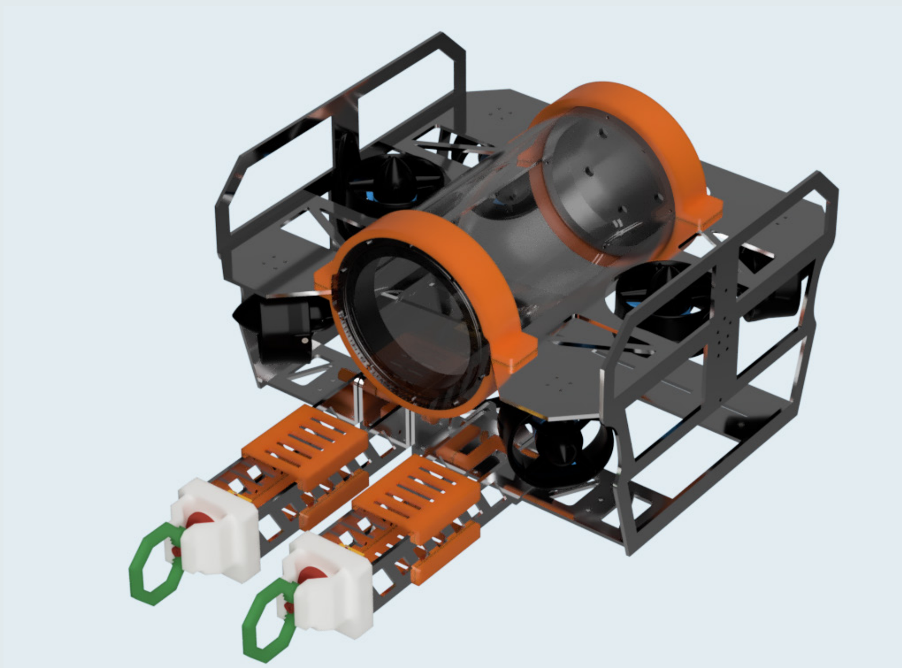
Robert College Makers

Salutis 1.2

2022 Technical Report



RCMAKERS

YOK DEME, KENDİN YAP!

Members of RC Makers

Ufuk Çetiner	CEO
Efe Özbal	Head of Design
Batuhan Kurtçu	Head of Programming
Can Duru	Electronic Engineer
Alya Kurt	Electronic Engineer
Pamir Oral	Mechanic Engineer
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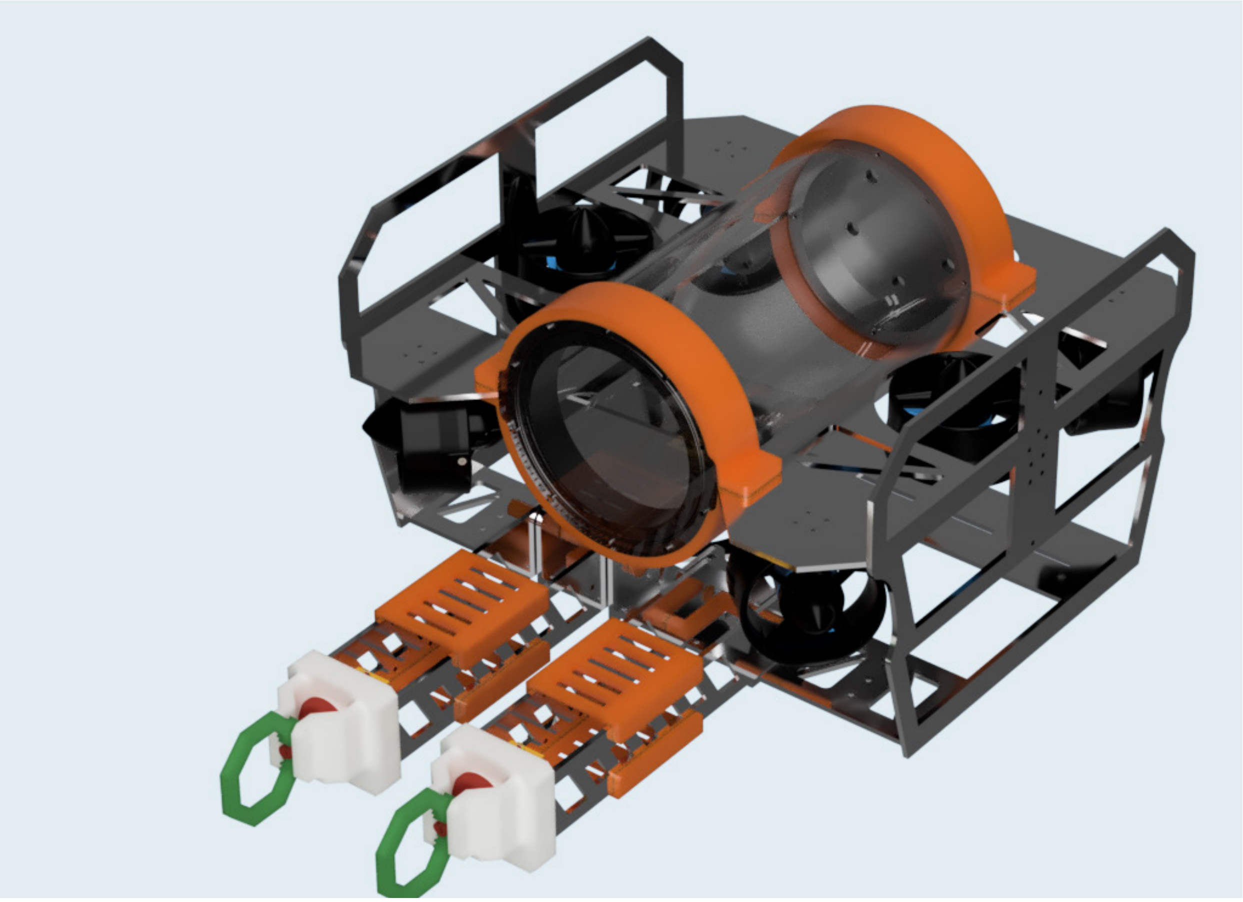
Abstract

The Marine Advanced Technology Education (MATE) Center has published several proposals to address global issues including the loss of coral reefs, plastic pollution, and the contamination of waterways. As a response our team, RC Makers, have assembled a ROV team to design and engineer a ROV that will be able to assist the solution to these issues. We call it “Salutis”.

We are constructing Salutis as a specialized team consisting of Robert College members, gathered under the name “RC Makers”. Salutis is designed to carry out many different tasks, equipped with the ability to move in all 3 dimensions freely, grab and rotate outside objects. Our ROV is equipped with many sensors(such as leak sensor, and depth sensor) to aid in many missions.

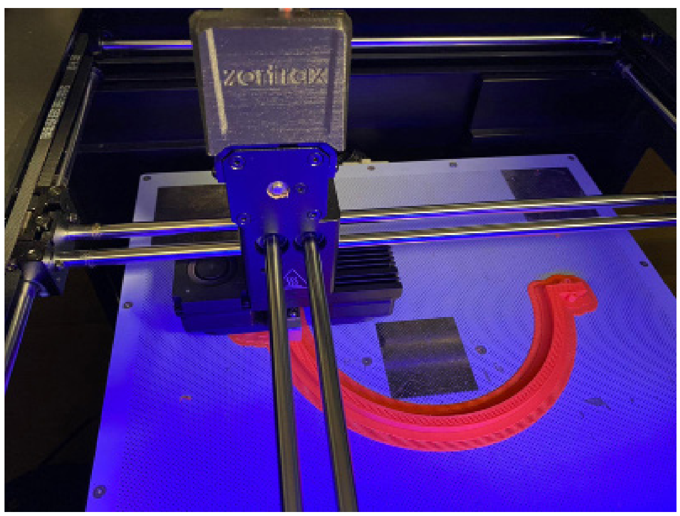
This document provides an overview of the design rationale, construction, and functionalities of our ROV that lead up to the final product.



Design Rationale

Material Choice

While it was not our main method, 3D printing played a big part in the production of the parts of Salutis. 3D printers are easy to use and they can produce precise parts that are in the exact shapes and proportions that we need. They also don't use too much material, it is an efficient solution compared to many others. However, it is important to note that 3D printing requires a lot of time, and can only produce plastic-based materials, it is far from ideal.



Propulsion

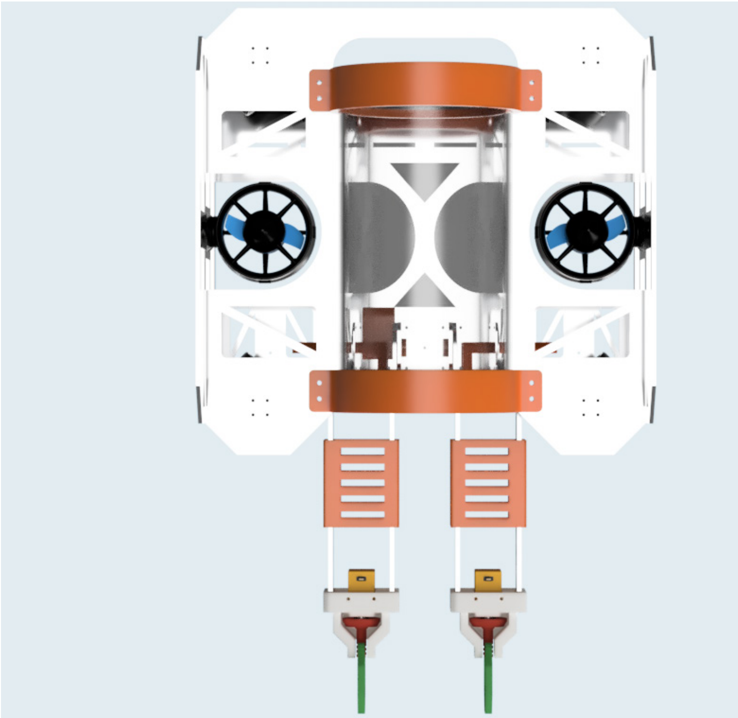
Salutis is equipped with 6 thrusters, adjusted in a configuration to allow for 3-dimensional motion. Two thrusters are placed around the center of the ROV, both facing up for vertical motion, while the other four are placed around the center, each at 45 degrees for horizontal motion. The configuration of the thrusters is compatible with the gyro board we are using, and makes the control of the ROV easier. We are using T100 thrusters -which were purchased from BlueRobotics- as they are very effective and costly-efficient.

Buoyancy

When designing an underwater vehicle, one of the key goals is to keep the vehicle from sinking, and that is why these vehicles always require different methods to counteract the vehicle's weight, and one of the most energy-efficient ways of doing so is directly tied to the material that the vehicle is made of, as materials with very small densities help the vehicle have buoyancy. This is why Salutis makes use of a tube filled with air and a skeleton made up of 4mm aluminum. With these materials, we get a total of buoyancy in water equal to around 4kg.

Specific Buoyancy Calculations

Our team calculated the bouyant force acting uppon our robot by using the specs of our robot. The specs of the robot is as follows:
Length: 42.00 cm Width: 42.29 cm Height: 25.60 cm Mass: 7565 grams
Volume: 3.480L
Using the appropriate formulas our team calculated the bouyant force acting uppon the robot as 3455 grams. The net force acting upon our robot in water is approximately 40.32 N downwards. The robot sinks in water at an accelaration around 5.33 meters per second squared.

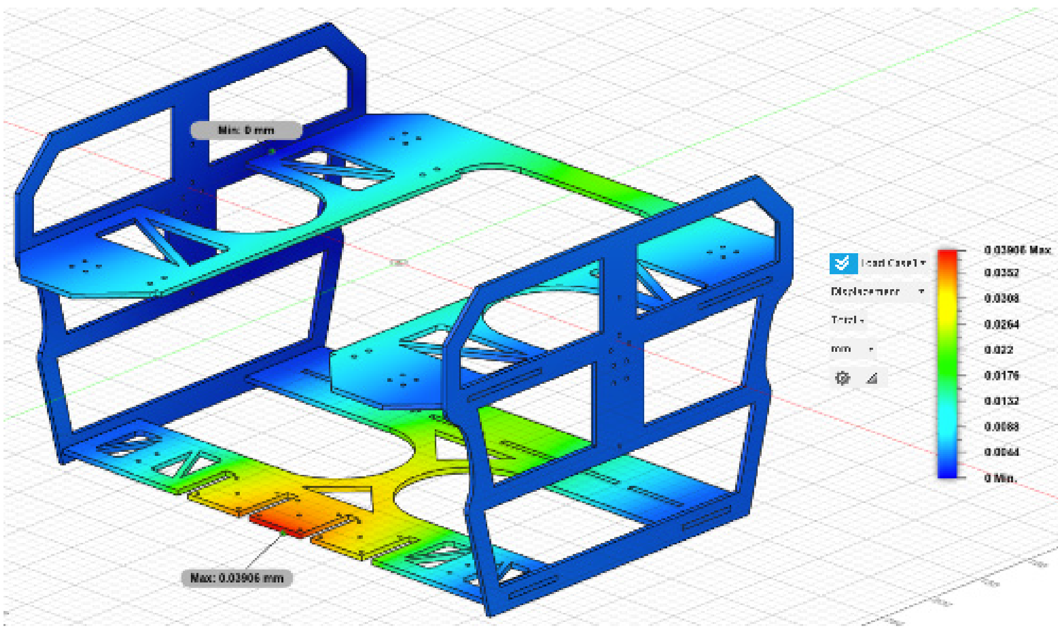


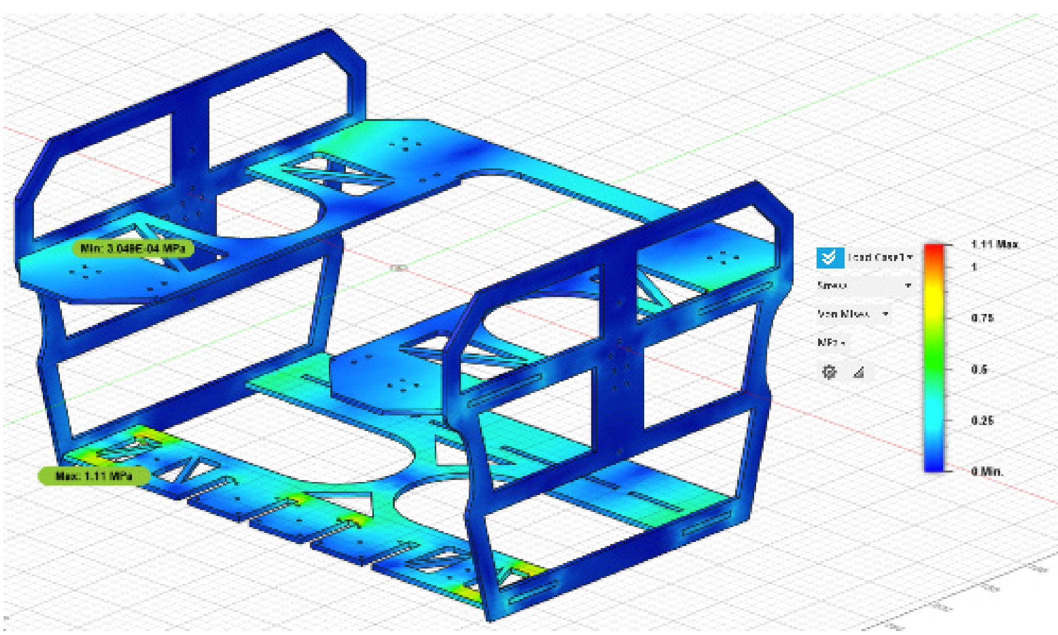
Preventing Sinking

Although Salutis uses a very light metal it still sinks in water. The T100 thrusters can have a thrust up to 23N and since we have 2 vertical thrusters we can balance the sinking motion by constantly running these 2 motors. However our team decided that this method of balancing would give the robot a very hard time navigating vertically since the vertical motors would be busy trying to keep the robot balanced. That's why our team decided to incorprate two strips of sponge under the robot that have a smaller density than water so that it neutralizes the downward net force without the use of constantly running the vertical thrusters.

Stress Test

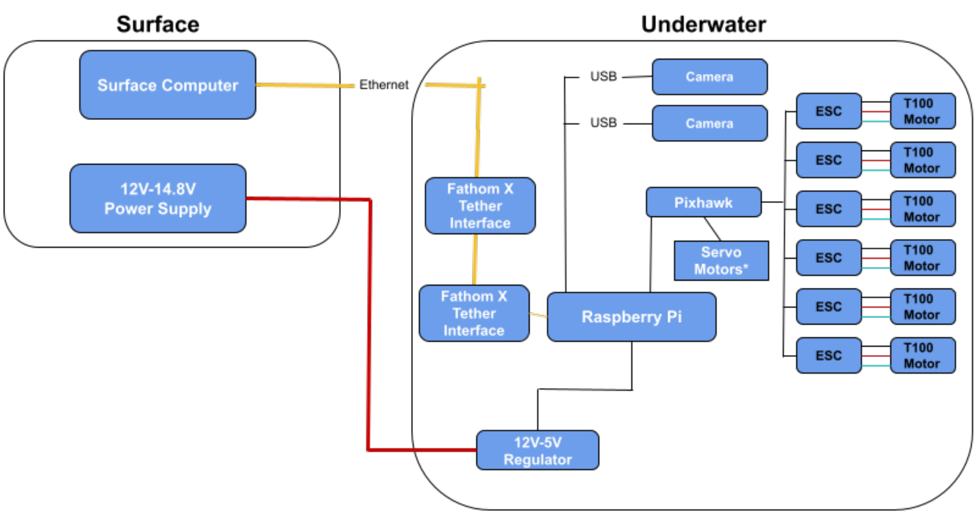
When designing the chassis for our ROV, it was crucial that our design would be able to maintain all of the weight on it without getting damaged in the process. It was also important to know how much outside stress our chassis would be able to withstand. That is why we need to know the amount of stress put onto each part of the chassis to understand whether the material we use will be able to support it or not. For this reason, we used computer simulated stress tests to calculate the stress and displacement on every part of the chassis.





Electronics

In our electronic system, the companion computer, Raspberry Pi 3, is the main component that connects every other component together. It is where we see the operation status, command the robot and monitor cruical values like depth or pressure. Pixhawk-the gyro board- is connected to the Raspberry Pi through USB. Via the information pixhawk recieves from Raspberry Pi it commands appropriate motors to get the desired motion the pilot wants. Raspberry Pi uses information from Pixhawk's gyroscope and leak sensor-which is used to detect any potential leaks to protect the electronic system- in order to control the ROV. Motors are connected to the pixhawk via ESCs. These 6 ESCs are powered by a Power Distribution Board. There are also servo motors connected to the pixhawk which are used in the manipulator that grabs outside objects. Cameras are connected to the Raspberry PI via usb cables and they stream footage to the surface computer. Raspberry PI is connected to FathomX Tether Interface boards before its connection with the surface computer. The FathomX Tether Interface boards provide high speed data transmission over long distances.Adding up the currents from T100 thrusters(2.5 amps each), Pixhawk(2.5 amps), Raspberry Pi(2.5 amps),2 FathomX Tether Interface Boards (0.5 each), 2 cameras (0.5 each) and 3 servo motors(0.8 amps each) we get a total current of 24.4 amps.



*There are more than one servo motos present. They aren't shown in the diagram to reduce crowding.

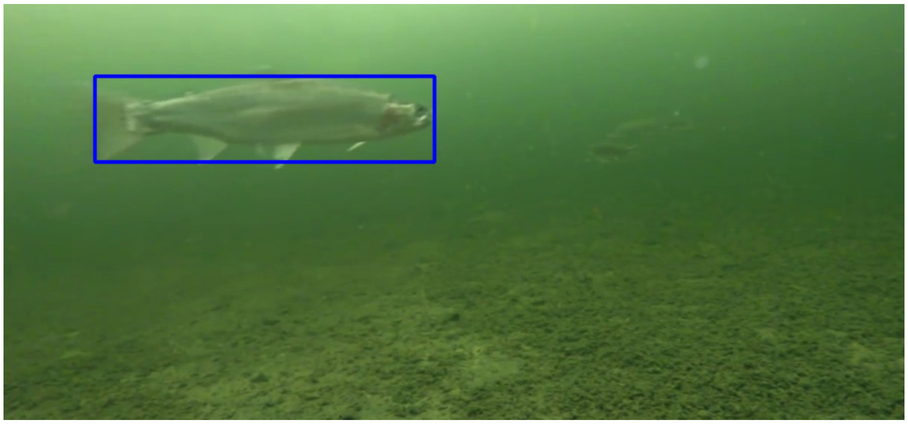
Software

Control Software

Raspberry Pi 3 is used to process the majority of Salutis's code which is in the waterproof tube. Also, ArduSub interface is used to establish communication among Pixhawk, raspberry pi 3, and other electronic pieces. With the use of Pixhawk, the code is able to process other variables such as the joystick input and depth and yaw angle. So, this allows the robot to stabilize itself and stay on the route by making corrections with its thrusters and keeping its angle and depth stable all the time. All of these pieces were provided with the necessary code to create a connection between the joystick and establish actions according to the input that comes from the Logitech controller. Python is used in order to write the code.

Image Processing

OpenCV library is used in order to detect the mission objects and create autonomous movement. A special object tracking algorithm is created by segregating individual objects from their backgrounds then determining their boundaries and finally drawing them on screen. The algorithm is created just for detecting and tracking the mission objects such as "morts" and the fishing net. Also as the robot will track the objects, it will center itself until the object that has been tracked is the center of our view by using its thrusters. This will be accomplished by using simple geometry and algebra; the robot will center itself autonomously until the tracked object's coordinates are at the middle of the cartesian coordinate system OpenCV uses. The algorithm will run on our headquarters by processing the image input it gets from the robot's camera.

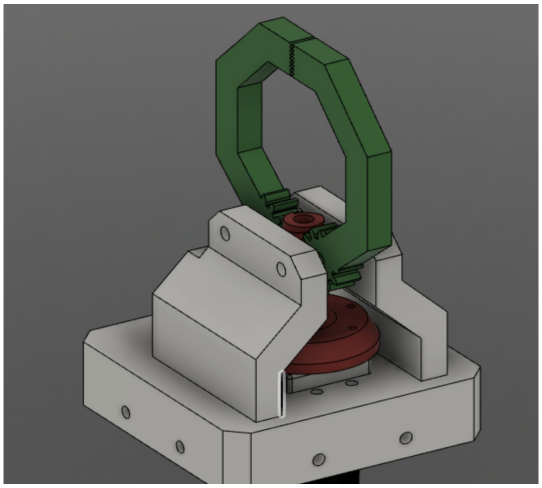


Sensors

Our team equipped Salutis with sensors to detect potential water leakages and carry out essential measurements. The leak sensor in the electronic enclosure is used to detect water leakages and inform the pilot. It detects water leakages by measuring the wetness in the environment with its sponge-tipped probes and communicates with Pixhawk and Raspberry Pi to inform the pilot about the leakage. One other essential sensor used is the depth/pressure sensor, which measures the pressure of the electronics enclosure constantly and informs the pilot about the water depth and pressure. Other sensors are Pixhawk based sensors which are measured by the Pixhawk itself. Pixhawk can measure acceleration, velocity, and angular velocity. Also, it can be used to determine with which angle Salutis is being deployed.

Mission Specifics

On top of free movement, Salutis is going to have to be able to manipulate outside objects for many of the tasks in the competition. For this reason, our team has designed a manipulator that is able to grab and hold onto outside objects and rotate them. The design has been created on AutoDesk Fusion 360 and has been built using a 3D printer. Servo motors inside the manipulator work to close the clamp, rotate the manipulator around its center.



Energy

We have a 12V-5V Regulator to regulate the voltage range. Since there is a certain voltage range in which the electrical systems in our vehicle can work properly. When this range is exceeded, damage may occur within the system. For this reason, the voltage must be kept constant within a certain range in order to protect the systems.
A 12V-5V regulator will be used in our vehicle to perform this task. This part draws the 12-volt current from the Anderson SB cable to 5 volts, where the Raspberry Pi can operate. Thus, Raspberry Pi can work safely.

Safety

As RC Makers, we value safety above all else, which is why both the construction and the design of Salutis were made keeping in mind the safety of all team members, and also the environment that our ROV is going to be operating in. One of the design choices aiming to protect the environment was to put guards around the thrusters so that no fish can enter the thrusters during operation and possibly get injured. For the safety of our members, all workshop equipment is used according to the safety rules.

Safety Rules

The following are the rules set in MakerSpace in order to keep every team member safe:

1. No one can use robotic space alone, which means there must be at least 2 students in the room for emergencies.
2. Each member must attend safety workshops to learn what to do during working times. Each member of our team must be informed and educated by a commissioner who has much more experience with safety than us.
3. Each member must check the machine before using it to make sure if it is working correctly or not.
4. Each member mustn't use any machine before reading instructions for how to use it and understand the safety rules for that machine.
5. Dangerous and professional work machines such as drills and soldering machines should be used by at least two people. While using such machines, students must use glasses to protect themselves.
6. For the machines that work aloud, members who will use them must wear a headset to protect their ears.
7. After using each machine or doing any operations, the member must clean up for the condition of the machines.

Project Management

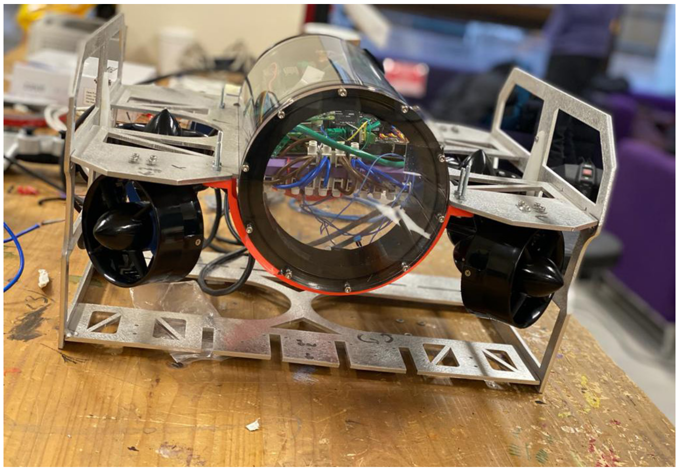
After the quarantine caused by the pandemic, our team has come together as the third generation of our school's ROV team. During this interval, our team could not operate properly, and some of the members left the team, so we had to recruit new members who were tested to see if they were qualified to be a part of the team. After we managed to form the new team, we started our weekly meetings, first talking about the competition and the requirements we are supposed to fulfill. In order to work more effectively, we separated into subdivisions of members who were qualified in specific tasks. There are three subdivisions: design, programming, and PR. Together, these subdivisions work to construct a successful ROV. Throughout the year, we met every Wednesday-if there were no issues that prevented us- but as the competition drew closer, we began to meet more frequently. Our team leader, Ufuk Çetiner, kept track of the organization of meetings and the to-do list of tasks.

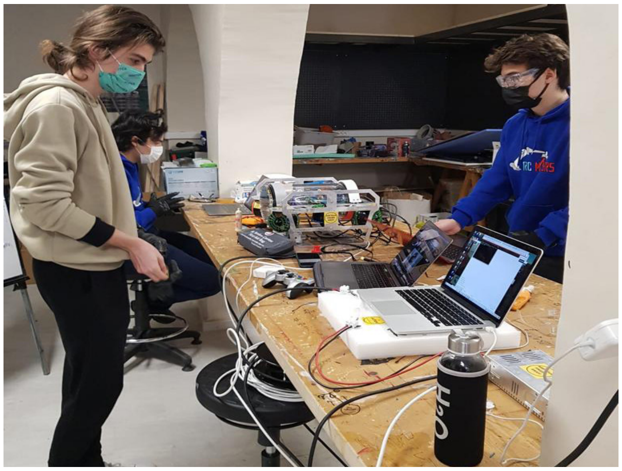
Challenges

The biggest challenges we faced were caused by the fact that most of the highly experienced students left our team and we had to keep going with a less experienced team with a lot of newcomers. So, a lot of our time and energy was spent teaching the new students. However, all of our team members were skillful and our leader did a great job organizing our time and the meetings. Another major challenge was creating a communication between the PR team, who manages relations with our sponsors, and the technical team. It was really difficult since both teams operated independently, so keeping both of the teams updated and informed was a major-challenge for our team from the very beginning.

Lessons Learned

As a team mostly consisting of inexperienced members, we had a lot to learn through this year's journey in taking part in the MATE ROV competition. One of the things we've learned was managing our time, since our school has a strict and challenging program, all of our team members had little time to spend on working on this project besides our meeting time. So, all of the team members had to adapt by managing their time more efficiently.
We also learned a lot from the regional tournament we attended. It was very revealing since it was one the first MATE tournaments most of our members ever saw. It was a great opportunity for us to learn the format and understand the competition.





Future Improvements

Because of our limited budget and time struggles, we couldn't do some extra missions we had in mind. We can add more functions to our robot, such as;
- Making a mini ROV inserted in the actual ROV to control the environment and collect the necessary things from the water more precisely.
- Choosing a material for our frame which has a closer density to water's, so it can move easily and more efficiently.

Also, we should do some improvements to our team. By saying that, we meant:
- Start the process of sponsorships earlier and find more money from them to create a more technological and modern robot.
- Research at the beginning of the process faster, so we can get to build quicker.

Finance

At the beginning of the year, our team leader compiled a list of required components based on ROV cases and input from experts. We evaluated our budget based on that list. Moreover, we compared multiple stores to select materials with the lowest cost and best performance. We sought to eliminate extraneous pieces and utilize as few resources as possible.
Though we sought sponsors throughout the year, because of our country's current state, we mostly relied on the meager funds provided by our school.
Furthermore, instead of relying only on our limited budget we further used our creative and unique solutions. Our design team with the 3D printer that is provided by our school, printed out their own robotic arms and chassis.

Project Budget

Budget for RC Makers ROV

				Reporting Period	
School Name:			American Robert College of Istanbul	From:	12/04/2022
Instructor:			Muhammet Resul Ertuğrul	To:	27/07/2022
Income					
Source:					**Amount:**
American Robert College of Istanbul					1,220$
Sponsor Pozitif Teknoloji					305$
Expenses					
Category	***Type***	***Description/Examples***	***Projected Cost***		**Budgeted Value*:**
Materials	Purchased	Aluminum Sheets, ABS, PLA	325$		350$
Manufacturing Devices/Services	Purchased	Laser Cutting, 3D Printers	500$		500$
	Re-use	3D Printers	1,300$		-
Electronics	Purchased	Bluerobotics ESC's/ Stepper Motors	400$		400$
	Re-use	T100 Thrusters, Cables	800$		-
Waterproof Containers	Re-use		323$		-
				Total Income:	1,525$
				Total Expenses:	3,673$
				Total Expenses-Re-use:	1,250$
				Total Fundraising Needed:	0

*Due to increasing inflation in our country the budgeted value is a little bit higher than the projected cost to counter the inflation.

Project Costing

RC Makers ROV Robot Project Costing					
School Name:			American Robert College of Istanbul	From:	12/04/2022
Instructor:			Muhammet Resul Ertuğrul	To:	27/07/2022
Funds					
Category	**Type**	**Expense**	**Description/Notes**	**Amount**	**Running Balance**
Materials	Purchased	Aluminum Sheets	1 meter by 2 meter aluminum sheet used to build the main frame and the robotic arm	305$	305$
Materials	Purchased	PLA	Used to print key parts for the inside of the waterproof capsule	12$	317$
Manufacturing Devices	Purchased	AnyCubic Resin Printer	Used in the making of 3D printed parts	550$	867$
Manufacturing Devices	Re-use	Zaxe X2 3D Printer	Used in the making of 3D printed parts	1,400$	2,267$
Electronics	Purchased	Bluerobotics ESC's	Key part in controlling the T100 thrusters, bought 6 of them	216$	2,483$
Electronics	Re-use	Raspberry Pi 3	Main electronic component	110$	2,593$
Electronics	Re-use	Fathom Tether X Interface	Provides high speed ethernet over long distances, bought 2	240$	2,833$
Electronics	Re-use	T100 Thrust*	Provides main thrust, bought 6	240$	3,073$
Electronics	Re-use	Pixhawk	Main gyroboard in the robot	183$	3,256$
Electronics	Re-use	Servo Motors	Controls the gripper, used in the pan and tilt controls of the camera	17$	3,273$
Electronics	Re-use	Cameras	Provides visual input	25$	3,308$
Electronics	Re-use	2 meter long ethernet cable	Provides ethernet connection	10$	3,283$
Electronics	Re-use	2 meter long power cable with anderson clips	Provides power connection	15$	3,323$
Electronics	Re-use	Power Supply	Provides power	35$	3,358$
Waterproof Containers	Re-use	Underwater Subsea Pressure Vessel Enclosure	Insulates electrical components from water	323$	3,681$
Sponsor Funding	-	-	Funds given by our sponsor *Pozitif Teknoloji*	305$	3,376$
				Total Raised	305$
				Total Spent	3,681$
				Final Balance	3,376$

*T100 thrusters are discontinued. The original seller does not provide a price tag for them anymore. Another price from a resale company has been used.

Acknowledgments

We would like to thank

- Our school, Robert College
- Dean of Student Activities Office, Joseph Welch
- Our Mentor, Muhammet Resul Ertuğrul
- Sencer Yazıcı

For their continuous support throughout this tough journey. They have all helped us in many different ways, and we are very grateful to all of them.

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Many images were taken from our members' design on Autodesk Fusion 360 and photographs are taken by our members.