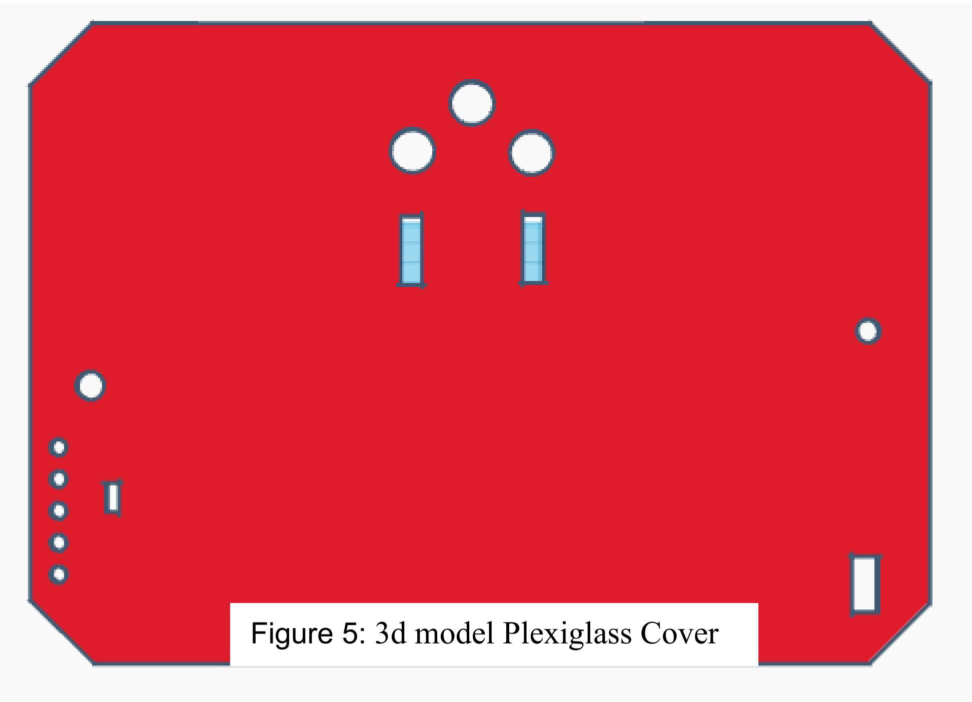


Figure 5: 3d model Plexiglass Cover

## Controller

We have a controller to manage the movement of our bot that is separate from our control box, it has two connectors on it with eight wires each, and a five pin plug that connects it to the control box. On our controller, we have two joysticks for controlling horizontal movement and a sliding potentiometer between them for controlling vertical movement. The controller is painted blue with an orange stripe along the back and a silver trim on the front. It also has some electrical tape artwork on the front. The joysticks have two potentiometers in them that measure the position of the joystick. All the signals from the controller go through the aforementioned connectors to the control box.

## Propulsion

For propulsion, we chose bilge pump motors because they are cost and time effective. We decided against other types of more expensive motors because we would have to code, which not all of our employees know how to do. This would cause another training petition that we do not have the time to spare for. Our choice was also influenced by cost-effectiveness because, for the cost of 6 bilge pump motors, we could only afford one blue robotics motor. Some final deciding factors were their durability, ease of acquiring, and ease of assembly. All decisions were made and evaluated to get in the water and testing as soon as possible and with a majority vote. We chose a vectored motor formation because it allows us to strafe, it also provides us with more precise movements to complete tasks such as following a corroded rope to look for points of failure. All of the motors that we use on our ROV were bollard tested to ensure that all motors were consistent in the amount of thrust that is given. Our company also tested two different power consumption motors with three different propeller sizes. In the end, we decided on 500GPH motors with 50mm propellers for the most efficient power-to-thrust ratio.

## Buoyancy/Ballast

For our current buoyancy we are using PVC tubes filled with air, some weights were used to trim our ROV to slightly negative buoyancy. Being negatively buoyant allows us greater maneuverability in water because when doing tasks such as irradiating diseased coral we want to float down over the coral, so as to not harm the coral further by smashing into it.

To calculate the needed buoyancy we used the following function:

$$L(r) = W\pi r^2$$

Where *L* is the needed PVC tube length in cm, *r* is the inner radius of the tube and *W* is the amount of water the bot needs to displace in cubic cm. Our bot weighs 1600 grams and therefore needs to displace 1600 cubic cm of water. We have two tubes that have an inner radius of 2.575cm when evaluating the tube in terms of *L* we get:

$$L(2.575) = 76.81$$

We decided on ABS(Acrylonitrile Butadiene Styrene) rather than PVC (Polyvinyl Chloride) because ABS is slightly positively buoyant whereas PVC is negatively buoyant therefore ABS will give bore buoyancy for its size. We created two tubes slightly longer than half of 76.81 and attached them to the bot for buoyancy. Our company chose this over crab buoys because the tubes are much more durable than other more spongy buoyancy options, they are also able to withstand much more pressure. On our tether, we have buoyancy so that the tether stays positively buoyant to stay out of the ROV’s way while completing tasks. This buoyancy is made out of Kickboard foam and pool noodles because they are cheap and easily accessible.

## Payload and Tools

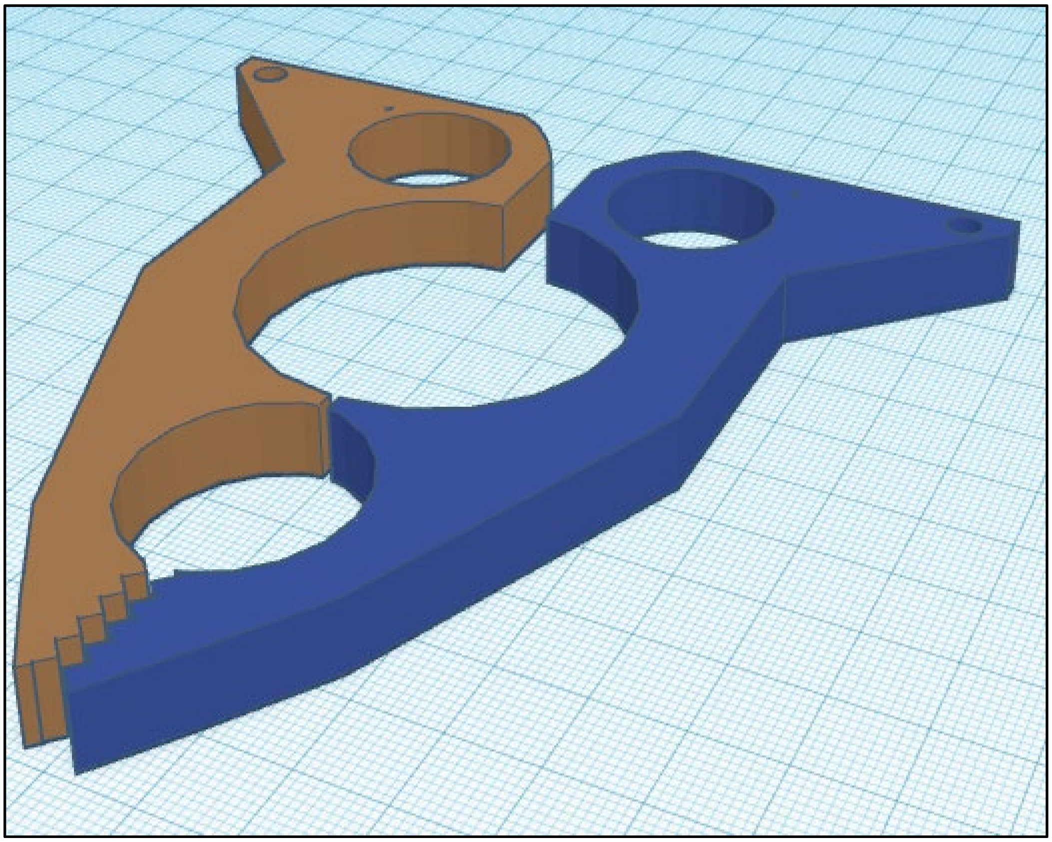
“Payload tools were designed to meet mission requirements”

## Cameras

Our bot has four cameras: we have an upwards-facing camera that is looking at the tether so we can follow the tether back up to the surface, we also have a downward-angled camera that helps us maneuver around things and helps us in certain tasks, a forward-facing camera that is tilted so we can navigate, see our manipulator, and complete tasks. We have a downward-facing camera that has UV lights for the UVRX task. Instead of using regular video cables that are stiff and may break when they bend, we used Cat6 cable which is a more flexible alternative so that when the wires bend, they won't snap. We have a power bus with connectors for all four cameras three of which are connected to a three-way switcher. For the three-way switcher, there is one power in and 3 power out. It cuts off power for two so only one is on at a time this makes sure we will never exceed our power budget. For viewing our camera outputs, we have three monitors, all purchased from a local thrift store which helps us in our goal of being as cost-effective as possible.

## Manipulator

Our manipulator is custom designed by our team to complete the wide variety of tasks that our ROV may be challenged with. The manipulator has a hydraulic actuator and piston, the piston is mounted inside a PVC tube in our chassis to prevent it from being damaged or the hydraulic line from being detached, and the actuator is mounted inside a foot pedal at the surface to allow the user to have their hands free to rotate the servo controller of fix other components if need be. Underwater we have a waterproof servo that is able to rotate our manipulator 90 degrees, this one degree of rotational freedom allows us to pick up and move a much wider variety of objects. The reason that we chose to actuate the manipulator with hydraulics rather than with a servo was that the servo had no control over how hard it grabbed and this would cause it to harm any delicate sea life, the servo would also put us over our power budget, and although there are workarounds the most effective solution in the end was still hydraulics because of the superior control.



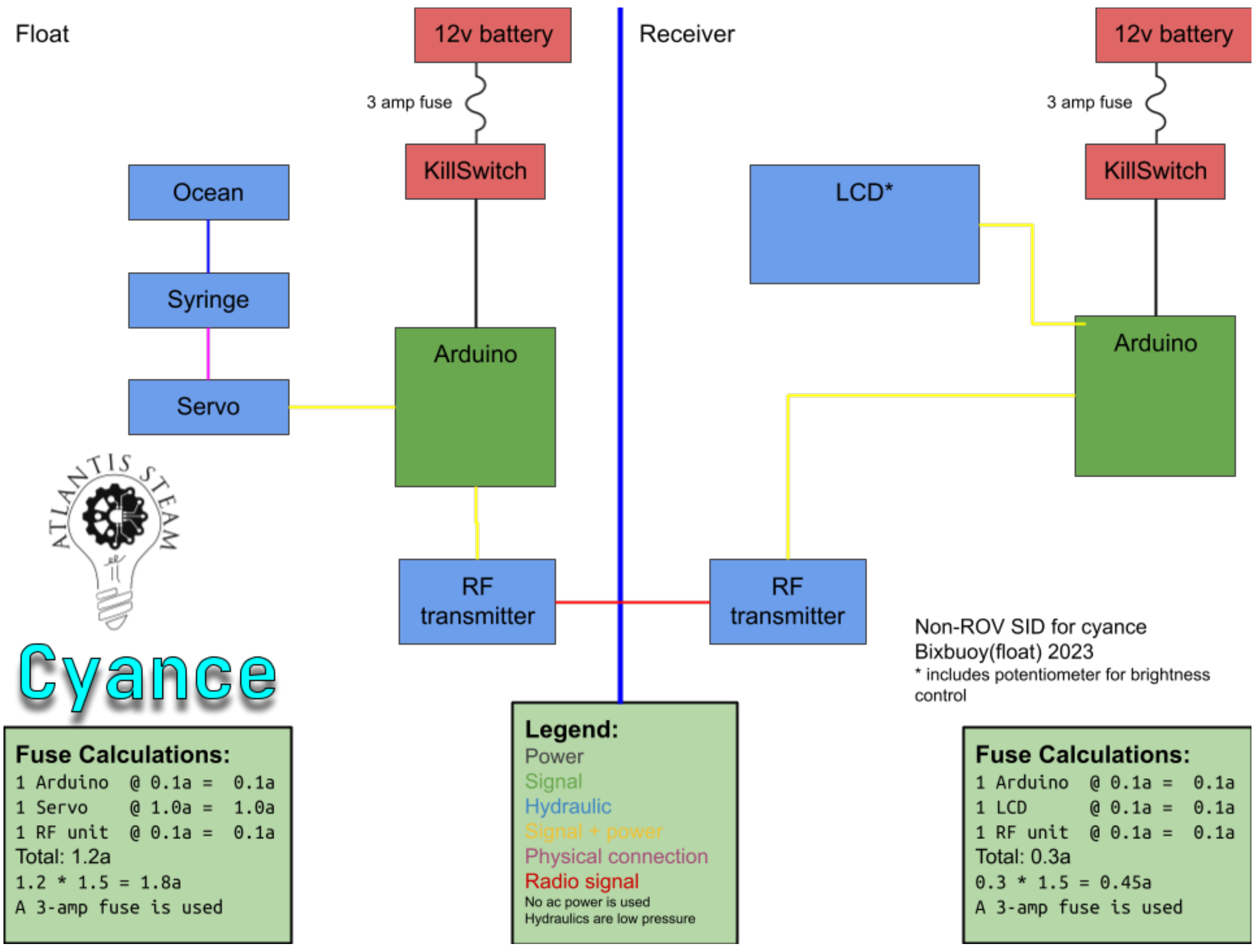
**CAD model of the manipulator(photo credit Caleb Arndt)** Vertical profiling float

At Cyance we have designed and built a buoyancy engine-powered vertical profiling float named "Bixbuoy" after our mentor's dog called Bixby. This float consists of a small Pelican case containing electronics, a syringe extending below the case, and a metal casing around the syringe. The casing provides weight as well as protection for the syringe from potential hazards. This casing has additional weights secured on either side of it to achieve the perfect level of buoyancy. The Pelican case contains all electronics, is watertight, and has a pressure release system. The electronics inside of the case consist of an Arduino UNO, a 5V continuous servo, a 5-amp fuse, a radio transceiver, and an enclosed 9V alkaline battery. The battery power first goes through the aforementioned fuse before then reaching the Arduino. The servo communicates its position to the Arduino via digital pin nine. The servo rotates a drive screw which pushes or pulls the syringe's plunger. This changes the amount of water the buoy displaces by sucking in or pushing out enough water to change its buoyancy. To communicate the time and our team number back to the receiver we have a radio transceiver connected to the Arduino. Our receiver consists of a circuit board, Arduino, 9V battery, power switch, radio transceiver, LCD[2] display, and a potentiometer. The Arduino controls the LCD which displays the team number and time transmitted from the buoy. The potentiometer controls the brightness of the LCD screen and the

[2] LCD stands for Liquid Crystal Display

transceiver receives the buoys signal. To activate the system simply toggle the power switch on the back of the battery container, press the reset button on the Arduino, close the case, and place it in the water. The Arduino is pre-loaded with a program that manages the multiple descents and ascents needed as well as communication with the receiver.

The receiver can be turned on and off via a switch on the outside. When the buoy is at the surface the LCD should display the time and team number.

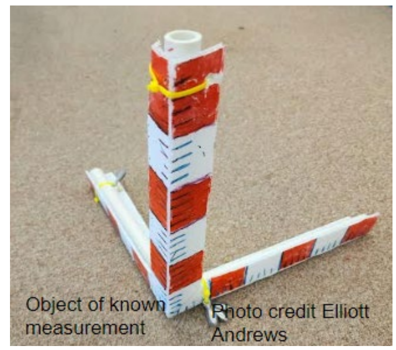


Fry Flyer


The Fry Flyer Photo Credit Elliott Andrews

We designed and built a payload tool to move fish fry, which we call “the fry flier” to complete the task of taking the fish to a safe environment and releasing them. The second iteration had two separate open boxes with magnets on the open face to keep the boxes together and stop the fish fry from dropping out during the task and only released with a tug on the rope that it is attached to.

Measurer


Object of known measurement Photo credit Elliott Andrews

To complete the task of measuring deceased coral our team came up with a method of dropping down a device that we knew the exact measurement of next to the coral so that we could look at the device and know the coral's exact measurements. Drawn every centimeter on this device are black lines and every 5 cm the color is switched between orange and white for more visibility underwater, the orange sections also let you count faster while in the middle of mission tasks.

UVRX


UVRX Photo credit Elliott Andrews

Our first iteration of the device to administer UV RX to the coral included a horizontally cut-in-half peanut butter jar to allow the lower half to be used as an enclosure for the UV light. This first iteration was changed by switching to using the top half and spray painting it blue to stop light from coming in during the mission and switching to using a more favorable camera with a few tiny lights surrounding it. On our first attempt at soldering, we forgot a few pieces of marine-grade heat shrink and the ground and power touched and fried the camera. We fixed the previously stated issue by buying a new camera and excessive checklists for heat shrink (which saved us a few times later).

On our third(final) iteration we used the lid for the peanut butter jar to make it dismountable so that during the task where we find which environment was safe for the fish we could have the bot sit on the pool floor and observe both habitats at once with our camera system with a camera on either side of the bot. The reason we decided to keep this design is that the guard around the UV is modular and therefore not necessary to deal with after completing the task.

## eDNA retrieval

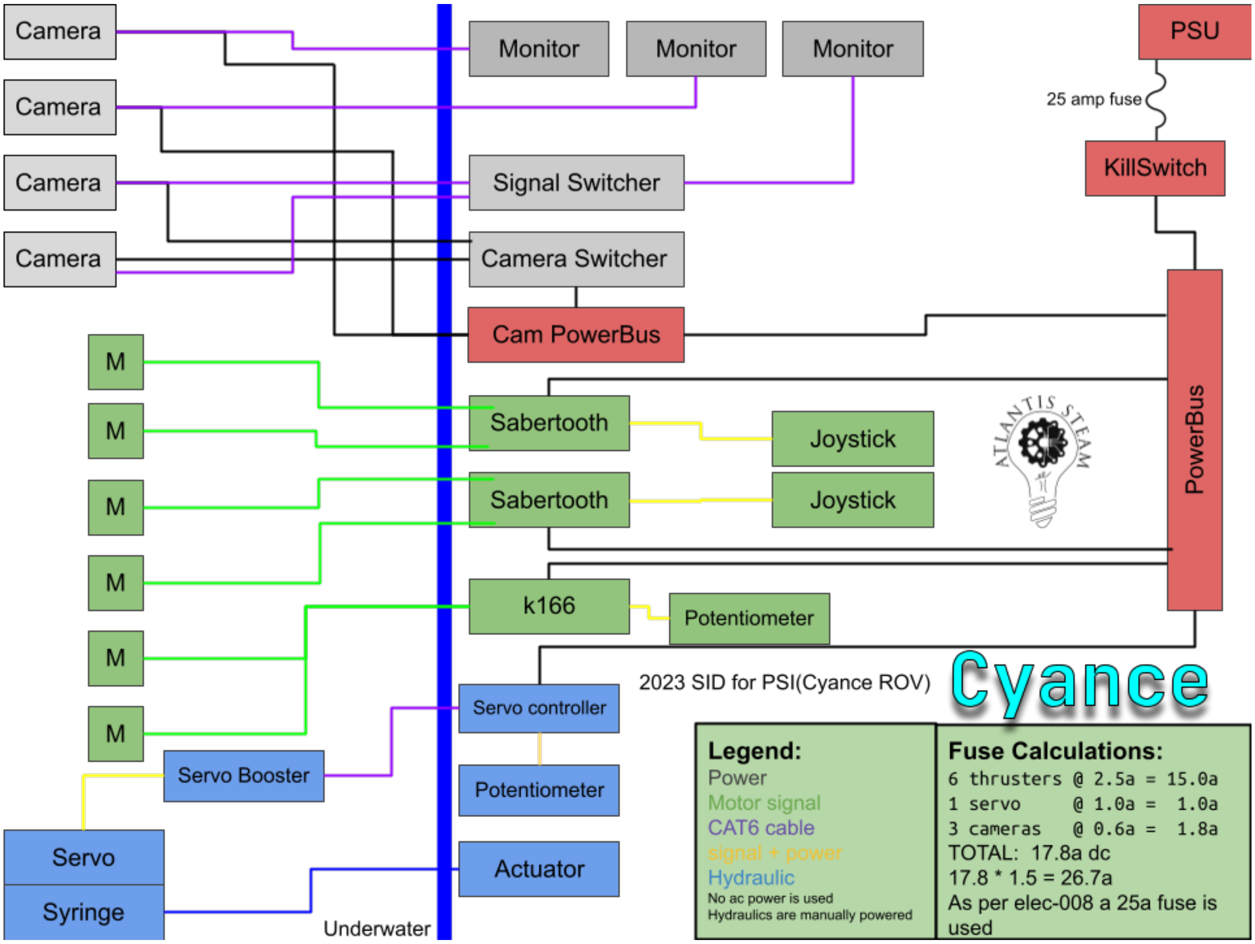
Our eDNA retrieval tool is designed to use the water pressure around the tool to suck up the water around the dying coral to identify diseases. After identifying diseases the ROV can carry down prescribed medicine to help cure the coral, having this info allows the medicine to target what type of medicine the coral requires, and not waste different types trying to identify the coral. The tool uses the pressure of the water around the syringe to force water into the syringe, when you pull out a syringe on the surface the pressure of the water forces the syringe to fill up.

## BUILD vs BUY, NEW vs USED

Cyance is committed to allowing people from all around the world to have access to ROVs, so we have incorporated many different materials that are more available to other less developed programs. Our chassis was fully built out of PVC because it is a resource that is available all around the world and is not as fancy, and inaccessible as materials such as laser-cut acrylic. All of our company's cameras are car cameras that were potted in epoxy resin. We built a payload tool to facilitate task 2.3 by recycling a Jiff peanut butter jar. The peanut butter jar was recycled by cutting it in half longitudinally. We used Erector set pieces in building our manipulator, we used these because they are easy to use and affordable. We have three monitors that we got from a local thrift store.

Given that this year's team was our first year competing we did not have anything to reuse from a previous year's bot, so anything that you see here is reused from previous teams. Rather than using joysticks from a previous team, we decided to use new joysticks so that they would pick up on all of the fine movements that could make the difference between success and failure. We also purchased all new motors so that we would not have any issues with the propulsion systems.

SID Diagram




Safety

Cyance values safety above all else and we are dedicated to ensuring the safety of all employees. To do this we require the necessary safety gear to be worn during all potentially hazardous activities. For example, when employees are soldering they are required to wear safety glasses. Another safety precaution we take is washing hands upon arrival, and departure of break.

On our bot we employ a variety of safety methods such as tether management. The tether is made up of 6 CAT 6 cables,10 thruster wires, and a hydraulic tube that is all wrapped up in a tether casing. At the bot, we have a PVC pipe with padding that the tether feeds into so the wires are protected from strain.

# Safety Checklist

## In lab

- Different safety gear is worn depending on the situation.
- Area clear, no tripping hazards.
- Equipment is cleaned up properly.
- Equipment is only in a safe environment.
- Always have a buddy when doing possibly dangerous tasks.

### Soldering:

- Wear safety goggles and masks.
- Clear the nearby table space.
- Turn on a fan.

### Resin:

- Wear a mask, and gloves.
- Turn on a fan to ventilate.
- Clear the nearby tablespace.
- Place down newspaper.

## On deck

### Setting up on deck:

- Area clear/safe (no tripping hazards, items blocking the way.)
- Tether is laid out neatly, and coiled up.
- Plugs are out of reach of water.
- Verify that the power switch is off.
- The thrusters are covered by shrouds.
- No exposed wire while power is on.
- All screws and nuts are tightened.
- The tether is always secured to the bot.
- Always check that there is a 25-amp fuse.
- Call out, ¨Test thrusters. ¨
- Perform thruster test.
- Verify video feeds.
- Test the manipulator.

### Launch

- Call out, ¨prepare to launch¨.
- Deck crew members call out, ¨Ready¨.
- Launch ROV.

### ROV Retrieval

- Pilot calls out ¨ROV surfacing. ¨
- Deck crew calls out ¨ROV on surface. ¨
- Stop Thrusters.
- Remove the ROV from the water.

### Loss of Communication

- Check wiring.
- Check plugs.
- Check the fuse.

### Maintenance

- Verify that thrusters are free spinning.
- Visual inspection for any damage.
- Cables are secured.
- Screws are tightened.

Budget

We designed our budget in system sections, each section is labeled as a different system on our bot to make it easier to find the total for each different labeled section. We decided to try to use mostly things we already had in our space so we didn't have to spend more on supplies we already had. This allowed our company to save money, and keep our bot at the same if not better price to performance. Our company is not covered by any schools, and we are a non profit organization so all of the products that are used on our bot were purchased from money we fundraise. One of our companies main goals is to make a cost effective bot that more rural communities could access, and to show them that to compete at this class you do not need $200 thrusters, and A $150 waterproof enclosure.

**CYANCE BUDGET 2023**

| CYANCE 2023 FINANCIALS | | |
|---|---|---|
| **BUDGET** | **Est Cost** | $4,010.00 |
| Control Box | $500.00 | |
| Hydrolics | $25.00 | |
| Thrusters/Tether | $350.00 | |
| Cameras/Monitors | $500.00 | |
| Manipulator | $200.00 | |
| BixBuoi | $250.00 | |
| Buoyancy | $100.00 | |
| Payload Tools | $400.00 | |
| Poster | $450.00 | -$450.00 |
| Printing | $15.00 | -$15.00 |
| R&D | $500.00 | -$500.00 |
| Competition Fee | $200.00 | -$200.00 |
| Tshirts | $100.00 | -$100.00 |
| 3D Printing Est | $320.00 | -$320.00 |
| Misc Supplies | $100.00 | |
| **Bot Cost** | **$4,010.00** | **$2,425.00** |
| Total Team Hours | 1664 | |
| Cost Per Hour | $10.00 | |
| **Team Cost for Season** | **$16,640.00** | |
| **TOTAL COST** | **$20,650.00** | |
| Member Cost/Month | $368.75 | |
| Approx $370/month per team member | | |

| Titles | Qty | Retail | Reused | Total |
|---|---|---|---|---|
| **Propulsion System** | | | | |
| thrusters | 6 | $28.00 | 0 | $168.00 |
| joystick | 2 | $13.99 | 0 | $27.98 |
| **Total** | 8 | $41.99 | | $195.98 |
| **Camera System** | | | | |
| cameras | 5 | $25.00 | 0 | $125.00 |
| cat 6 | 6 | $25.00 | 0 | $150.00 |
| monitor 1 | 1 | $79.99 | 0 | $79.99 |
| monitor 2 | 1 | $29.99 | 0 | $29.99 |
| monitor 3 | 1 | $79.99 | 0 | $79.99 |
| **Total** | | | | $464.97 |
| **Manipulator** | | | | |
| servoblock | 1 | $30.00 | 0 | $30.00 |
| waterproof servo | 2 | $50.00 | 0 | $100.00 |
| voltage converter 12 to 6 | 1 | $13.00 | 0 | $13.00 |
| 1 1/2 flat metal stick | 14 | $0.11 | 0 | $1.54 |
| part of an erector set | 1 | $15.00 | 0 | $15.00 |
| **Payload Tools** | | | | |
| Jif lid | 1 | $6.78 | 0 | $6.78 |
| **Total** | 1 | $6.78 | 0 | $6.78 |
| power off switch | 1 | $4.00 | 0 | $4.00 |
| servo commander | 1 | $30.00 | 0 | $30.00 |
| pelican box | 1 | $162.95 | 0 | $162.95 |
| power bus | 1 | $2.00 | 0 | $2.00 |
| **Total** | 4 | | | $198.95 |
| **Chassis** | | | | |
| 1 4 way | 1 | $3.57 | 1 | $3.57 |
| 5ft pvc | 1 | $10.00 | 1 | $10.00 |
| 19 t's | 19 | $0.75 | 19 | $14.25 |
| 16 45 | 16 | $1.32 | 16 | $21.12 |
| 1 1/2 to 2in. T | 1 | $3.89 | 1 | $3.89 |
| **Total** | | | | $52.83 |
| **Bix Buoi** | | | | |
| Stepper Motor/Screw Drive | 1 | $65.00 | 0 | $65.00 |
| arduino | 1 | $18.00 | 0 | $18.00 |
| 100ml syringe | 1 | $3.50 | 0 | $3.50 |
| **Total** | | | | $86.50 |
| **Misc** | | | | |
| heat shrink | 2 | $7.69 | 0 | $15.38 |
| marine grade heat shrink | 1 | $17.00 | 0 | $17.00 |
| hot glue | 1 | $10.00 | 0 | $10.00 |
| PLA | 2 | $25.00 | 0 | $50.00 |
| tape | | $5.00 | 0 | $0.00 |
| zipties | | $4.00 | 0 | $0.00 |
| **Total** | 6 | $88.69 | 0 | $77.38 |
| **ROV COST** | | | | $2,500.86 |
| **Research & Development** | | | | |
| R&D | 1 | $500.00 | 0 | $500.00 |
| Manipulator R&D | 1 | $20.00 | 0 | $20.00 |
| **Total** | | | | $520.00 |

visors:

Problem-solving

Our team Cyance has faced quite a bit of problems, for example, our camera system, when we waterproofed our first camera we tested it before and after potting, before potting the camera was clear and functional but after potting it was foggy to the point where we couldn’t use after that point, so we waterproofed a new one and it worked. Another similar problem that had occurred was one of our cameras wouldn't turn on after waterproofing so we waterproofed a new one that worked. When we waterproof cameras we put a lens on the end before filling a tube with the camera in it with epoxy resin due to this in two of our cameras there was an air bubble between the lens and the camera, so next time we waterproofed we made sure to get all air out before pouring epoxy resin over it.

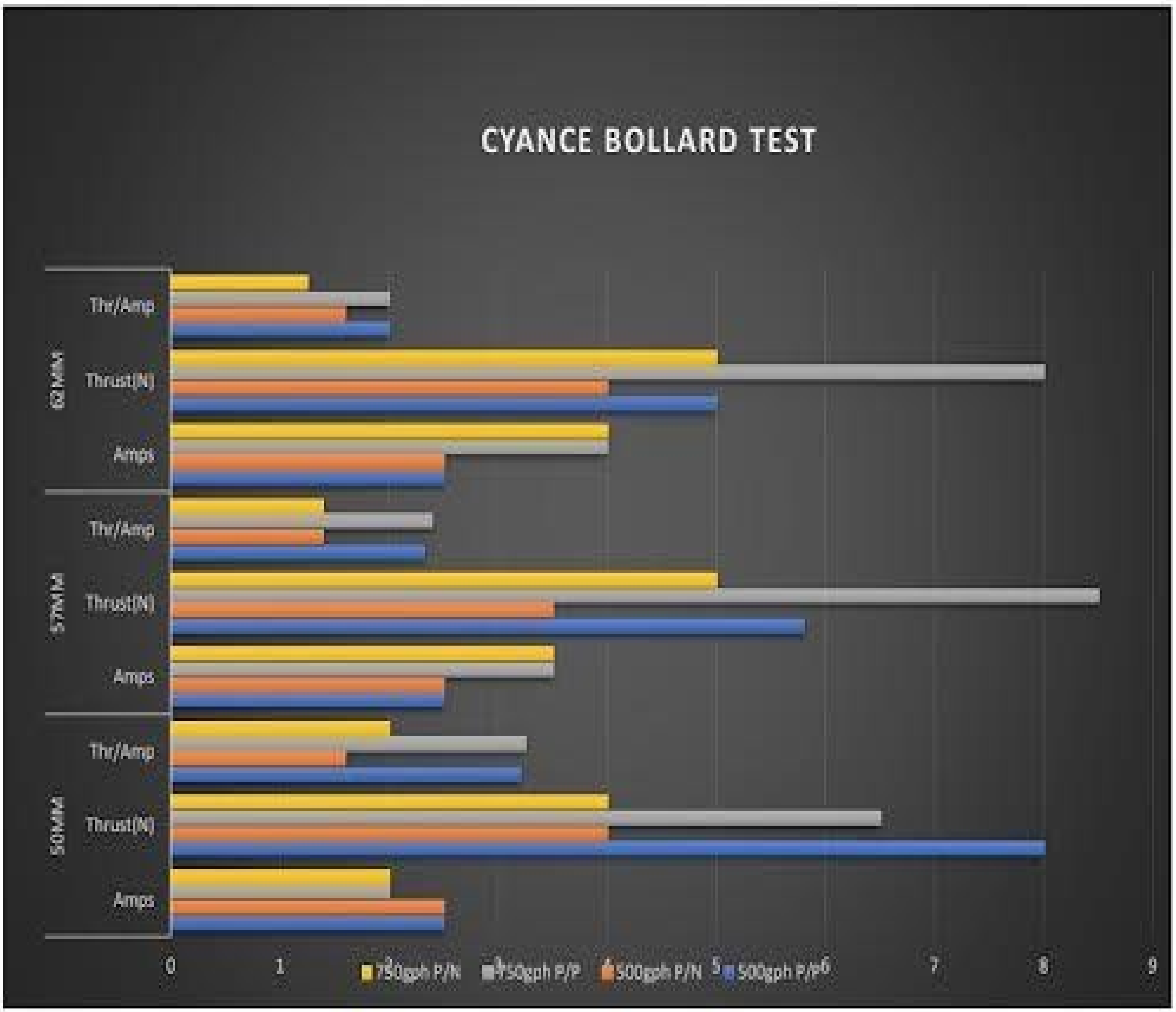
One of the biggest problems we faced was our manipulator. We had trouble connecting the hydraulics tubing to the syringe. Because of the pressure inside of the hydraulics line would snap the syringe off of the hydraulics line or the syringe itself would snap. This issue would force us to use a hook during competition rather than a manipulator, if the break happened during flight we would end up not functioning for the rest of the mission. Our solution ended up being to secure the connection with epoxy(what type) rated to 4000 psi, this allowed us to put lots of force on the manipulator without fear of breaking it.

Another issue we have had was our vertical profiling float, it has had three iterations. In the first, we had a fairly large chassis and used a stepper motor for moving the syringes. The stepper motor driver got too hot for use in an enclosed space. In our second iteration, we rebuilt the whole chassis significantly smaller and we switched to a servo rather than stepper motor. Then after regionals, we created a third iteration with radio capabilities; these abilities allow the buoy to communicate with the control station.

# CYANCE BOLLARD TEST RESULTS

| P/P=Positive to Positive<br>P/N=Positive to Negative<br>GPH=Gallons per hour | | 500gph | | 750gph | |
|---|---|---|---|---|---|
| | | P/P | P/N | P/P | P/N |
| 50MM | Amps | 2.5 | 2.5 | 2 | 2 |
| | Thrust(N) | 8 | 4 | 6.5 | 4 |
| | Thr/Amp | 3.2 | 1.6 | 3.25 | 2 |
| 57MM | Amps | 2.5 | 2.5 | 3.5 | 3.5 |
| | Thrust(N) | 5.8 | 3.5 | 8.5 | 5 |
| | Thr/Amp | 2.32 | 1.4 | 2.4 | 1.4 |
| 62MM | Amps | 2.5 | 2.5 | 4 | 4 |
| | Thrust(N) | 5 | 4 | 8 | 5 |
| | Thr/Amp | 2 | 1.6 | 2 | 1.25 |

| Chosen Thruster Configuration | | | |
|---|---|---|---|
| P/P=Positive to Positive<br>P/N=Positive to Negative<br>GPH=Gallons per hour | | 500gph | |
| | | P/P | P/N |
| 50MM | Amps | 2.5 | 2.5 |
| | Thrust(N) | 8 | 4 |
| | T/A | 3.2 | 1.6 |



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