

Table of Contents

- 1. Abstract**
- 2. Project Management**
 - i. Company Overview
 - ii. Member Roles and Responsibility
 - iii. Project Planning and Time Management
- 3. Engineering Design Rationale**
 - i. Design Evolution
 - ii. Mechanical Rationale
 - iii. Software Rationale
 - iv. Troubleshooting and Testing Techniques
- 4. Mechanical Components**
 - i. Frame
 - ii. Propulsion
 - iii. Buoyancy
 - iv. Tools
- 5. Electrical Systems**
 - i. Topside Control Unit
 - ii. Onboard/Underwater Control Unit
- 6. Code management**
 - i. Cameras/Vision System
 - ii. Thruster System
 - iii. Claw System
- 7. Safety**
 - i. Company Safety Philosophy
 - ii. Training
 - iii. Vehicle Safety Features
 - iv. Operational and Safety Checklist
 - v. Lab Protocols
- 8. Finance**
 - i. Budgeting/Cost Organization
 - ii. Budgeting/Cost Chart
- 9. Float**
 - i. Design Process
 - ii. Software Organization
 - iii. Code
- 10. Conclusion**
 - i. Acknowledgements
 - ii. References

1. Abstract

We are H₂Operations from Francis W. Parker School in Chicago, Illinois. Our team was started in 2018 by a small group of five passionate high schoolers, and it has grown into more than 25 members this year. We pride ourselves on fostering a welcoming and inclusive environment for any students interested in learning more about what we do. Regardless of age or skill level, there is a place for everyone on our team.

Throughout the past few years, H₂Operations has transitioned from reworking a previous robot to creating a new one with recycled parts. Our system this year is made up of 6 subteams; Electrical, Float, Marketing, Mechanical, and Software Cameras and Software Code. We started our season earlier this year to introduce new members to our programs and allow all team members to gain hands-on experience with every level of production, from prototyping, building, to programming. We attached a claw to grip coral species and lobster pots more efficiently, a downward facing camera to aid in tasks like flying the transect, and a forward facing camera to help with visibility of invasive crabs. We aim to create a robot that not only competes in the MATE ROV competition, but could effectively clean the oceans, especially in harsh environments. Our team has worked diligently this year to make a lasting positive impact in the waters around us.

We work hard to collaborate on any issues our team faces and work together to make sure we reach our full potential.

2. Project Management

i. Company Overview

Developing employee skill sets is at the heart of our company, with a strong focus on fostering problem-solving/critical thinking, communication, and teamwork/collaboration. This year, our company decided to design a new ROV modeled after previous robots. It utilized last year's design, but modified it based on what worked well and what didn't. Throughout the whole process of designing and building our robot this year, we faced challenges that required teamwork and communication to solve.

In order to strengthen our problem solving in our employees' skillsets, we significantly focused on our enclosures and minimizing leakage, as we experienced issues with leakage last year. This was a major growth opportunity in problem-solving and critical thinking — we were forced to analyze last year's failures and develop smarter solutions. Using that feedback, we modified the frame design, created a new tray design, acquired new leak-resistant Blue Trail penetrators, worked on a new gripper design, and upgraded from four thrusters to six to enhance our robot's speed and capabilities. Working through these challenges grew our team's ability to think critically and turn setbacks into improvements.

To enhance our communication as our second focus, we had bi-weekly leadership meetings to ensure all team members are aware of our progress. In the past, we struggled with having only one person know an important skill, and issues would arise when they graduated. This represented a clear growth opportunity — poor knowledge-sharing was holding our company back. To combat this, we introduced subteams so each member could dedicate their time to their passions and become an expert in their field. Communication between subteams was particularly necessary as we reviewed last year's problems and determined how to fix them. We started our season earlier, where leadership led workshops on CAD, soldering, and safety. These changes built a stronger culture of consistent communication that allowed our entire company to grow together.

Organization was also a major point of growth and a key opportunity to develop teamwork and collaboration. This was our third focus. In past years, our workspaces were disorganized, tools and supplies went missing, and our digital spaces were a mess. We spent time organizing our online presence, on Social Media and our Google Drive, to efficiently produce our robot and track documentation with ease. We continued using our Google Sheets to-do list, due to previous success with it, to build strong organizational habits and reorganize our operations. This promoted teamwork and collaboration as we pooled our knowledge to solve tasks and worked together to remain organized.

Throughout our entire season, communication, organization, and problem solving have been key traits within our company, as we needed to be clear and organized in our dialogues to create the best robot possible and solve any occurring issues. These changes enabled us to function more effectively, increasing productivity, efficiency, and collaboration, and proved that growth in each of these three skillsets directly strengthens our company as a whole.

ii. Member Roles and Responsibility

CEO: Solena Ornelas Pagnucci '26

The CEO creates vision for the team and big picture. They give directions to the heads of departments to make this vision a reality. The CEO also organizes the team and creates systems for success, they also fix and navigate through larger problems.

COO: Charlotte Paul '26

The COO organizes the different subteams, coordinating with each head to put the robot together. They facilitate the testing of the robot and all poolside procedures. They also track all purchases that are made, making sure that the team uses their budget effectively and wastes as little as possible.

Electrical:

Electrical Head-

Delilah Davis '26
Electrical Engineer-
Lila Petry '28
Wallace Davis '28
Jorge De La Cruz '29
Dhruv Moorthy '26

Electrical designs the inner workings of the robot, and are responsible for providing power to the thrusters, camera, and gripper. Electrical includes wiring, soldering, and problem solving.

Mechanical:

Mechanical Head-
Felix Farkas '26
Mechanical Engineer-
Tayler Brewer '29
Abe Erlinger '28
Theo Hirsch '29
Linus McMullan '29
John Campoverde '29
Jayden Flores '29

Mechanical designs the frame, and any other pieces/props the team needs using Onshape, laser cutters, 3D printers, and other mediums when necessary.

Software:

Code Head-
Paige Randell '26
Code Programmer-
Zoe Mensah '29
Camera Head-
Tegan Druger '27

Cameras consist of uploading software using a raspberry pi system to receive live camera feed and wiring the camera systems. Code consists of coding the thrusters and grippers using Arduino and Python coding languages.

FLOAT:

FLOAT Head-

Krysi Aguilar '27

FLOAT Engineer-

Carmen Connor '27

Scarlett Mosquera '28

Selene Gutierrez '28

Sienna Holt '27

FLOAT is a sub-team that combines all aspects of engineering—coding, mechanics, and electronics in creating the FLOAT, a vertical autonomous robot

Marketing:**Marketing Head-**

Naia Trukenbrod '26

Marketing Member-

Shriya Chaudhari '28

Khaliah Lastic '28

Marketing creates and designs the merchandise (sweaters, shirts, stickers, logo), poster, presentations, and handles all outreach, documentation, organization, and submission. We manage social media, take photo and video documentation, and ensure that the team gets what they need with judges, administration, coaches, and mentors.

iii. Project Planning and Time Management

Time Period							Progress
September	M	T	W	TH	F	S	We kicked off our season in mid-September with an increase in membership. To bridge any knowledge gaps, we held workshops about useful skills for members to know, such as CAD, soldering, and safety. We also went over the feedback and ideas we wrote down at the end of last season to plan what changes we wanted to make for this season and form goals for our season.
	1	2	3	4	5	6	
	8	9	10	11	12	13	
	15	16	17	18	19	20	
	22	23	24	25	26	27	
	29	30					
October	M	T	W	TH	F	S	
			1	2	3	4	
	6	7	8	9	10	11	
	13	14	15	16	17	18	
	20	21	22	23	24	25	
	27	28	29	30	31		

<table><tr><th>November</th><th>M</th><th>T</th><th>W</th><th>TH</th><th>F</th><th>S</th></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td></tr><tr><td></td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td></td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td></tr><tr><td></td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td></tr><tr><td></td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td></tr><tr><th>December</th><th>M</th><th>T</th><th>W</th><th>TH</th><th>F</th><th>S</th></tr><tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td></td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td></tr><tr><td></td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td></tr><tr><td></td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td></tr><tr><td></td><td>29</td><td>30</td><td>31</td><td></td><td></td><td></td></tr></table>	November	M	T	W	TH	F	S							1		3	4	5	6	7	8		10	11	12	13	14	15		17	18	19	20	21	22		24	25	26	27	28	29	December	M	T	W	TH	F	S		1	2	3	4	5	6		8	9	10	11	12	13		15	16	17	18	19	20		22	23	24	25	26	27		29	30	31				In November and December we worked on designing our frame, electrical system, and integrating our thrusters into our system. We also had a school wide assembly to teach the school about our team and what MATE is. It was also a great opportunity for outreach as the rising freshmen were able to learn about ROV.
November	M	T	W	TH	F	S																																																																															
						1																																																																															
	3	4	5	6	7	8																																																																															
	10	11	12	13	14	15																																																																															
	17	18	19	20	21	22																																																																															
	24	25	26	27	28	29																																																																															
December	M	T	W	TH	F	S																																																																															
	1	2	3	4	5	6																																																																															
	8	9	10	11	12	13																																																																															
	15	16	17	18	19	20																																																																															
	22	23	24	25	26	27																																																																															
	29	30	31																																																																																		
<table><tr><th>January</th><th>M</th><th>T</th><th>W</th><th>TH</th><th>F</th><th>S</th></tr><tr><td></td><td></td><td></td><td></td><td>1</td><td>2</td><td>3</td></tr><tr><td></td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr><tr><td></td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr><tr><td></td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr><tr><td></td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td></tr></table>	January	M	T	W	TH	F	S					1	2	3		5	6	7	8	9	10		12	13	14	15	16	17		19	20	21	22	23	24		26	27	28	29	30	31	After designing our first prototype, we went back and refined the frame design to ensure that all components were best placed and would enhance our robot.																																										
January	M	T	W	TH	F	S																																																																															
				1	2	3																																																																															
	5	6	7	8	9	10																																																																															
	12	13	14	15	16	17																																																																															
	19	20	21	22	23	24																																																																															
	26	27	28	29	30	31																																																																															
<table><tr><th>February</th><th>M</th><th>T</th><th>W</th><th>TH</th><th>F</th><th>S</th></tr><tr><td></td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td></td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td></tr><tr><td></td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td></tr><tr><td></td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td></tr><tr><th>March</th><th>M</th><th>T</th><th>W</th><th>TH</th><th>F</th><th>S</th></tr><tr><td></td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td></td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td></tr><tr><td></td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td></tr><tr><td></td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td></tr><tr><td></td><td>30</td><td>31</td><td></td><td></td><td></td><td></td></tr></table>	February	M	T	W	TH	F	S		2	3	4	5	6	7		9	10	11	12	13	14		16	17	18	19	20	21		23	24	25	26	27	28	March	M	T	W	TH	F	S		2	3	4	5	6	7		9	10	11	12	13	14		16	17	18	19	20	21		23	24	25	26	27	28		30	31					In February we finalized our design for our robot and started the final build after many adjustments. We also thought about our tether and strain relief. In March we combined all components, including the enclosures, the frame, the gripper, the thrusters, and the cameras. At the same time the Float team was working hard to complete the float and practice.							
February	M	T	W	TH	F	S																																																																															
	2	3	4	5	6	7																																																																															
	9	10	11	12	13	14																																																																															
	16	17	18	19	20	21																																																																															
	23	24	25	26	27	28																																																																															
March	M	T	W	TH	F	S																																																																															
	2	3	4	5	6	7																																																																															
	9	10	11	12	13	14																																																																															
	16	17	18	19	20	21																																																																															
	23	24	25	26	27	28																																																																															
	30	31																																																																																			
<table><tr><th>April</th><th>M</th><th>T</th><th>W</th><th>TH</th><th>F</th><th>S</th></tr><tr><td></td><td></td><td></td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td></td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td></tr><tr><td></td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td></tr><tr><td></td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td></tr><tr><td></td><td>27</td><td>28</td><td>29</td><td>30</td><td>1</td><td></td></tr></table>	April	M	T	W	TH	F	S				1	2	3	4		6	7	8	9	10	11		13	14	15	16	17	18		20	21	22	23	24	25		27	28	29	30	1		As we got closer to our competition date we knew that we had to test in the pool. We built all the necessary props in order to test and headed over to the pool at Underwater Safaris, since our school doesn't have a pool. There we were able to practice the tasks, deploy the float, and check if there was any water leakage.																																										
April	M	T	W	TH	F	S																																																																															
			1	2	3	4																																																																															
	6	7	8	9	10	11																																																																															
	13	14	15	16	17	18																																																																															
	20	21	22	23	24	25																																																																															
	27	28	29	30	1																																																																																

3. Engineering Design Rationale

i. Design Evolution

Our focus when creating the new frame was the switch from four thrusters to six thrusters. Our initial design for six thrusters was to have four horizontal thrusters at 45 degree angles to the robot, and two vertical thrusters. But, due to the weight of our robot in past years we decided instead to have four vertical thrusters and two horizontal thrusters. This placement optimizes our

ability to move underwater. To create space for the horizontal thrusters we chose to raise the enclosures and place them underneath. The vertical thrusters were moved from the enclosure supports to the four corners of the robot. Another goal we had for the frame was to remove as much 3D printed material as possible. For example, last year our enclosures were secured with 3D printed clamps which screwed into 3D printed spacers, but this year we took the side profile of the clamp and laser cut five out of delrin, effectively recreating the clamp shape. These were then secured to the enclosure supports using an M6 screw on each side. Despite the two new thrusters we wanted to make sure the robot was as compact as possible. We did this by moving the enclosures much closer together, and raising them as little as possible while still being able to safely attach the horizontal thrusters underneath. Finally, we redesigned our strain relief system to be a more structured component on the robot. Our past robots had strain relief that was just rope wrapped around the tether and tied to the frame, but this year we are using a cable gland attached to a pvc pipe which goes through holes in the tops of the enclosure supports.

ii. Mechanical Rationale

We have six thrusters, four vertical and two horizontal, all of which are spaced evenly across the robot to ensure even propulsion. There are four vertical thrusters placed at the four corners of the robot. There are also two horizontal thrusters that are placed underneath the robot, to provide ample waterflow. We raised the enclosures as little as possible while still being able to safely place and operate the horizontal thrusters, so as to not move the center of mass of the robot too much. The frame itself has many holes in the sides and bottom to ensure that all thrusters receive enough waterflow to run smoothly. The enclosure clamps were switched from being 3D printed out of PLA material to Delrin because PLA material has a tendency to take on water each time it's submerged, which affects buoyancy. We could not remove all 3D printed materials, as the arm for the gripper and wall supporting the downward facing camera are too complicated to laser cut. Despite not all 3D printed material being removed, we have drastically reduced our use of it which helps stabilize buoyancy greatly. Last year our robot was unnecessarily wide, wasting material and creating an odd center of mass. This year, we placed our enclosures as close together as possible to have a more centered center of mass, and has the added benefit of using less materials. Our strain relief features a cable gland attached to PVC pipe which runs through the tops of the enclosure supports. This design is much safer and far more efficient than our previous strain relief designs.

iii. Software Rationale

This year, the software design for the BlueRobotics thrusters is coded to 6 thrusters that move in the direction of: Up, Down, Forward, Backward, Pitch, and Yaw. Each thruster has a minimum PWM of 1350, and a maximum PWM of 1650. The thrusters are coded through Python 3.0 where the PWM and directions are defined, and then they are connected with an Arduino Mega in order to send the direction signal to the robot in order for it to move. In previous years, we

have had only 4 thrusters, but in order to move faster through the water we have added two extra thrusters. The gripper is from ServoCity and it is attached to the robot. The gripper opens and closes with the PlayStation 4 controller, which is also coded through Python 3.0 and Arduino. This year we are using two external cameras from Deepwater Exploration, one facing downwards and one facing forwards. The cameras connect to a model B raspberry pi stationed in the dry enclosure, which is running a DWE operating system flashed by image onto a 64 GB SD card. The raspberry pi then communicates via ethernet with a poolside computer, setting up a local server where camera settings can be altered. The server then sends the footage from the cameras to Deepwater Exploration's application, Discovery, where the cameras can be streamed or recorded.

12 volts of power are sent from a poolside power box into the camera's enclosure, where a stepdown converter from Go Builda then takes that voltage down to five, which is what powers the camera system. 12 volts rather than 5 are sent initially in order to prevent power dispersion which may otherwise affect camera performance.

New additions this year are the DWE operating system, which allows for simpler, more reliable and more compatible camera streaming, and cobalt connectors on all penetrators, which enable easier transportation as well as less likelihood of water leaking in.

iv. Trouble Shooting and Testing Techniques

In preparation for the MATE ROV Competition, troubleshooting and testing focused on preventing common failure points. Thrusters were tested for correct direction and response to avoid control errors and uneven movement by seeing which direction air came out of the thruster. ESCs were reinforced with 3D-printed mounts to prevent wire strain and physical damage, which can cause sudden motor failure. All electrical connections were checked and secured because loose or partial connections lead to power loss or intermittent signals. Full system tests under load were performed to detect voltage drops, overheating, and control lag that don't appear in isolated testing. When issues occurred, the system was tested component-by-component and retested repeatedly until the specific source of the malfunction was identified. One time an issue occurred was when a team member accidentally shifted various wires in the arduino, having messed up the system; in order to ensure this wouldn't happen again, we made the following rule: access to the ROV and its systems were also limited to specific team members to prevent accidental changes or wiring errors during handling. Another issue we ran into was having connections that were loose, needed resoldering, or were old and faulty. This meant we had to do a lot of soldering and needed to teach the younger team members how to solder. Fixing these connections provided a great learning opportunity and even great team bonding. These challenges ended up reducing future avoidable mistakes and improved overall reliability.

4. Mechanical Components

i. Frame

Nemo's frame is made out of two materials: pink acrylic and Delrin, a high performance thermoplastic polymer. The frame is held together using M6 screws and bolts, and M3 screws and bolts. L brackets are used to keep pieces at 90 degree angles. The enclosures are secured to the robot using velcro. Nemo features a pincer claw attached to an arm 3D printed from PLA which screws into the bottom piece of the frame using M6 screws. The arm also has a place for the forward facing camera to screw in, and is angled towards the claw to provide a clear field of view. Next to the claw is the wall where the downward facing camera is screwed in. The wall is 3D printed out of PLA and screws into the bottom piece of the frame using M6 screws.

ii. Propulsion

Nemo features 6 T200 Thrusters from Blue Robotics. Four of the thrusters, two on each side of the robot, are oriented vertically. The other two thrusters are underneath the robot and are oriented horizontally. Every thruster has a shroud to protect motors from being damaged from debris.

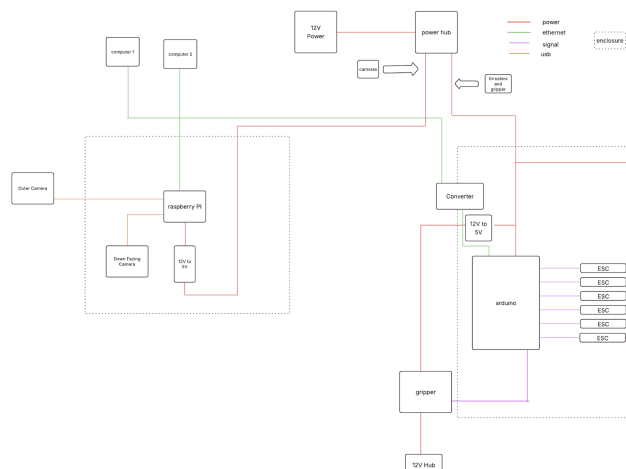
iii. Buoyancy

Nemo has two enclosures which house all of the electronics; this is done to evenly distribute weight across the robot to have a center of mass as close as possible to the center of the robot. Also, the two enclosures distribute buoyancy across the robot instead of a lot in one central area. Weights are added as needed to counteract positive buoyancy.

iv. Tools

To cut out the acrylic we used a Glowforge laser cutter, and to cut out the delrin we used an Xtool laser cutter. All of our 3D printed elements were created with PLA material on Prusa MK4s and Prusa Minis.

5. Electrical Systems



i. Topside Control Unit

Nemo's 20m long tether contains 2 Cat 5 cables from Blue Robotics and a power cable from Blue Trails Engineering. The two cat 5s connect to our computer, while the power cable connects to our poolside electrical box. There is a secondary power switch on our poolside, as well as a volt/ammeter, a second arduino to receive float transmissions, and a buck converter to turn the 12 v coming into the box into the 5v the Arduino requires. There is also a monitor on our poolside cart which runs our code for our thrusters and cameras and provides our camera footage. Our driver watches the screen while using a video game controller to control our thrusters and gripper. There are also electrical components on our poolside box that we prefer to keep outside of the water and our enclosures. It gets its power from our power box through a multi-fuse system, and a cat6 cable to our robot. The reason we place the electrical equipment in a box is to protect it from any water that may splash out of the pool. The water is a huge risk to any of our electrical equipment and the box we 3D printed is crucial for its protection.

We prioritize our safety by trying to make sure that the wires coming out of our poolside box by making sure the wires don't become too long or tangled. Before testing in the water, we go through an extensive checklist to actually make sure that we are properly prepared for testing. This includes making sure that the code is there, checking the camera feeds and making sure the tether is undone. We also assign people to have specific poolside roles so that every part in the poolside process is accounted for. Our tether has a tether manager to make sure that the wire doesn't experience strain while also limiting its intended traveling area.

ii. Onboard/Underwater Control Unit

Our robot, Nemo, has 6 thrusters. There are two going up, two going down, one going left and one going right. In previous years, we had only four thrusters with two going up and two going down. Since we wanted to have more maneuverability this year, we decided to add two more this year.

The electrical system for Nemo was designed to keep the key principles of reliability and consistency in mind. Safety is especially a big concern for us because we have experienced issues of leakage previously due to the endcaps of the enclosure not being sealed tight enough. Water leakage inside the enclosures places the electronics at a high risk of severe damage. Knowing this, we began this year testing different methods for sealing.

We are continuing to use XT30, 60 and 90 connectors in replacement of the Anderson connectors. We found that in previous years, using XT cables created stronger connections, and has less risk of disconnection.

Another issue that we have faced in previous years is spaghetti wiring inside the enclosure. We realized that if a leakage were to happen, having a system with lengthy and tangled wires makes the system have a high risk to short-circuit due to the proximity of the wires. Making sure the wires are shorter and thereby more neat reduces the risk of such a thing happening.

In past years, we had issues with soldering wires. The soldered connections were not strong enough. Specifically, the ESC (Electronic Speed Controller) wires would often disconnect. We decided to improve upon this by holding soldering workshops for any newcomers to ROV. By doing so, the connections with our ESC's are much more secure, making sure that our work process is more efficient. Each of our ESC's are attached to an arduino which is powered through a USB. The enclosure is placed upon an enclosure tray, which is 3D printed by CAD (computer automated design) software. This helps us secure all the electrical equipment inside the enclosure.

In the second enclosure, we have a raspberry pi connected to three Explore HD cameras, which have a range of 400m-1300m . These cameras were purchased from Blue Trail Engineering, and are mounted at various points on the ROV. One is to the left of the enclosure and one is below. Enclosure 2 and enclosure 1 receive 12V from the power box. Then we step it down to the 5V using a buck converter to input power into the Raspberry Pi. This sends the camera data back to the drivers via a 2nd cat 5 cable. There is a 20 A fuse on the power line into enclosure 1, and a 10 A fuse on the power line into enclosure 2, which adds an additional layer of protection to our system.

6. Code Management

i. Cameras/Vision Systems

H₂Operations uses cameras that are connected to a model B raspberry pi. They run on the Deepwater Exploration operating system (DWEOS). This software is more compatible than systems of previous years as DWEOS was designed specifically for the Deepwater Exploration cameras our team uses. The operating system was flashed by image to an 64 GB SD card from Amazon Basics which was then inserted into the raspberry pi. The raspberry pi sends the data via an ethernet cable to a poolside computer, when doing this the raspberry pi then sets up a local server. This allows for direct communication between the raspberry pi and the poolside computer. This server also shows if the cameras have a stable connection and allows for their setting to be altered if needed to. The local server then sends the camera to a Deepwater Exploration application, Discovery, this is where the cameras can be both streamed and/or recorded. The cameras receive power via a CAT6 cable, which is attached to a Go Builda stepdown converter, bringing power to the cameras down from 12 volts to 5 volts, as 5 volts is the maximum amount of power the cameras can handle. Our team opted to send 12 volts of power from the poolside power box initially in order to prevent power dispersion as the electricity moves down the tether from affecting the camera's performance.

ii. Thruster/Claw Systems

The thruster and claw code are programmed through Arduino and Python. There are Six BlueRobotics T200 thrusters coded through Python 3.0 with individual directions: Up, Down, Forward, Backward, Pitch, Yaw. They have a minimum PWM (pulse with modulation) of 1350

and a maximum of 1650. The ServoCity thruster is also programmed through Arduino and Python with a set range of 0-180 degrees.

7. Safety

i. Company Safety Philosophy

It is a priority for H₂Operations to ensure that no individual is harmed during the development of our ROV. We would also like to ensure that our product mitigates harmful impact on the environment, and for this reason, we use acrylic and delrin for our robotic frame. Acrylic is a sustainable material and both acrylic and delrin are recyclable.

ii. Training

Underwater robotics companies often require their individuals to do advanced processes such as soldering, drilling, and using epoxy. For these reasons, we make sure that each individual has adequate training to do these tasks safely and effectively. It is the responsibility of our experienced mentors and heads of each department to instruct the inexperienced team members on the procedures mentioned above. This includes but is not limited to wearing goggles, cleaning your equipment regularly, and making sure you have constant focus on the current task.

Mentors and heads will often demonstrate an example of how to do a certain task, then allow the student to do it themselves while supervising and ensuring proper safety. Only after a few times of completing the task successfully under supervision is the person fully trained. We also have labeled bins with places to put each specific tool so that we know where something is when we need it.

iii. Vehicle Safety Features

One major preventative measure taken to ensure that the electrical system does not overload is programming the 'X' button on our PlayStation 4 controller to stop all thrusters in case the thrusters do not shut off. Our robot has tightly sealed enclosures to prevent any interaction between the water and the electrical system of our ROV. The robot also has a tether of sufficient length to make sure that the wire doesn't experience strain while also limiting its intended traveling area.

Our current procedure follows all safety features in the pool. We have a tether manager during pool testing so that the tether doesn't get tangled. Our ROV also has rounded corners, to prevent individuals from injuring themselves. We make sure that all our screws are locktight to minimize their chances of releasing. We also have guards for our thrusters to prevent anything from getting inside.

Our wires are kept as short as possible as to avoid any tangling, and we have designed a case to act as a safety belt over the PCB to protect it from damage. We also designed an enclosure tray which holds our Arduino and all the ESC's attached to it to ensure that the electronic system isn't free-floating.

iv. Operational and Safety Checklist

H₂OperationsSafety Checklist 2026

Pre-Power (Pilot, Co-Pilot, and Desk Crew)

- ☐ Area is clear and safe (no tripping hazards or obstructions)
- ☐ All team members are wearing safety glasses
- ☐ Tether is laid out on the deck and is free of damage
- ☐ Tether is connected and secured to our power system
- ☐ Tether is connected to strain relief and secured to ROV
- ☐ Verify electronics housing is properly sealed and fasteners are tightened.
- ☐ Visual inspection of electronics for damaged wires or loose connections
- ☐ Vacuum test electronics housing
- ☐ Vacuum port is securely capped
- ☐ Thrusters are free from obstructions

Vacuum Test (Desk Crew)

- ☐ Verify electronics housing and CEH are properly sealed
- ☐ Connect vacuum pump to the electronics housing and CEH
- ☐ Vacuum down the electronics housing and CEH to -10 Hg and verify they hold this pressure for 10 minutes.
- ☐ Remove vacuum pump and securely cap vacuum port
- ☐ Return vacuum hand pump to case

Power-Up (Pilot, Co-Pilot, and Desk Crew)

- ☐ Control computers up and running
- ☐ Ensure deck crew members are attentive
- ☐ Co-pilot calls out, "power on!"
- ☐ Co-pilot calls out, "performing thruster test"
- ☐ Test thruster and verify thrusters are working properly
- ☐ Ensure cameras are positioned correctly
- ☐ Test electrical and pneumatic components that require pilot input

Impact and Test Pneumatic System (Pilot, Co-Pilot)

- ☐ Verify all pneumatics lines on the ROV are properly connected to the MATE air supply
- ☐ Verify that the compressor is switched on
- ☐ Adjust pressure regulator to 40 PSI
- ☐ Activate pneumatic system and open main valve
- ☐ Verify there are no leaks and pneumatic lines are securely connected while under pressure

- ☐ Activate pneumatic tools and verify the pressure returns to 40 PSI after the tool is shut off.

ROV Launch (Pilot, Co-Pilot, and Desk Crew)

- ☐ Deck crew members handling ROV call out, "Hands On"
- ☐ Carefully place ROV in the water
- ☐ Check for bubbles
- ☐ Visually inspect for water leaks
- ☐ If there are any large bubbles, pull to surface immediately and proceed with Leak Detection Protocol
- ☐ If no issues are detected call out, "prepare to launch"
- ☐ Deck crew members handling ROV remove their hands from the vehicle and call out, "hands off!"
- ☐ Co-Pilot calls out "thrusters engaged" and pilot begins mission

ROV Retrieval (Pilot, Co-Pilot, and Desk Crew)

- ☐ The pilot calls out, "ROV surfacing"
- ☐ Desk Crew calls out, "ROV on surface. Disable thrusters"
- ☐ Co-Pilot calls out, "Thrusters disabled"
- ☐ Deck Crew call out "Hands on," and remove ROV from water
- ☐ Co-pilot calls out, "safe to remove ROV"
- ☐ After securing the ROV on deck, deck crew calls out "ROV secured on deck"
- ☐ Team begins demobilizing

Leak Direction (Pilot, Co-Pilot, and Desk Crew)

- ☐ Immediately power down the ROV and remove the ROV from the water if a mission is occurring
- ☐ Visually inspect ROV to identify the source of the leak. Do not disassemble any part of the ROV until the source of the leak is detected.
- ☐ Install pressure testing equipment and use soapy water to verify the source of the leak.
- ☐ Create a plan and repair the leak.
- ☐ Check all systems for damage and verify proper operation
- ☐ Document the source and cause of the leak and detail the corrective action and design changes made.

Loss of Communication (Pilot, Co-Pilot, and Desk Crew)

- ☐ If no communication, power down ROV, retrieve via tether
- ☐ If communication restored, confirm there are no leaks, resume operations
- ☐ If communication has not been restored, begin troubleshooting procedures and isolate the issue. Determine if the issue is with hardware or software.
- ☐ Document the problem and detail the corrective actions made to solve the problem.

Pit Maintenance (All Team Members)

ii. Budgeting/Cost Chart

School Name: Francis W. Parker				Reporting Period			
Coaches: Elizabeth Druger, Brianna Ifft, Xiao Zhang, Jasmine Priatna, Julia Ehrhardt					From	9/15/25	
Funds					To	5/13/26	
Date	Type	Category	Expense	Description	Source/Notes	Amount	Running Balance
10/6/2025	Purchased	Electrical	Enclosure	Bulkhead Enclosures, Back plates, 4 Thrusters	Used for enclosure	\$ 3,000.00	\$ 3,000.00
10/16/2025	Purchased	Robot Materials	Sensor	IP68 Underwater Ultrasonic Obstacle Avoidance Sensor (6m, UART)	Ultrasonic Sensor	\$ 64.00	\$ 3,064.00
12/8/2025	Purchased	General	Merch	32 Shirts and 11 Hoodies		\$ 1,379.22	\$ 4,443.22
1/28/2026	Purchased	Prop Materials	PVC	3 20' 1/2 in PVC Pipes	Porter Pipe Supply	\$ 82.22	\$ 4,525.44
2/4/2026	Purchased	Robot Materials	Connectors	10 T connectors and 10 L connectors	Blue Trail Engineering	\$ 234.00	\$ 4,759.44
3/16/2026	Purchased	Electrical	Soldering	Solder Tips Replacement	Tils Wall	\$ 23.98	\$ 4,783.42
4/1/2026	Purchased	General	Pool	Cost of Pool Rental	Pool Cost	\$ 700.00	\$ 5,483.42
5/7/2026	Purchased	General	Pool	Cost of Pool Rental	Pool Cost	\$ 450.00	\$ 5,933.42
	Purchased	General	GoPro	GoPro	GoPro for recording	\$ 205.00	\$ 6,138.42
						Total Raised	N/A
						Total Spent	\$ 6,138.42
						Final Balance	\$ 8,861.58

9. Float

i. Design Process

For our vertical profile this year we used our base design from last year. This includes the following: a clear, plastic waterproof container from BlueRobotics, a syringe pump, a 3D printed holder, a 3D printed cone at the top of the FLOAT,

This year we wanted to improve our previous model. The first thing we did at the start of ROV this year was test out different non-water absorbent filaments that we could use when printing our cone. This would help with making sure that there were no air bubbles to enhance the precision of reaching neutral buoyancy.

Another one of our adjustments included fixing our problem of constantly having to unscrew and open our enclosure to change code. This year we decided to re-program our float code to the Arduino Cloud Agent. Arduino Cloud is an all-in-one IoT solution that allows for us to upload code via Wi-Fi, a solution to our problem of constantly reopening our enclosure. Arduino Cloud also allows us to share our projects with each other, allowing for multiple people to work on code at once. With this new change came difficulties. We had to rewrite and adjust our code on the new platform and rewire our entire robot. Initially, we struggled with combining the code for our transmitter, receiver, stepper motor, and pressure sensor. This took a lot of trial and error to finally achieve a working code.

ii. Software Organization

The FLOAT team experienced some issues with organization of software early on. We resolved this by switching our coding program to a brand new one: Arduino Cloud Agent. On the Arduino Cloud Agent, the code is written on files named “Sketches,” which we are able to type code into. These sketches can be given names, and we used this to our advantage to designate certain sketches for our main code and testing codes. Because our boards — the Arduino UNO R4 Wifi, and originally the Arduino MKR Wifi 1010 — have wifi connectivity, they can be connected to the cloud.

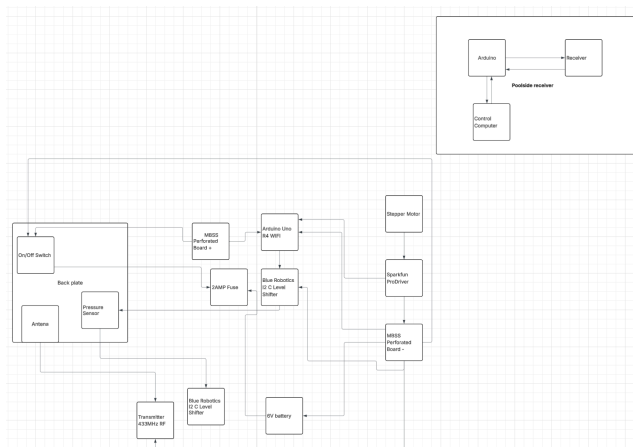
In the Arduino Cloud Agent menu, we can give our boards names and connect them to a Sketch of our choice. This lets us know what board we were using last and what code works with it. The Arduino Cloud Agent menu also allows us to easily see our boards' status, where online means it's connected to Wifi, and offline means it is not. Our switch from Arduino to Arduino Cloud Agent allowed us to be able to upload programs wirelessly to our boards. Knowing all of this information is critical to make sure our FLOAT is working properly.

iii. Code

This year, we are using the Arduino Cloud Agent, a C++ language platform. We ordered our pressure sensor and transmitter from BlueRobotics, our stepper motor and Arduino MKR Wifi 101 board from Arduino, and our SparkFun ProDriver board from SparkFun Electronics. The Arduino MKR Wifi 101 board contains the code we write, and the SparkFun controls the stepper motor. The BlueRobotics transmitter is for collecting the data package of pressure, depth, and time. The receiver from Arduino is connected to our laptop and receives the data that the transmitter sends.

We started our code with adding several libraries to add functionality: The BlueRobotics MS5837 Library adds support for the sensor we use, the RH_ASK Library provides features that makes using our transmitter easier, and the SparkFun ProDriver Arduino Library gives us more control over our stepper motor. After inserting libraries and defining values, our code then starts with a 5 second delay right before the rest of the system turns on. At this moment, the transmitter turns on to collect pressure, depth, and time data. We have coded the stepper motor to follow either 1 or 0, 1 being the pump expelling water, and 0 being the pump intaking water. The stepper motor first spins at 0 to intake water. After the FLOAT has been turned on and has reached a certain depth, it will stop, configure a package of data, and transmit the data to the receiver. Then, the stepper motor is coded to spin the opposite way at 1 to release the water to reach positive buoyancy, pushing the FLOAT upward towards the surface of the water.

Iv. Circuit Diagram



10. Conclusion

i. Acknowledgements

We would like to emphasize our immense gratitude for our lead mentors, Elizabeth Druger and Brianna Ifft, and our additional mentors Xiao Zhang, Jasmine Priatna, Nora Wiltse, David Anderson, and Julia Ehrhardt for their compassion and dedication to us and our team. We are eternally grateful for the Francis W. Parker Robotics Endowment Fund that is the fundamental basis of our company's function. Additionally, we would like to thank Mate II for hosting the MATE ROV Competitions again this year.

ii. References

1. Blue Robotics
2. MATE ROV
3. Top Tech Boy
 - a. Coding (Python & C++ languages) learning tutorials
4. Onshape
 - a. CAD learning tutorials