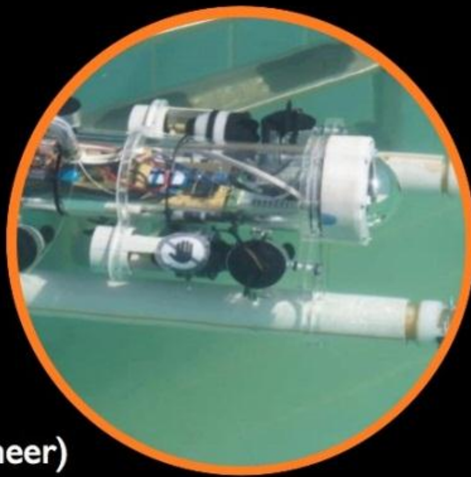
OCEANUS

Sailing into the Future

Notions Academy
Alexandria, Egypt



Team Members

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- Youssef El Gendy (CFO, Tether man)
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Abbreviation	Figure description
ROV	Remotely Operated Vehicle
PVC	Poly vinyl Chloride
AVR	Advanced Virtual RISC
RPM	Rotations per minuet
IR	Infrared

Acknowledgements

Oceanus had taken huge efforts to accomplish this ROV. However, it would not have been possible without the support and help of many individuals and organizations. We would like to extend our sincere gratefulness to all of them.

We desire to thank the Marine Advanced Technology Education (MATE) and the Arab Academy for Science, Technology and Maritime Transport (AASTMT), for organizing the competition.

We are highly indebted to Notions Development Academy for the guidance and constant supervision as well as for the technical and academic help. We are also indebted to Brilliance Language School for its donation to us.

Also, we would like to express our gratitude towards our parents and our special gratitude to Eng. Kareem Youssri for giving us such attention and time, and teaching us electronics, mechanics and programming, as well as our mentor Moamen Mohamed who helped us a lot.

Furthermore, we would like to thank Eng. Mamdouh Azmy and Eng. Galal Salama for helping us in understanding the advanced options of Solid Works and ANSYS.

Finally, special thanks to Notions' last year rangers (Notions co.) team for sharing their experience with us.

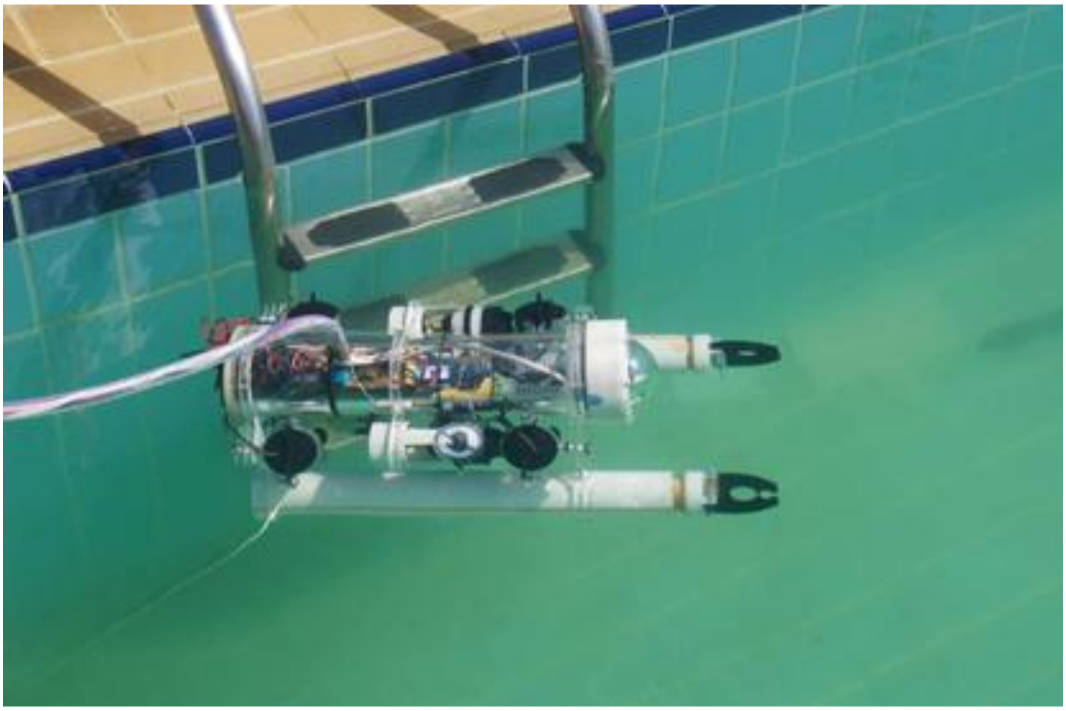
Oceanus Co. Staff

Abstract

Water occupies 71% of Earth surface, and it is considered the largest ecosystem, including diversity of creatures needing suitable conditions to live just as the purity of water, food sources and appropriate temperature. As we all know, the safety of ocean and its creatures is related to a variety of human activities such as food, oil and transportation. Unfortunately, ocean is suffering from many hazardous phenomena; for example, water pollution, which affects human activities negatively. In addition to water pollution, ocean endures from over fishing, and a change in its circulation pattern.

As a result, Oceanus Co. could not stand without taking serious actions in order to save the underwater world. Therefore our company designed and built a ROV with a wide range of special features to enhance its performance under-water. Our employees' deep experience is harnessed to build acrylic housings, efficient arms and hard frames, aiming to provide the customer the sophisticated service he desires. Apart from high-quality and efficiency; Oceanus was aware that the low cost is an influential factor that must be taken into consideration.

As *Triton* was made step by step, starting from the frame ending with its programming in C, it has been capable of accomplishing all the missions successfully beginning with installing our professional temperature sensor over the vent opening and ending with removing the biofouling adequately. Our well trained pilot can navigate smoothly under-water using gamepad as well as joystick which provides an easy control for the ROV's body, arms and motors.



1. Design Rationale

The innovation and construction of Oceanus ROV was completely based on a very organized and technically designed plan. Throughout the project a five step design process has been followed by the company as shown in Fig.1.

Fig. 1: Steps of design process.

During the stages of developing the ROV, Oceanus was restricted to some strategically steps in order to reach the final image. Oceanus staff determined what is exactly needed; they researched, developed ideas, and concluded to the required methods.

Beforehand the releasing of the ROV, results of the components were tested and analyzed using several designing programs such as Solid Works and Ansys until Oceanus staff reached the ideal design.

1.1. Frame

Oceanus' ROV's first design *"**Zeus**"* was a pentagon-shaped ROV made of ½″ of PVC as shown in Fig.2. It was destined for the Egyptian local competition. However, the PVC proved that it was not ideal for the frame.

Fig. 2: *Zeus* body

After testing and observing the PVC's body, Oceanus staff concluded that the ROV's water resistance was too high and it did not achieve the critical floating as a result of leakage of water inside the PVC body, thus the tubes were drilled which caused the filling of PVC frame with water. Since the ROV must move not only its dry mass, but also the mass of the water in the frame, it caused a significant increase in mass which dramatically slowed down the ROV and the thrust power had to overcome the increased weight. As a result of the large number of PVC connectors present in Zeus, an incoherent in the main frame has been unfortunately caused.

Fig. 3: *Triton's* body.

Oceanus' second ROV generation, "*Triton*", was a Dry-Hull system as shown in Fig.3. *Triton* was destined for the MATE ROV challenge. A dome was put on the top of the ROV to decrease the water resistance achieving a smooth movement of the ROV. The Acrylic body of *Triton* proved that it is smaller, lighter, and much more efficient than the PVC body.

1.2. Thrusters

Triton is pushed by eight Johnson Pump thrust motors of 1250G/H power. Oceanus mechanical team carried out several tests on different combinations of motors and propellers in order to obtain the best thrusters [Appendix IV]. Also, it was decided to use a motor housing to decrease the water resistance and to improve the flow of the water.

Fig. 4: Johnson pump 1250 G/H.

1.3. Motors setting and degrees of freedom

In fig.5, the motors arrangement can be clearly identified. Four thrusters are arranged horizontally and four vertically.

Fig. 5: *Triton's* thrusters' arrangement.

Triton has movement around six degrees of freedom as shown in fig.6, four horizontal thrusters are installed for three different movements (surging, heaving and swaying along the longitudinal vertical, and transverse "lateral" axes respectively) and four vertical thrusters are installed for three rotations (rolling, yawing, and pitching around these same respective axes).

Fig. 6: *Triton*'s degrees of freedom.

1.4. Propellers

Fig. 7: Harbor 50mm left propeller.

Oceanus' staff cared to select suitable propellers to combine between the efficiency and the less current consuming. Thus, fig. 7 shows the harbor model 50 mm propeller with three blades was the ideal propeller [Appendix III]. Also Oceanus' staff has distributed the thrusters with left & right propellers to provide stable movement for the ROV as shown in fig. 8 and 9 [2].

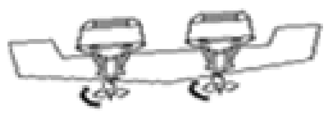


Fig.8: Propellers steering (same direction).

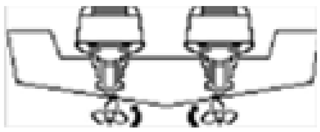


Fig. 9: Propellers steering (opposite direction).

1.5. Buoyancy

High center of buoyancy and low center of gravity were primary concerns in building up *Triton as shown in fig. 10;* to give the camera platform maximum stability about the longitudinal and lateral axes and to balance the body rapidly if any vibration occurs. The thrusters are mounted at the top of the vehicle lateral alternating with each other to center the gravity, rotation and buoyancy forces. In other words, instead of having the center of buoyancy and gravity at the sides of the body, the center of buoyancy is fixed at the center top of the ROV and the center of the gravity is fixed at the bottom of the ROV to insure the maximum stability under water.

Fig.10: Centers of buoyancy and gravity

1.6. Manipulators

The two grippers' manipulators are fixed in the front of the ROV. They are isolated from water by a polyethylene case from the front. They end with a hard-chrome which is drilled to lengthen the axe in order to increase the suction force of the motor and they are closed with oil seals to prevent the exposure of water, as shown in fig.11.

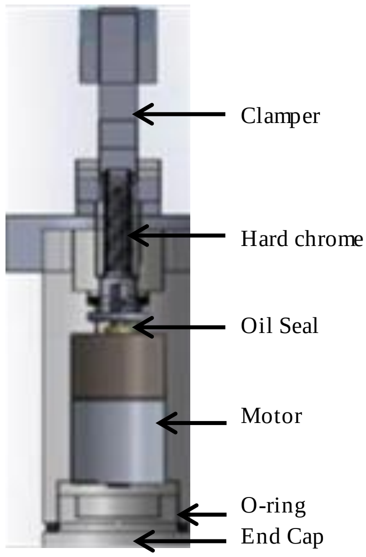


Fig. 11: Manipulators' sealing.

Powerful DC geared motors with a 4mm diameter shaft are fitted with a 75:1 metal gearbox which is made of steel. In addition, it has a stall current of 3.3A, a stall torque of 8.8Kg/cm and finally RPM of 180. Manipulators are mounted with the clamper-shaped grippers to accomplish the tasks.

1.7. Lighting

As shown in fig. 12 increasing the water depth leads to decreasing the ambient light. The strength of the light absorption also depends on the cleanliness of the water. Although Triton is equipped with cameras with IR light, with decreasing the brightness the image noise increases.

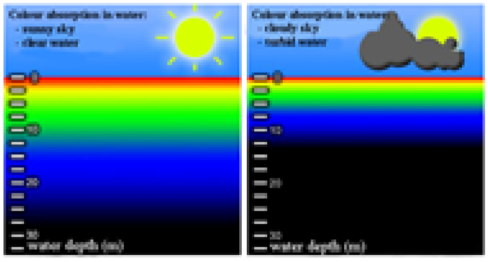


Fig. 12: Color absorption chart.

To provide adequate lighting, two radiators are mounted on the ROV. In each radiator Seoul P7 LEDs are placed. These emitters have the following data:

- Lumen: 700.
- Lumen max 900.
- Current: 300 mA.
- Volt: 12.0 V.
- Watt: 10.08 W.
- Angle: 160 °.

Fig. 13: Lamps' housing.

Fig. 13 shows the lamp housing. At the front, the housing is sealed with a transparent acrylic disc. The disc has a thickness of 10mm and a diameter of 3cm which can easily withstand high pressure. The LEDs optics' radiation angle is 35°.

1.8. Camera

Triton is equipped with one Super Circuit high resolution, low light (0.5 Lux) pinhole cameras as shown in fig. 14. It has a 0.85cm color CCD and provides a 90° horizontal field of view in water. One camera is located in the center of the dome. The OPTICS (Onboard PlaneTary Illuminated Camera System) uses a set of spur gears, powered by servo motors; to rotate the cameras .It is also capable of providing a full 180° field of view in the vertical plane. *Triton* is also equipped with an Inuktun crystal camera of high resolution (400 TVL), low light (1.0 Lux), and 0.64cm color CCD camera. It is externally mounted on the chassis, opposite OBS, which provides an unobstructed view of the tool during mission execution Our company enhanced camera lens to a wide angle lens 164° to give us a fisheye view.

Fig. 14: Camera.

1.9. Panning device

Fig. 15: Pan and tilt Camera.

To make the observation of the underwater world better, a swivel mechanism of the camera was opted. While navigating the ROV with a joystick, the camera rotation is performed with a second analog stick. The camera can be rotated approximately 180°/180°. The more the analog stick is pushed to the side, the more the camera turns. If the analog stick versa released the stick, thus the camera returns back to the original position 0°/0°. This allows the navigation and a look around together by one camera. Also, it has the advantage of being returned quickly for orientation. The camera in the original position would inform the pilot about how the ROV is oriented in the water. Fig. 15 shows the camera navigation system.

1.10. Insertion technology

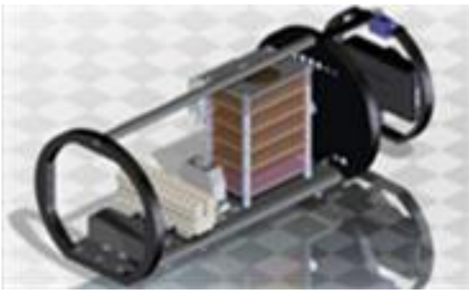


Fig. 16: Insertion of electrical system.

Aiming to achieve perfection, the crew needed to make several modifications and checking on the electric board. Unsuccessfully, the staff had a difficulty in pulling the electric boards and un-drilling the wires as this leaded to scratching the electronics can. As a result of these difficulties, the interior of the ROV was modified hence; electronics and camera tilting device are combined into a slot shown in fig. 16. Electronics and camera tilting can be completely pulled out of the tube without damaging it. Therefore, this technique can be easily maintained as required.

1.11. Isolation

Fig. 17: End Cap.

The electronics cans are composed of one optically clear acrylic tube. The tube has an outside diameter of 12cm and is sealed by O-rings incorporated into 1.5cm end cap; which is shown in fig. 17, and 3.0cm front cap as shown in fig 18. The cans have been successfully pressure tested to two bars in the pressure vessel.

Fig. 18: Front caps, dome caps and dome.

2. Electrical system

The electrical system has four key components shown in fig. 18; the topside control unit, the tether, the ROV control can, and the ROV pay load control can. [Appendix I electrical schematics].

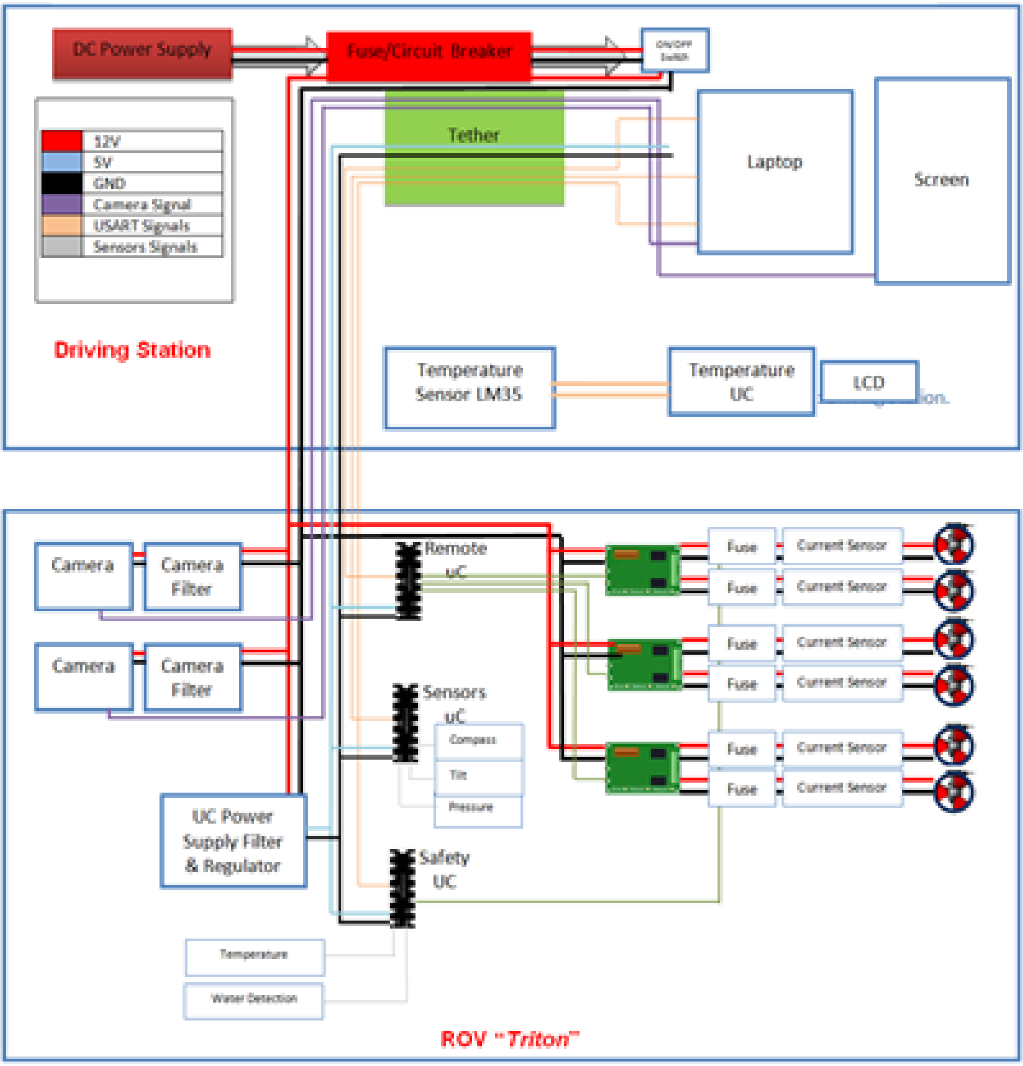


Fig. 19: Connection between the driving station and *Triton*.

2.1. Driving Station

The topside control unit is based on a laptop. It allows the pilot and the copilot to monitor all the information needed for improving the driving capabilities. The station is split into five main operations as shown in fig.20; ROV navigation, thruster power control, safety and emergency stop, lighting control and video feeds. The driving station communicates with the ROV, through two microcontrollers in the ROV and a laptop in the driving station, by sending and receiving a series of serialized packets. The video feeds from the ROV are directly interfaced to the driving station's screen and the laptop's screen. Also, a GUI is coded using C# language to display the Sensors readings on the laptop's screen and to control the ROV.

Fig. 20: Driving station.

2.2. ROV Electronic Can

Triton's current control system represents one of the greatest innovations since Oceanus began producing ROVs. Oceanus' first ROV, Zeus utilized an on/off control system using a relays' board. Although it presented a certain degree of reliability that is difficult to replicate with a reliable system, it offered only very limited maneuverability.

Triton Control Can which is shown in fig. 21 houses all the electronics required to operate the ROV, controlling of the thrusters, reading form sensors and finally providing communications with the driving station.

Fig. 21: Electronic can.

2.2.1. Forward and Upward Thrusters' Control

The controlling system which drives the forward and upward thrusters is adapted to include variable speed for better control of the ROV by using 2x12 H-bridge circuits from Sabertooth shown in fig. 22. This variable speed propulsion system is controlled by Serial communication (USART) signals generated from the microcontroller which drives the motors [5].

Fig. 22: Saber tooth 2x12 H-bridge.

2.2.1. Manipulators' motors Control

The manipulators' motors and other tools which do not require variable speed control are switched by an on/off controlling system using a Relays' boards of a rectangular shape. This board can control up to eight bi-directional motors. A controlling board is connected with relays' boards using RJ-45 sockets and cables. It is used to provide communication between the relays' board, the H-bridge circuits and communicating with the driving station. Fig. 23 shows el relays 1st relay board.

Fig. 23: Board of relays.

2.3. Sensors

2.3.1. Pressure Sensor

Honeywell pressure sensor which is shown in fig. 24 is used to measure the water depth. It has a measurement opening that is threaded into a hole in the end cap. The transducer can measure water depths up to 16m (200PSI). Using the microcontroller, the pressure sensor's reading is converted into depth, taking into account the configurable water density and current atmospheric pressure. This measurement will act as feedback to an auto-depth function featured in the control system as a future work.

Fig. 24: Pressure transducer.

2.3.1. Temperature Sensor

An integrated circuit LM35 temperature sensor shown in fig. 24, capable of recording temperatures from -40°C to +125°C, monitors the internal temperature of the electronic can. It sends analog values which are converted into digital ones using the microcontroller. This allows the pilot to monitor temperature and shutdown or reduce demand on the ROV in the event of overheating.

Fig. 25: LM35 temperature sensor

2.3.2. Current Sensor

Pololu current sensor shown in fig. 26 is used for over-current protection and kill switch for emergency stoppage. In our design every motor has a current sensor connected in series with it to insure the maximum safety of the ROV and to monitor the behavior of the motors. The current sensors' reading are displayed on the main driving station [6].

Fig. 26: Pololu current sensor.

2.3.3. Voltage sensor

A voltage sensor is equipped in *Triton*. It is monitored on the driving station to ensure that the output from the onboard power supplies is within an acceptable range. It sends an analog value which can be converted to a digital ones by using the microcontroller

2.3.4. Accelerometer

A Sparkfun 3-axis accelerometer shown in fig. 27 is used as an orientation sensor for the positioning of the ROV. Accelerometer sensor provides three separate angle measurements, angular velocities and linear accelerations in all three axes. Measuring accuracy is provided by built-in Kalman filter. As a future work on pressing a special button the ROV will maintain a special angle automatically [7].

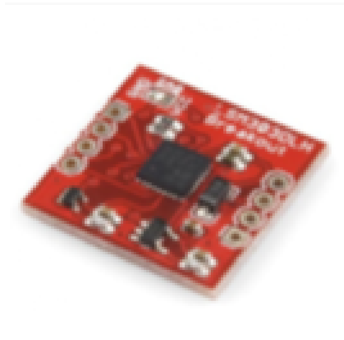


Fig. 27: LSM303DLH 3-axis accelerometer combined with a 3-axis magnetic compass

2.3.5. Compass

For operator's convenience, a 3-axis magnetic compass is included in the ROV. It is combined with the Sparkfun orientation sensor. It is used to provide the pilot with all the information needed for improving the driving capabilities [7].

2.4. Tether

The ROVs tether is used to transmit power and data between the ROV and the driving station. *Triton*'s tether is about 20.0m. So for easier transportation, Oceanus designed a tether splitter shown in fig. 28. The tether splitter consists of a 60mm diameter acrylic tube and 2 end caps.

Fig. 28: Tether Splitter.

The tether splitter helped in decreasing the drag force of the tether on the ROV as shown in fig.29.

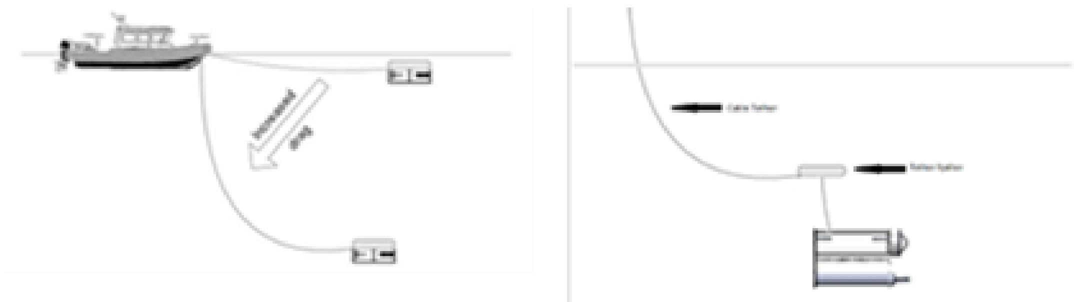


Fig. 29: Drag force with and without the splitter.

3. Payload

One of the main tasks for this year's MATE ROV competition is installing a temperature sensor over the hydrothermal vent at the ASHES site and obtaining real-time temperature data over an extended time period. Likewise, reporting and graphing temperature readings every 1.5 minutes over a 6-minute time frame. Accuracy of the temperature reading is one of the important issues that have been put into consideration. Researches were carried out to determine the most ideal sensor until reaching four types of temperature sensors which are: Thermocouples.

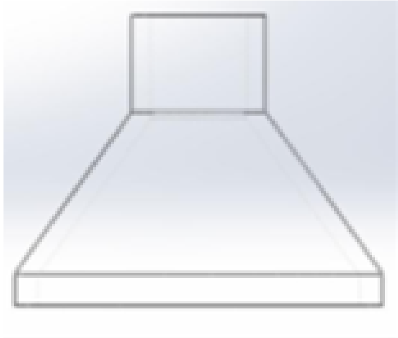


Fig. 30: Lofted shape PVC body.

Resistance Temperature Detectors "RTD."

Thermistors.

Integrated-circuit temperature sensors .

The LM34 and LM35 series, which are kinds of integrated-circuit temperature sensors, proved to be the ideal way to have an accurate measurement. The LM35 produces an output that is proportional to Celsius temperature. LM35 was used and isolated it in lofted shape Polyethylene body, due to the narrow ¾ inch PVC pipe set inside a five gallon bucket. In other words, Oceanus had to make the design shown in fig. 30 Lofted to quickly set the temperature sensor approximately 4 cm down inside the ¾ inch connector.

Fig. 31: *Triton* accomplishing the payload task.

Fig. 31 shows how *Triton* installed the temperature sensor over the vent.

4. Reflections

Building a robot from A to Z required hard work and teamwork as the challenges and the obstacles which Oceanus' Staff faced wouldn't have overcome them unless working as a team with creativity and thinking 'outside the box' towards a diverse range of problems and tasks. The staff had challenges with teamwork as we faced different opinions but in the end we passed these differences and chose the best for *Triton* which is something greatly higher and a greater purpose than individual self. This incredible experience had an effect in our personality and our vision to the upcoming considering our purpose to the future; as some of us decided to follow some careers depending on what they have most preferred during this experience such as programming, electrical or mechanical engineering.

5. Lessons Learned

Throughout this amazing experience, lots of lessons were learned, which might be impossible to list all of them. Like the technical lessons and skills, the crew learned how to use various art designs, electric and mechanic programs for instance Altium, Solid Works, ISIS, Code Vision, Ansys in addition to Photoshop. Actually, before joining the company, the majority of the company members had never exposed to or trained on how to work with programs identical to these, however; now every member of the company can proudly say that he/she can deal with them excellently.

As well, many of the members gained the precious skill of being able to work safely around and control all of the tools used during the manufacture of *Triton*. Moreover, the crew has learned how to write professionally technical reports, sketch flowcharts and illustrate a variety of vehicles with different programs.

Aside from the technical aspect of *Triton*, the communication skills between the company members have greatly developed. Oceanus staff didn't only learned how to communicate with public, throughout the presentations and the interviews with different companies in order to find sponsors, but also how to communicate clearly with others inside or outside of the company.

The most important lesson learned is how to work together as a united team and how to organize time between the ROV training and diverse responsibilities in general. These qualities will surely help all Oceanus staff progress more in their lives and enhancing their future.

6. Teamwork

A successful ROV cannot be reached without the presence of teamwork as it is one of the most important success factors existing in the company. *Triton* was built from the ground and manufactured by all team members, with the supervision of mentors. In addition to the construction of the ROV, the technical report was written by all the company's members. In other words, both of the report and the construction of the ROV were a company effort.

A detailed Gantt chart was developed, in order to ensure that all the work will be done in time. The Gantt chart is also provided in fig.32 where it is clear that each member was selected for a specific role and had the responsibility to accomplish a defined task. Thus, there was no overlap in the work and each member was aware of his responsibility. Every week, a table was filled with the takes done consequently which facilitated enormously writing the technical report.

The company members were always in touch. They were communicating to synchronize meeting times and discussing their tasks together. These communication methods built a strong sense and a wonderful spirit of teamwork in the company which strengthened the cooperation between the staff members. As a result of the enhancement of the team spirit, the rate of work was enhanced too.

Fig. 32: Gantt chart.

7. Safety:

Oceanus Co. cared for both of staff and ROV safety. Beginning with the staff safety; as they:

- Used eye-goggles and rubber gloves while working.
- Used insulated tools while working.
- Made sure that the circuits are not connected to a power source while repairing any damaged circuits.
- Used a current tester to test if the electric current is still passing through the wires.
- Worked on wooden floor to avoid the electrical surge that may ground the person and the whole electric current will pass through his body.

Oceanus staff has put the *Triton*'s factor of safety four times the range the crew could face so all our components were tested to a pressure of two bars which is approximately equal to 20.3 meters. See appendix III.

7.1. Mechanical wise:

- The end caps of the electronics can are isolated by a layer of rubber as the motors' wires pass through them.
- O-rings are incorporated into the end caps; to maintain complete isolation at a pressure of two bars.
- Kort nozzles are attached to the motors.
- *Triton* doesn't have any sharp edges.
- A caution sign is attached to each motor.

7.2. Electrical wise:

- A 25Amp. fuse is connected to the power line of the tether placed in the driving station.
- 5Amp. fuse is placed on each motor.
- 1A fuse is connected to control module.
- Current sensor is connected to each thruster; to give an alarm if high current was consumed.
- Temperature sensor is placed inside the electronics can to detect overheating.
- Water detector sensor is installed inside the electronics can which automatically stops the ROV if any leakage occurred.
- An emergency button is placed in the driving station to shut down the system in case of any emergencies.

8. Vehicle system:

Oceanus Co. crew was aware of the significance of our wide featured ROV in the economical field as Eng. Ashraf Zahran from Oceaneering stated in fig.33. *Triton* is designed to match with the commercial taste as it is characterized by easily removable arms so as to give the ROV the potency to be replaced by whatever the client desires. In other words, the client may change them to larger or stronger grippers since our grippers are portable and can be replaced with another design which is an advantage existing in our vehicle allowing *Triton* to do different and more difficult missions with more flexibility.

Fig. 33: Oceanus ROV with Oceaneering representative.

9. Troubleshooting:

Throughout the manufacture of the Oceanus ROV, our company faced some problems which our crew overcame quickly.

To begin with the mechanical part, a pressure chamber shown in fig. 34 was made to test all pieces used, such as the electronic can and the tether splitter [8]. The aforementioned chamber simulates a depth of over 20.3m, which is approximately four times the specified in the MATE ROV competition rangers' class. In addition, after testing the fail of the isolation of the electronic can, a layer of wax was put. Finally, a thick layer of rubber replaced the wax, as the wax wasn't that efficient.

Fig. 34: Pressure Chamber.

As for the electrical part, when ROV's gamepad control was used; some of the motors failed to respond to the buttons pressed, and was hard to figure out if the problem was with the connection between the pressed button and the electric circuits or with the connection between the electric circuits and the motor. In order to solve this puzzle, the crew decided to implement a LED and a current sensor on each motor. If the button is pressed on and the LED is not emitting light and the current sensor is not working, then that shows that the problem is with the connection between the button and the electric circuits. And if the LED is emitting light and the current sensor is not working then that means that the problem is with the connection between the electric circuits and the motor.

After using the aforementioned techniques, Oceanus crew has accomplished a great success in overcoming technical problems.

10. Challenges

10.1 Technical challenges:

Isolating the electric can was the most challenging technical problem facing the crew and at the same time, passing the wires from the outside to the inside. First, the crew tried to pour wax over the end cap ,but it soon made spaces around the wires which allowed passage of water. So, the wax was replaced with a thick layer of rubber which prevented any leakage.

10.2 Non-technical challenges:

Since the beginning of the company's meetings, there were some non-technical issues to be discussed. The first issue was the leak of organizing: each member wanted to be charged of a specific position. Fortunately, this problem was solved by elections and filtration the candidates with consulting our mentors.

The first disappointment experiment the crew had was the test of the first version of the ROV and it took it more than an hour to complete the missions. As a result, the crew became grimed because they worked hard before the trial day. Nevertheless, the crew soon had the imperturbability and decided not to waste more time and energy on a useless matter. The staff finally realized that nothing would come easily and notified the disadvantages of the design that time, and rearranged the old strategies until concluding that the exemplary design would be the dry-hull system.

11. Future improvements

Next time Oceanus desires to participate in the MATE ROV competition, the crew aims to use all *Triton*'s sensors, such as tilt, compass, accelerometer, and finally pressure sensor, in order to maintain a certain depth and a certain angle on pressing a special button.

12. Budget:

All values are in approximated USD.

Items and quantity	Donations	Expenditures	Re-Used	Actual
Electronics (on ROV)			24	24
Electronics (topside)		71		71
Acrylic Tube			28	28
Acrylic ROV Body Sheets		114		114
Acrylic DOOM		7		7
End caps		43		43
Propellers * 8		86		86
Propeller coupling * 8		20		20
Thrusters * 8		314		314
Thrusters Housing & kort nozzles		46		46
Tether			30	30
Cameras 3		86		86
Servo Controller Board		21		21
Miscellaneous Electronics Parts				286
H-Bridges	286			286
Pressure Sensor	107			107
Digital Compass tilt compensated	36	10		46
Current sensors * 8		86		86
Water Detection *2		7		7
Team Shirts	71			71
Total				**$1780**

Table 1: Budget Sheet

Contributors	
Brilliance Language School	$143
Notions Academy	$357
Total	$500

Table 2: Donations

13. References

[1] The ROV Manual: A User Guide for Observation Class Remotely Operated Vehicles download free
[2] http://www.boatfix.com/how/props.html
[3] www.homebuiltrovs.com/
[4] www.atmel.com/Images/doc2503.pdf
[5] http://www.dimensionengineering.com/datasheets/Sabertooth2x25.pdf
[6] http://www.pololu.com/catalog/product/1187
[7] https://www.sparkfun.com/products/10888
[8] http://www.homebuiltrovs.com/pressurechamber.html

Appendix I: Electric Circuits

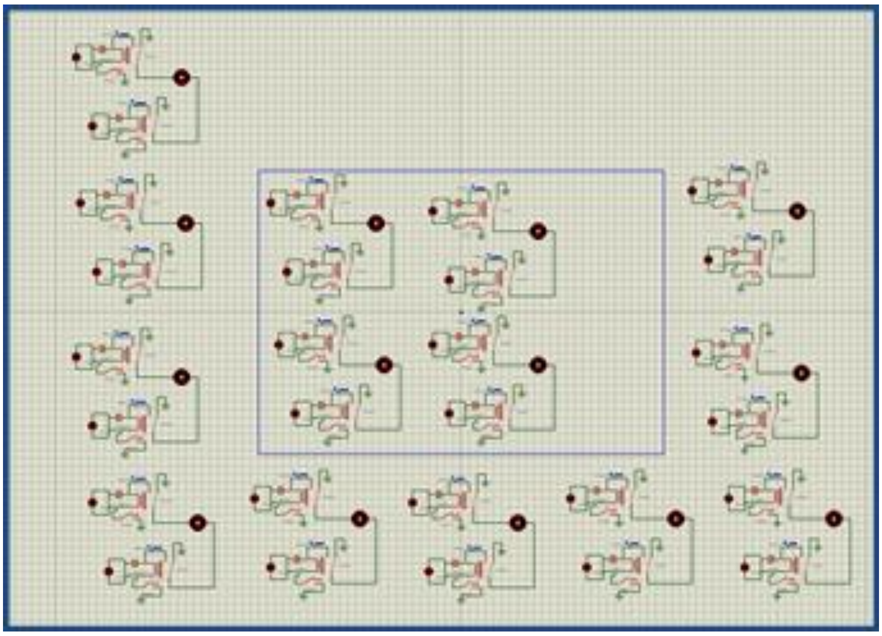


Fig. 35: Board of relays simulated on Proteus

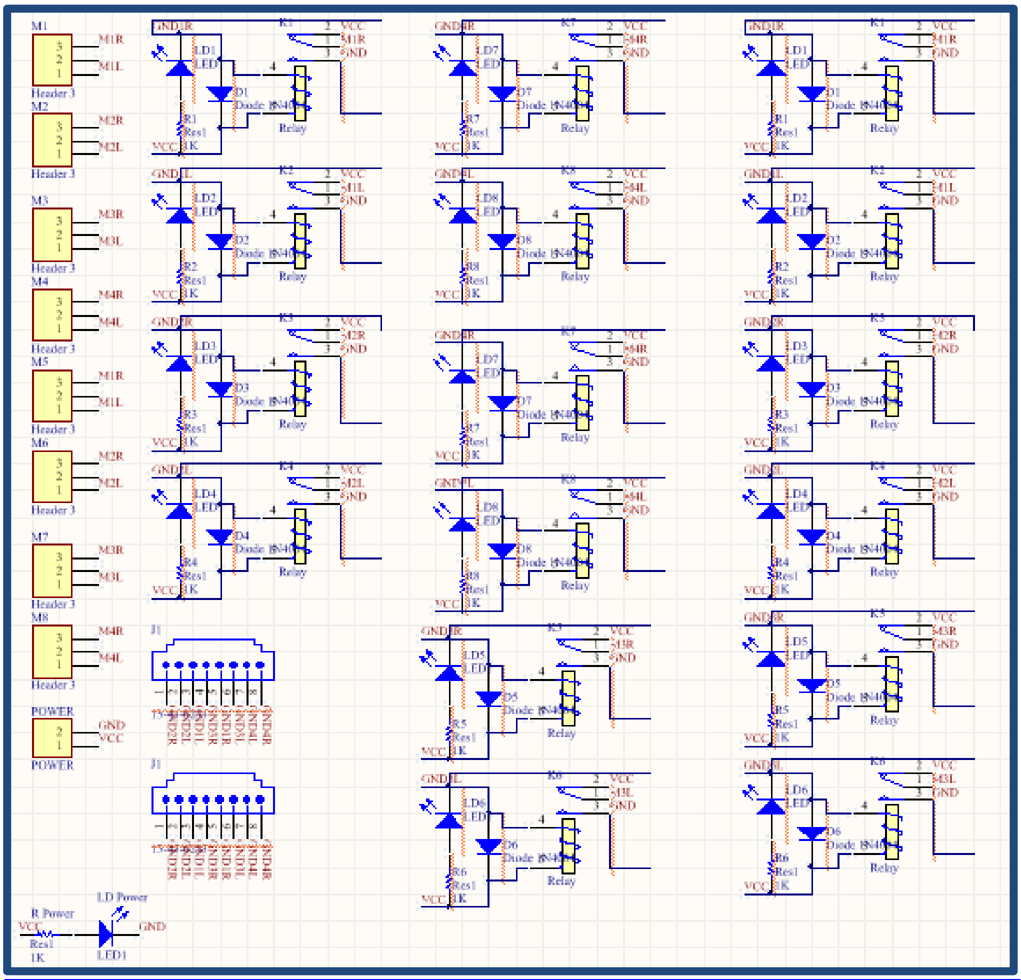


Fig. 36: Schematic diagram of board of relays

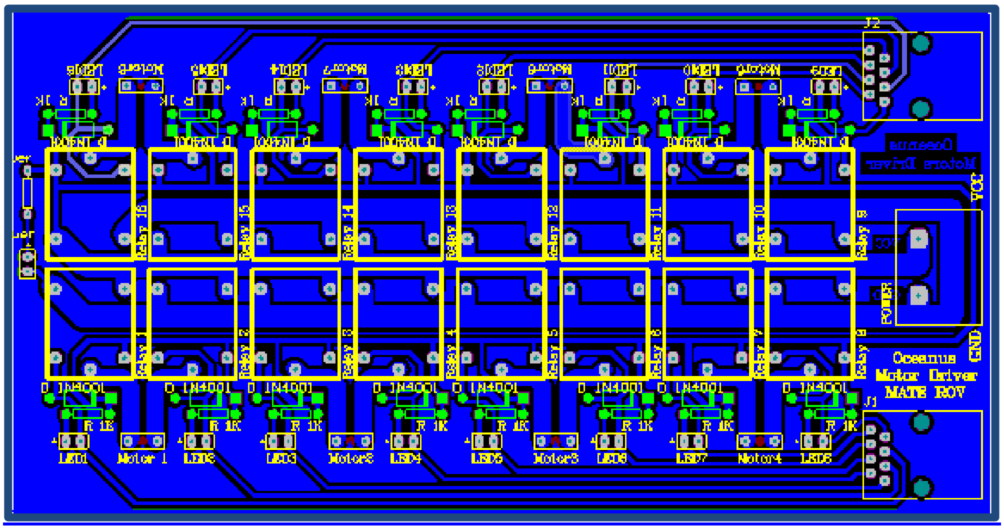


Fig. 37: Implementation of the board of relays

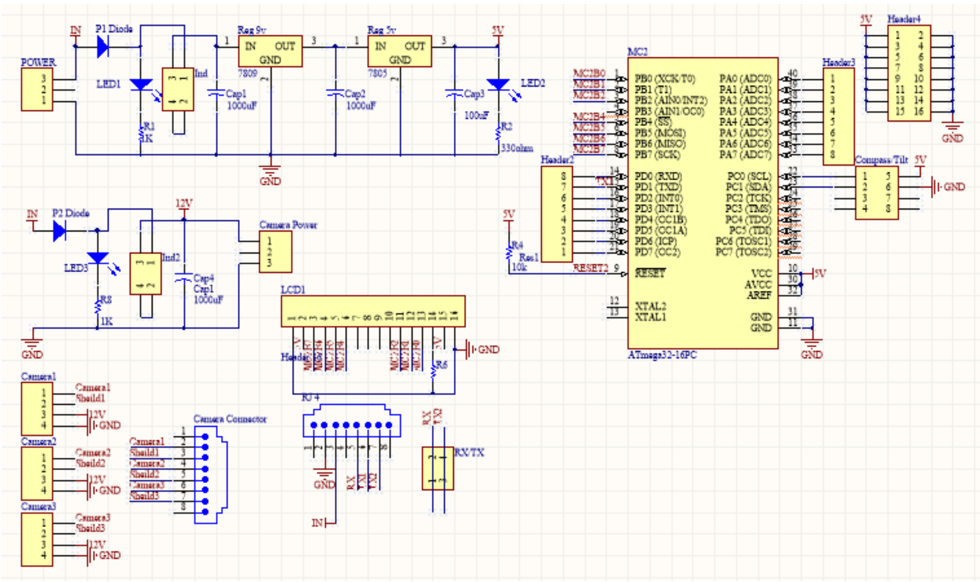


Fig. 38: ROV’s control board

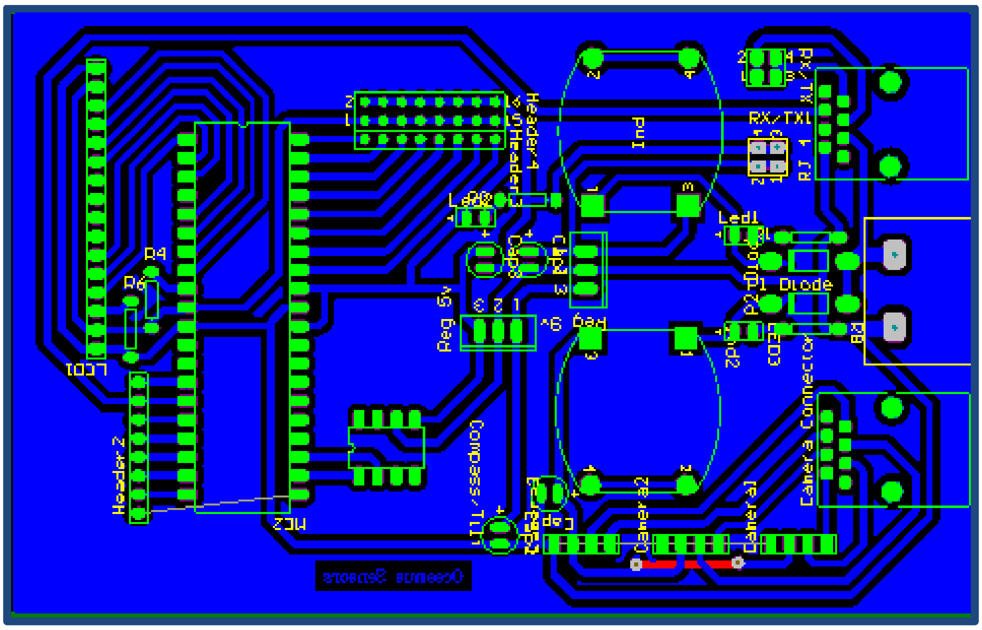


Fig. 39: Implementation of the ROV’s control board

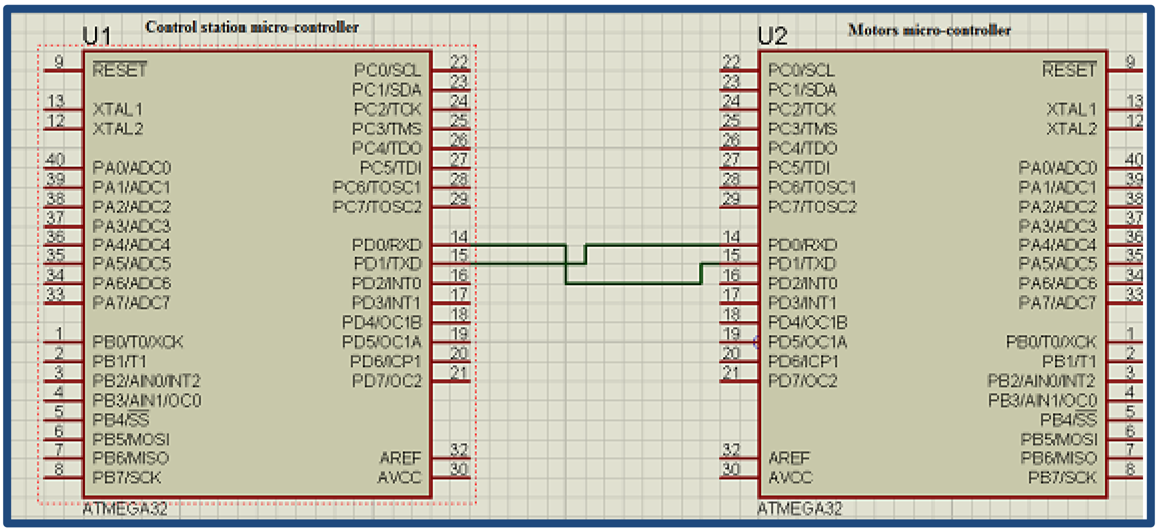


Fig. 40: USART communication between driving station & ROV simulated on Proteus

Appendix II: Code Flow Charts

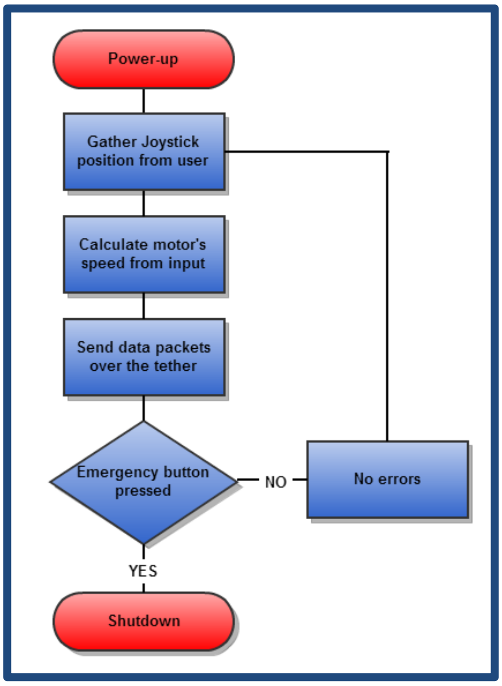


Fig. 41: Driving Station's code flow chart

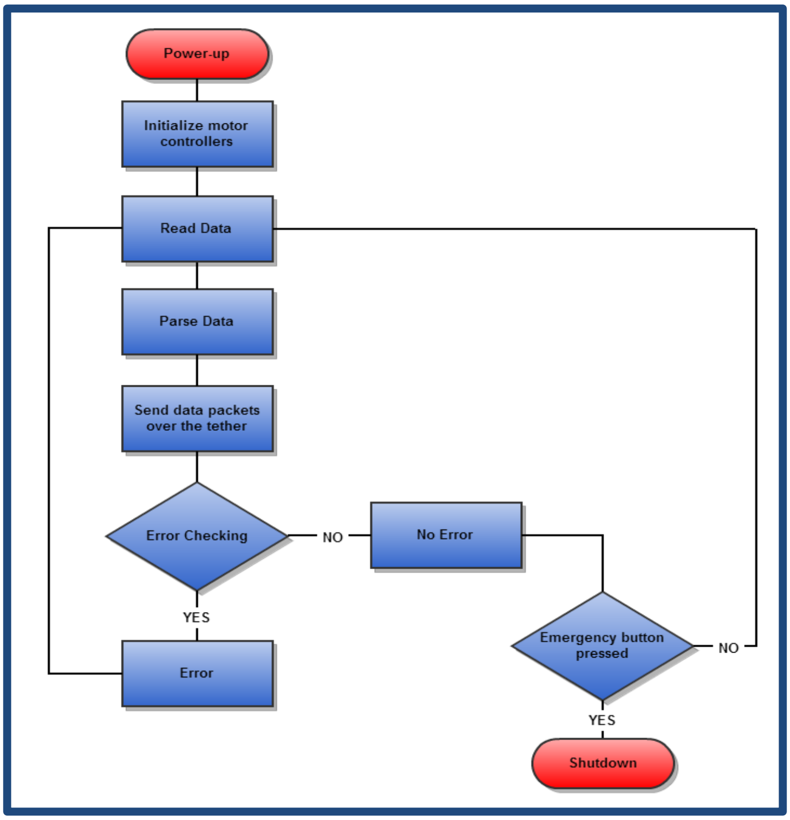


Fig. 42: ROV's motors' code flow chart

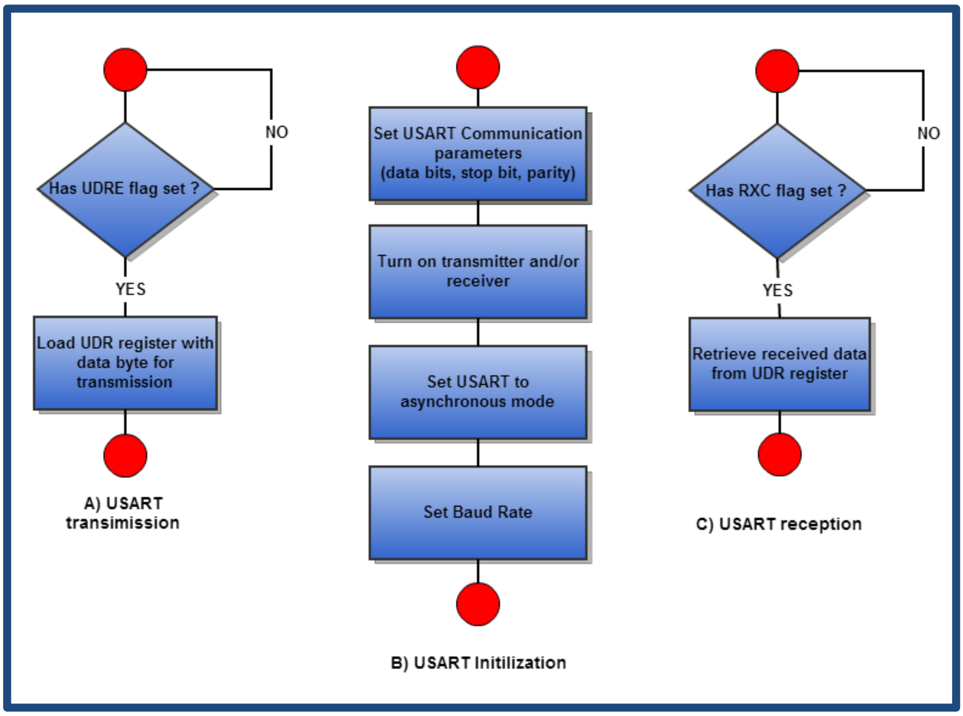


Fig. 43: Code flow chart of USART between driving station & ROV

Appendix III: Safety Check list

General	
Presence of our coach or our mentor while working.	
Wearing safety gloves on when dealing with dangerous or corrosive substances.	
Wearing lab coats when dealing with acids	
Electrical	
Working on a wooden floor to avoid electric shock.	
Using insulated tools only.	
Unplugging the power while repairing any damaged circuits	
A fuse is implanted in each circuit.	
Using current tester when testing the electric current.	
No damaged wire insulation.	
Melting wax	
Wearing masks.	
Extinguishers are present BEFORE starting melting wax.	
Using a double boiler.	
Drilling and cutting	
Wearing eye goggles.	
Wearing hearing protection.	
Keep sharp and drilling tools in tool boxes when they are not in use.	

Table. 3: safety check List

Appendix IV: Motor Test

Motors	Propellers				Forward Thrust	Backward Thrust	Motor RPM	Current	
	Diameter		Blades	Pitch					
Rule Bilge Pump 350 GPH	50 mm	Left	3	42	0.35	0.27	4100 RPM	2.14	2
		Right	3	42	0.41	0.12		2.16	1.9
	60 mm	Left	3	45	0.48	0.12		3	1.9
		Right	3	45	0.48	0.12		3	1.9
	75 mm	Left	3	?	0.6	0.4		4.7	4
		-	-	-	-	-		-	-
	10 mm	-	-	-	-	-		-	-
		Right	4	65					
Rule Bilge Pump 500 GPH	50 mm	Left	3	42	0.51	0.18	5770 RPM	3.7	2
		Right	3	42	0.51	0.14		3.75	1.96
	60 mm	Left	3	45	0.46	0.31		3	2.8
		Right	3	45	0.49	0.44		3.11	3
	75 mm	Left	3	?					
		-	-	-	-	-		-	-
	10 mm	Left	-	-	-	-		-	-
		Right	4	65					
Johnson Bilge Pump 500 GPH	50 mm	Left	3	42	0.45	0.16	5755 RPM	3.5	2
		Right	3	42	0.45	0.16		3.5	2
	60 mm	Left	3	45	0.44	0.18		3.5	2
		Right	3	45	0.44	0.18		3.5	2
	75 mm	Left	3	?					
		-	-	-	-	-		-	-
	10 mm	-	-	-	-	-		-	-
		Right	4	65				6.8	5.5
Rule Bilge Pump 1100 GPH	50 mm	Left	3	42	0.75	0.25	7600 RPM	5.1	4.4
		Right	3	42	0.75	0.25		5.1	4.6
	60 mm	Left	3	45	0.80	0.15		7.08	6.3
		Right	3	45	0.80	0.23		6.6	6.1
	75 mm	Left	3	?				9	6.7
		Right	-	?	-	-		-	-
	10 mm	-	-	-	-	-		-	-
		Right	4	65				10	9
Johnson Bilge Pump 1250 GPH	50 mm	Left	3	42	0.75	0.27	8225 RPM	4.7	4.0
		Right	3	42	0.75	0.26		4.8	4.6
	60 mm	Left	3	45	0.82	0.54		6.8	6.1
		Right	3	45	0.82	0.54		6.8	6.1
	75 mm	Left	3	?				9	6.4
		-	-	-	-	-		-	-
	10 mm	-	-	-	-	-		-	-
		Right	4	65				9.2	8.5

Table 4: Comparison between thrusters

Fig. 44: Testing the thrusters