الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحري

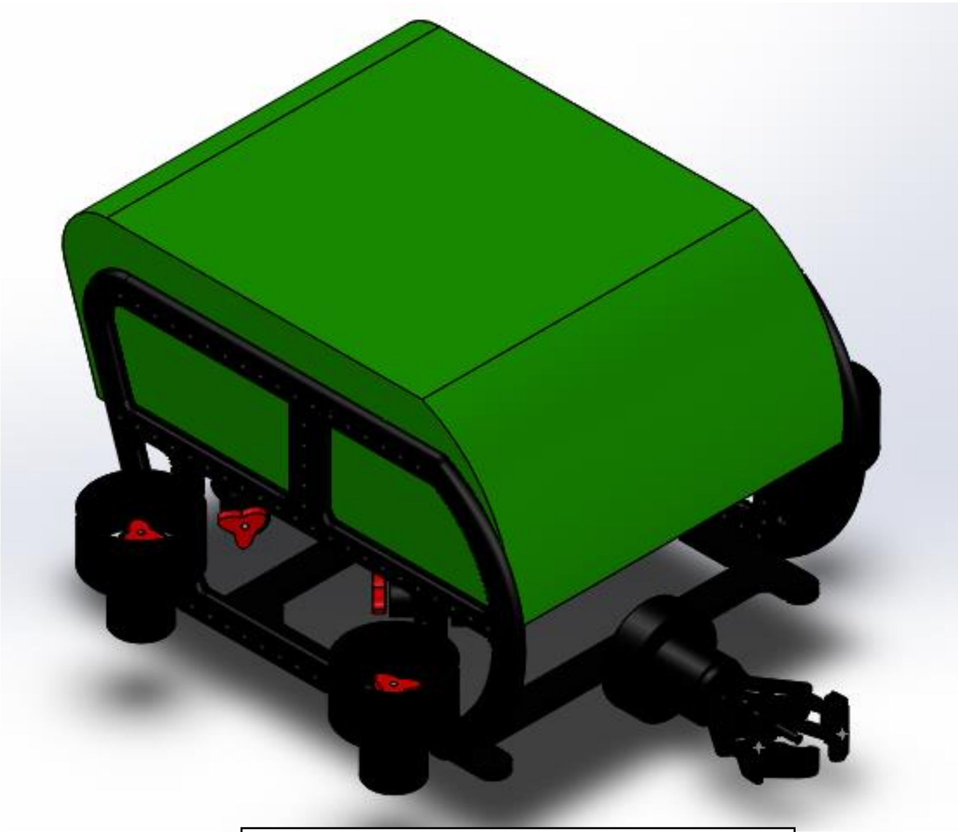
Arab Academy for Science, Technology & Maritime Transport

2015 MATE International ROV Competition

TORBINI ROV TEAM

2015 Technical Documentation

Alexandria, Egypt



ROV solidworks design

Name	Company Role, Competition Role	Major, Semester	Name	Company Role, Competition Role	Major, Semester
Ziad Mostafa	CEO, Co-Pilot	Electrical Major, 9th Semester	Ramy Tarek	Electrical Team, Mission Specialist	Electronics Major, 10th Semester
Mahmoud Badra	CFO, Pilot	Mechatronics Major, 8th Semester	Abdulrahman Aboud	Mechanical Team, CNC Operator	Mechatronics Major, 8th Semester
Hussien Roshdy	Electrical Team, Programmer	Computer Major, 9th Semester	Taher Nazeh	Mechanical Team, CADD	Mechatronics Major, 8th Semester
Samir Osama	Safety Manager, Tether Manager	Electrical Major, 10th Semester	Ahmed El-Faham	Mechanical Team, CNC Specialist	Mechatronics Major, 3rd Semester
Omar Alsadany	Electrical Team, Tether Tender	Electronics Major, 10th Semester	Eng. Ahmed Ramy	Mentor	Marine Engineer
Mohab Eweda	Electrical Team, Research	Electrical Major, 9th Semester	Eng. Mohamed Elbana	Mentor	Mechanics Engineer
Yousef Awad	Mechanical Team, Operations	Mechatronics Major, 8th Semester	Eng.Abdulrahman Abouelkhair	Team support	Mechatronics Engineer
Omar Badra	Trainee	Electrical Major, 1st Semester	Mai Faramawy	Team support	Electronics Major, 10th Semester

Table 1: Team Members

I. Abstract

Dolphin ROV is our company's fully functional product resulting from nine months of dedication and hard work. It is designed specifically to support the polar science community and the offshore oil and gas industry. Main features of Dolphin ROV are its ability to maneuver through a 75cmx75cm hole in the ice, identifying and collecting samples of aquatic species, deploying sensors, determining the threat level of icebergs to area oil platforms after taking measurements, performing subsea pipeline inspection and repairs, testing anode groundings and measuring flow rate of the water current among other features.

Dolphin ROV relies on eight thrusters as follows: Four thrusters in vertex position for horizontal movement and four for vertical movement. It is also equipped with one main gripper and four cameras to ensure clear vision for our ROV.

Power and motion electronics were assembled and modified carefully, but our software was developed and coded from scratch via open source modifiable Arduino software allowing the user swift correction of any fault.Furthermore, the ROV's design enables adding or removing any extra hardware or required software.

Safety is our company's main priority so for example fuses and safety labels have been added, control box is removable in order to fix any problem as soon as it happens and our electronics system ensures preventing current from increasing drastically.

This detailed report will take you through the design and construction process step by step and modifications done after the previous year, as well as expenses, safety considerations and future improvements.

From Left to Right:

1stRow: Ziad Mostafa, Mahmoud Badra, Samir Osama, Hussien Roushdy, Ahmed Elfaham, Ramy Tarek, Yousef Awad.

2nd Row:Omar Alsadany, Abulrahman Aboud, Taher Nazeh, Mai Faramawy, Mohab Eweda, Omar Badra.

3rd Row:Eng. Ahmed Ramy, Eng. Mohamed Elbana, Eng. Abdulrahman Abouelkhair.

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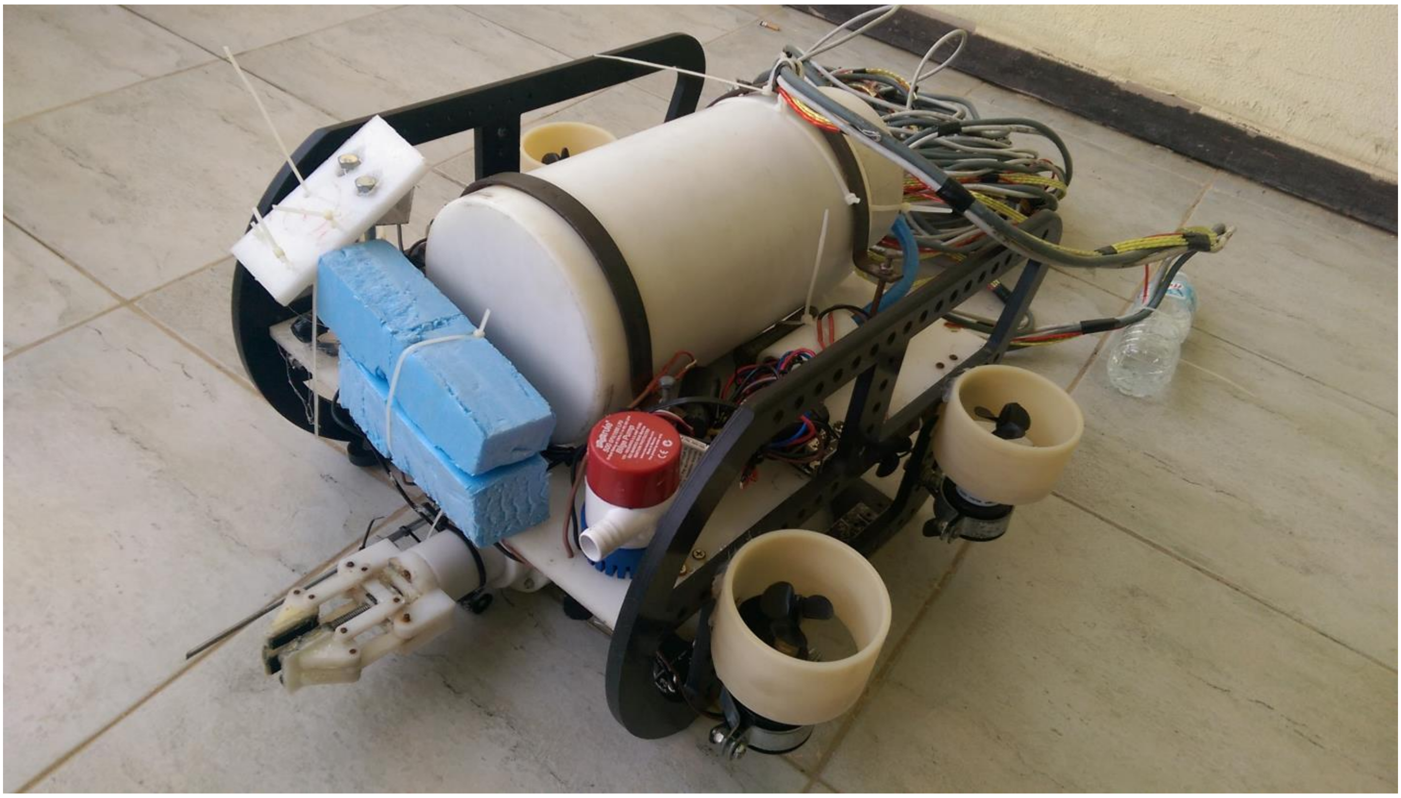


FIGURE: COMPLETED DOLPHIN ROV

Project Costing

Arab Academy for Science, Technology and Maritime				Reporting period	From:	25/01/2015
Arab Academy for Science, Technology and Maritime					To:	15/04/2015
Type	**Category**	**Expense**	**Description**	**Notes**	**Amount**	**Running Balance**
Re-used	Hardware	Vehicle body frame	Polyethylene frame	Re-used from the previous year competition	-54.6	-54.6
Re-used	Electronics	DC/DC converter	Meanwell® SD-500L-12	48V/12V 40A	-91	-145.6
Re-used	Electronics	Joystick	Logitech	Logitech extreme 3D pro	-91	-236.6
Re-used	Electronics	DC motor drivers	9 motor drivers	10A rating current	-187.2	-423.8
Donated	Hardware	Electrical tools	Donated by AASTMT	Soldering iron, glue gun, driller and cutter machine	-195	-618.8
Re-used	Electronics	Control unit	Arduino™ Mega ADK	Used as the control unit of the vehicle	-45.5	-664.3
Re-used	Electronics	Arduino shield	Signal distribution board	Used for distributing the signal to the motor drivers	-6.5	-670.8
Purchased	Electrical	Cables	Electrical cables	30 meters power cable and 10 meters power cable for inner wiring	-19.5	-690.3
Purchased	Hardware	Cables	Video cables	2 video cables	-13	-703.3
Purchased	Hardware	Cable	CAT-6 cable	30 meters CAT-6 Cable for communication between Arduino and joystick	-15.6	-718.9
Purchased	Electronics	PCB	PCB, Connectors	Used for supplying the motor drivers	-6.5	-725.4
Purchased	Electrical	Bilge pumps	Johnson Pumps	8 modified bilge pumps used as thrusters	-364	-1089.4
Purchased	Mechanical	Propellers	3 blades propellers	8 propellers	-52	-1141.4
Purchased	Electronics	DC/DC converter	RAM power DC converter	48V/12V 5A	-10.4	-1151.8
Purchased	Electronics	DC motor drivers	2 motor drivers	10A rating current	-41.6	-1193.4
Purchased	Electronics	USB extender	CAT-6 cable extender		-15.6	-1209
Purchased	Hardware	Thruster holders	Stainless steel holders	Used for fixing thrusters on the vehicle	-10.4	-1219.4
Purchased	Hardware	Tie wraps	Plastic tie wraps pack	Used for tying up the inner wirings inside the enclosure	-1.3	-1220.7
Re-used	Electrical	DC motor	12V DC motor	Used for turning vlave task	-26	-1246.7
Purchased	Hardware	Stainless steel screws	50 screws	Used for assembling the body frame parts together	-3.25	-1249.95
Purchased	Hardware	Stainless steel nuts	50 nuts	Used for assembling the body frame parts together	-3.25	-1253.2
Purchased	Hardware	Cable gallands	3 gallands	Sealed gallands used for conneting the tether to the control enclosure	-11.7	-1264.9
Purchased	Hardware	Scotchcast	2 packs of schothcast	Used for sealing purposes	-28.6	-1293.5
Purchased	Hardware	Polyethylene	Cylindrical polyethylene block		-32.5	-1326
Purchased	Service	Machining	Control Enclosure machining		-19.5	-1345.5
Purchased	Hardware	O-Ring	Rubber O-Ring	Used for Sealing the control enclosure	-1.95	-1347.45
Purchased	Sensor	Video Cameras	4 rear car view cameras	used as a vision system	-52	-1399.45
Purchased	Hardware	Polyethylene	Cylindrical polyethylene block	Used for constructing cameras cables sealed connectors	-6.5	-1405.95
Purchased	Service	Machining	Cameras cables connercrtors		-15.6	-1421.55
Purchased	Hardware	O-Ring	Rubber O-Ring	Used for sealing cameras cables connectors	-0.65	-1422.2
Purchased	Hardware	Epoxy	10 packs of epoxy	used for sealing purposes	-19.5	-1441.7
Purchased	Electrical	Bilge pump	12V Rule® bilge pump	Used for pumping water inside the pipe lines task	-35.1	-1476.8

Electrical	LED	3 SMD 5050 LED module	Used as light system	-3.9	-1480.7
Mechanical	Gripper	Polyethylene Gripper	Re-used from the previous year competition	-18.2	-1498.9
Hardware	Polyethylene sheet	Polyethylene sheet	Used for constructing the pipe attatchment device	-13	-1511.9
Service	Machining	Pipe attatchment device		-3.9	-1515.8
Hardware	Fiberglass cover		Re-used from the previous year competition	-91	-1606.8
Sensor	Testing the grounding of anodes	LED, Resistance and PCB	Used for the testing the grounding of anodes task	-2.6	-1609.4
Sensor	Water flow rate sensor		Used for sensing the average water flow rate in the flume tank	-9.1	-1618.5
Electronics	Radio Shack® controlled A/V selector		Used for having a full view of all vehicle cameras and selecting a specific o	-45.5	-1664
Electronics	Laptop	Samsung® laptop	Donated by one of the team's memebers	-780	-2444
Electronics	External monitor	LCD monitor	Donated by AASTMT	-78	-2522
General		Funds donated by AASTMT	Used for general vehicle construction	1950	-572
Hardware	Technical documentation		Hard copy of technical documentation	-13	-585
Hardware	Marketing Pisplay		Printing the poster	-39	-624
Hardware	Team's member T-shirts	15 T-shirts		-54.6	-819
General	Transportation to reigonal competetion		Donated by AASTMT	-195	-1014
General	Meals		Donated by AASTMT	-780	-1794
				Total Raised	1950
				Total Spent	3744
				Total Balance	1794

- Note: All expenses are in US dollars.

III. Design Rationale

The polar science community and the offshore oil and gas industry are in need of remotely operated vehicles so Dolphin ROV will play a huge role in the field through collecting data about an iceberg to determine its threat level to offshore installations, replacing a corroded section of oil pipeline, controlling the flow of oil through a pipeline and testing the grounding of anodes.

To produce an efficient ROV able to complete the mission tasks as specified in the MATE competition manual this year, our team decided to design a very special ROV that would be robust, powerful and versatile,while maximizing safety, reliability and cost effectiveness.

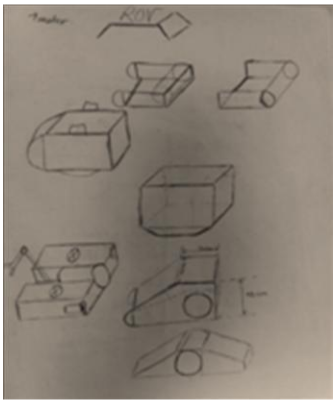


Figure 1: First Sketches of ROV

A. Mechanical System

1. Frame:

To avoid any mistakes thatcan happenin design andto allow the team to better visualize the end result early, Mechanical teamdecided to design the body in multi-stages, starting with simple sketches on papers (Figure 1) to a very detailed design usingComputer-Aided Design and Drafting (CADD). *Dolphin*ROV's frame is designed for optimum functionality with curved edges and lack of sharp ends proven to provide smooth motionunderwater as thecurvededgesdecrease the frictional resistance ofthe body and increase its velocity. Weighing 2Kg, Dolphin’s frame is lightweight and compact in size in order to accomplish the task of maneuvering through the 75cmx75cm hole in the ice easily.

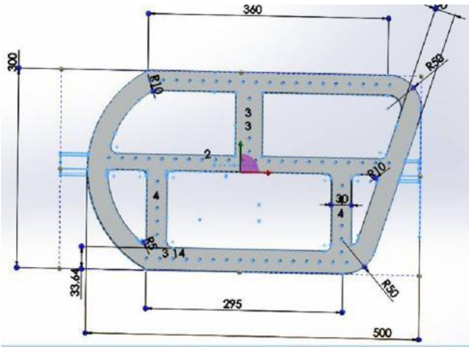


Figure 2: Solid Works™ Frame Design

Stress analysis onone frame at 20 meters water depth using Solid Works™3D design (Figure 2) with 0.49961326 Kg, volume of 551.44951202m^3, and density of 0.00090600-kg/$m^3$and weight of4.89 N. Its tensile strengthis$3.4e^{+007}$N/m^2showed the ability to withstand pressureof196200 N/m^2. Blocks of polyethylene were purchased and the final exact measurements of dimensions were handed to the Industry Service Complex at the Arab Academy campus, which is a very professional machining resource that provided us with the shaped frame.

The polyethylene blocks were cut using Computer Numerical Control (CNC) machine in order to produce smooth frame with no sharp edges to facilitate the movement of the vehicle in deep water. Our capable team of engineers could have easily reshaped the polyethylene blocks but this was going to be time-consuming. The frame does not require any extra measure to prevent its corrosion since polyethylene is already protected from corrosion.

Figure 3: Black polyethylene body Frame

2. Propulsion:

Johnson™ Bilge Pumps

Figure 4: Modified Bilge Pump Thruster

Johnson™ bilge pumps are used as thrusters, these pumps are produced for general aquatic purposes so they are already sealed and ready to use. They have a flow rate of 1250 GPH (Gallons per Hour), 12V DC at 3 AMP, 5 AMP fuse and power of 36 Watt. After calculating the resistance that acts on the body of Dolphin ROV by assuming submarine shape of the ROV and then calculating the power developed which is equal to 11 Watt after being multiplied by safety power factor we decided to use the motor of bilge pump as its power is suitable for the motion of the vehicle.

Four bilge pumps are used for vertical motion and four for horizontal motion. The outer pump is dismantled and the impeller is slipped off in order to mount a propeller covered with Kort nozzle for safety as in (Figure 4). The selection of propellers was done with the aid of Bp-δ, 3-blade, BAR. 0.5 graph (Figure 5). We obtained from the graph the dimensions of the propeller, which are 63 mm disk area, 1 cm boss diameter and 1.4 mm pitch. Mechanical System Analysis and Design Calculations were done to ensure that Dolphin ROV has ability to move in all directions.

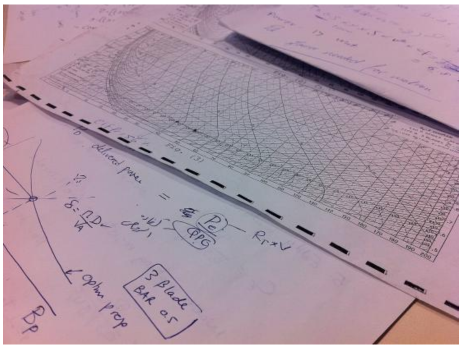


Figure 5: Selection Propeller Graph

Figure 6: Used Propeller

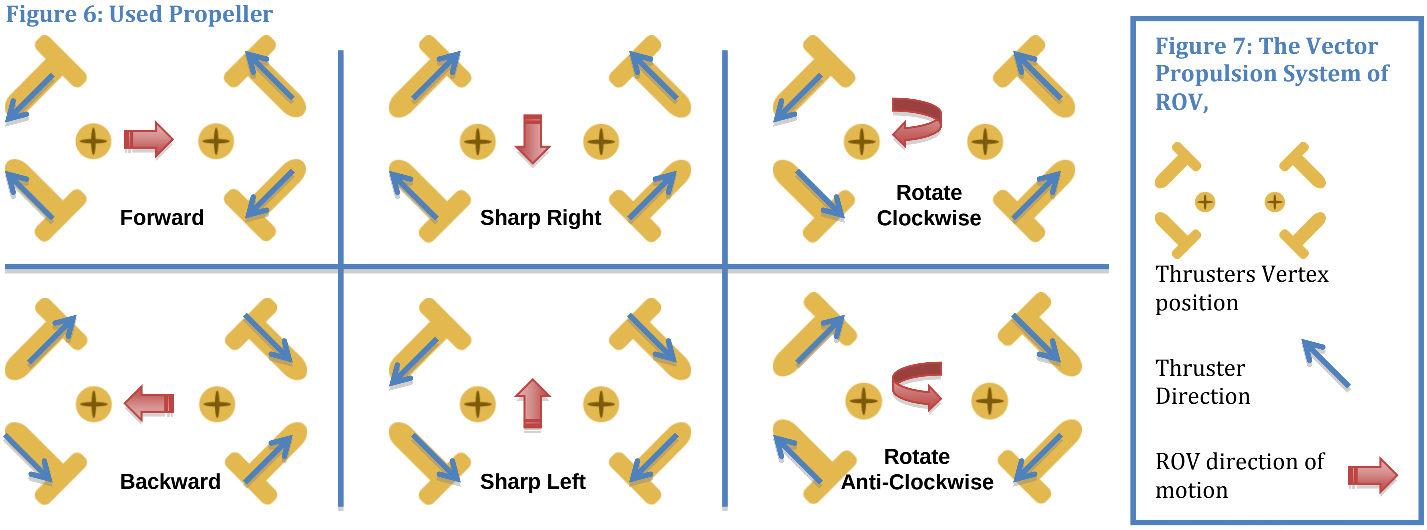


Figure 7: The Vector Propulsion System of ROV,

3. Electronic Enclosure

Our past experience with designing electronic enclosures for the components enabled us to design the enclosure needed and pick its material of production in no time. Last year we designed and built two electronic enclosures, one electronic enclosure included control components and the other one contained the electrical power components. We faced many problems regarding the wirings between both enclosures and their sealing so we modified our vehicle this year by only designing one enclosure made of polyethylene to contain all the control and power components. Dimensions of the polyethylene tube are 40 cm length, 11 cm outer diameter and 9 cm inner diameter (Figure 8). It is characterized by two stages of O-rings for waterproofing.

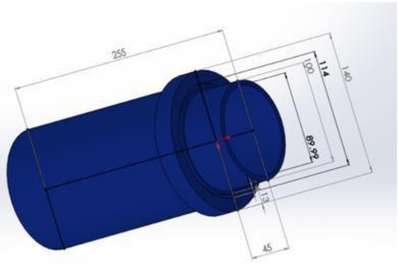


Figure 8: Enclosure *SolidWorks*™

4. Buoyancy

Dolphin ROV is equipped with buoyancy floats specifically designed to balance its residual buoyancy and give the ROV positive buoyancy.
Mechanical team decided to start with Neutral buoyancy equation to calculate the buoyancy and dimensions of the floats were calculated using Solid Works ™ software.
We are much more alert this year to buoyancy and balance problems than previous years. Previously, the team would be keen on producing the body first then it was balanced later by means of adding weights or water bottles. This year all calculations were made first including the choice of using polyethylene for the frame and testing it underwater for maximum balance to ensure that Dolphin ROV returns slowly to the water surface even in the case of thruster failure.

5. Manipulator

Figure 9: Main gripper

One main claw shaped manipulator made of polyethylene is designed by our mechanical team deriving its power from single motor of the Johnson Bilge pump (1250 GPH 12V DC at 3 AMP, 5 AMP fuse and power of 36 Watt) (figure 9). The motion of the motor rotates a shaft which determines the degree of opening of the gripper.
We designed the Grippers According to theory of Grip Strength (GS):

- Grip force= part weight x (1+part GS) x jaw style factor.
- Grip torque= Grip force x jaw length.

This manipulator will cover most major tasks in missions assigned to *Dolphin ROV.* It will be able to collect the algae sample from the underside of ice sheet, collect an urchin located on the seafloor, deploy a passive acoustic sensor. The manipulator will also be used for subsea pipeline repair as it will attach a lift line to the corroded section, remove U-bolts, return the corroded part to the surface and install and secure an adapter flange over both cut ends of the pipeline. It will install a gasket into a wellhead and insert a hot stab into the wellhead.

Figure 10: Configuration used for turning the valve

As for the tasks of turning a valve to stop the flow of oil through the pipeline and turning valves to ensure that oil will flow through a specified pathway, our mechanical team connected four screws of length 10 cm to a circular polyethylene plate 15 cm in diameter (figure 10). The circular plate is then connected to a slow rpm, high torque DC motor sealed by our mechanical team. Theconfiguration is placed at the bottom of Dolphin ROV when needed (in task 2 and 3).

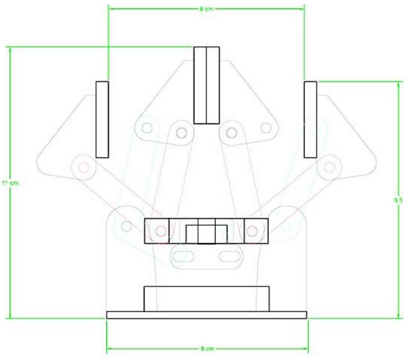


Figure 11: Gripper AutoCAD Design

6. Fiber Glass

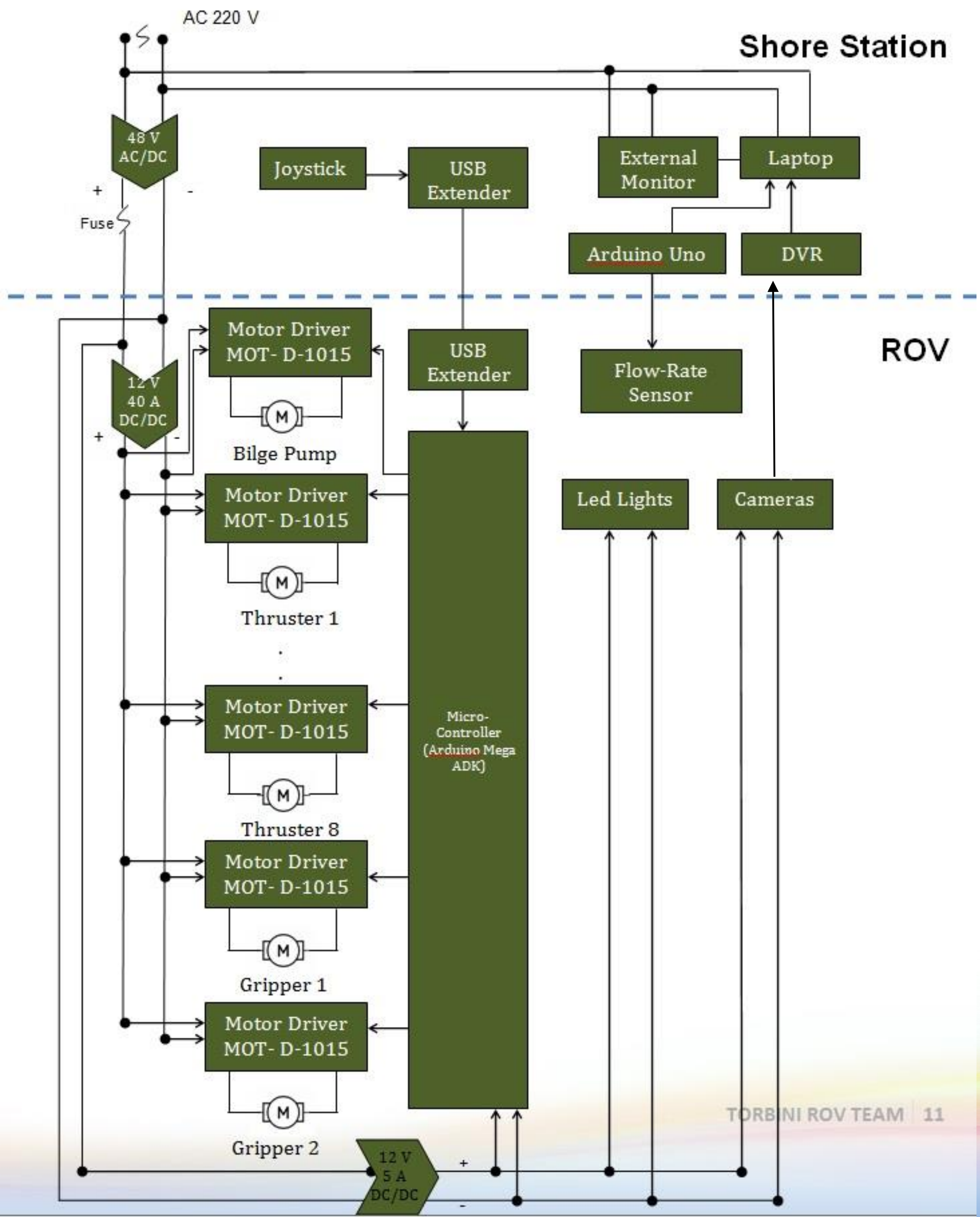
A 2-D design was sketched then a 3-D designwas simulated using solid works™. Our machining team constructed a wooden mold (Figure 12). Fiberglass sheets were cut; resin is added to 3 layers of fiberglass to increase strength. Final shape was dyed green (Figure 13). Dimensions are 38 cm width, 50 cm length, 15 cm height and 0.5 cm thickness.
Fiberglass will help in balancing dolphin ROV and giving a good final manufacturing shape.

Figure 13: Fiberglass Cover

Figure 12: Wooden Mold

B. Electrical and Control System

1. System Integration Diagram (SID):



2. Electrical System

2.1. Tether

Dolphin ROV's tether consists of a 2 mm 15A power cable 30 meters in length as it requires high power, data cable to transmit signals between analog joystick and ArduinoMega ADK microcontroller board. Also two camera cables, each cable is connected to two cameras, all covered with heat shrinks connected separately. Data and power cables are made of copper hair wires instead of regular TTL (Transistor-Transistor Logic) wires for much more powerful signal transmission..

Figure 14: USB Extender

A **TRIPP.LITE** ® USB over Cat6 Extender Kit is used that extends the USB cable distance from the Joystick at the base-station to on-board electronics with transfer rates of 1.5 Mbps to 12 Mbps (Figure 14).

2.2. Power Regulation

Two types of DC-DC Converters are used in*Dolphin* ROV:

Figure 15: Meanwell™ DC-DC Converter used for motors

- One DC-DC 48V to 12V (40A) Step down Buck Converter – with its own safety fuse. Used to supply motor drivers (figure 15).

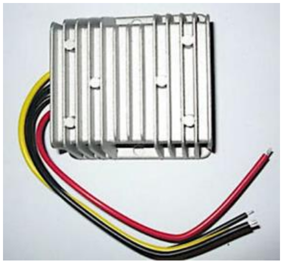


Figure 16: DC-DC Converter used for control

- One DC-DC 48V to 12V (20A) Step Down Buck Converter used to power Cameras, LED light system, Arduino ADK Microcontroller Board (Figure 16)

2.3. Power Distribution

In order to avoid any mistake in connections and reduce the number of wires inside the power enclosure, power received from the DC-DC converter passes through a connector which in turn distributes the power to the eleven motor drivers via eleven connectors with safety 10A fuse for each motor driver.
This Table shows power needed to operate Dolphin ROV:

Unit	Current (A)	Volt (V)	Power/Unit	Quantity	Max Power (W)
Thrusters	8	12	96	8	768
Gripper Motors	8	12	96	2	192
Bilge Pumps	3	12	36	1	36
Arduino	0.75	12	9	1	9
Camera	0.75	12	9	4	36
LED	0.75	12	9	3	27
Peak Power Available (22.375A * 48V)					1074

Table 3: Power Needed

2.4. LED Lights

Dolphin ROV is equipped with three sealed SMD 5050 square LED modules to simulate real life ROVs. They are installed at the front, top and bottom of Dolphin's body (Figure 17). This will facilitate the ROV's vision in deep Polar Regions and in oil and gas off-shore areas and will allow the ROV to identify the algae to grab it and other tasks.

Figure 17: SMD 5050 square LED module

3. Vision System

Four waterproofed wide view cameras are installed which will be used extensively in missions. The cameras are waterproofed but we used epoxy to seal the cameras from the back where the data and power cables, and around the lenses making them perfectly sealed.

Figure 18: Camera

- First wide view camera is installed on top of the front gripper to give us the exact knowledge of the gripper's position relative to the objects around it.
- Second wide view camera is mounted for overhead view of Dolphin ROV’s surrounding medium in order to aid in missions such as determining the algae on the surface.
- Third wide view Camera is used for bottom view of the ROV to see the gripper rotating the valve.
- Fourth wide view camera is used for rear view

4. Control System

4.1. Motor Drivers

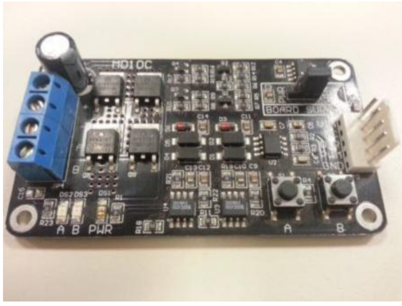


Figure 19: H-Bridge

11 Motor drivers (Figure 19)are connected to the DC converter. These drivers are of type MOT- D-1015 and dimension 7.5 cm*4.3 cm. They are capable of driving high current DC motors up to 10A continuous and 15A peak current at motor start.

These drivers support both locked-anti phase and sign-magnitude Pulse Width Modulation (PWM) signal as well as using full solid state components resulting in faster response time and eliminating the wear and tear of the mechanical relay, in addition to supporting motor voltage ranges from 3V to 25V and no heat sink is required. Just like the DC converter it is easy to fabricate motor drivers but this was also going to be time-consuming and the cost would be approximately equal to the purchased ones. The rarely used technique of PWM soft start was applied here to prevent current from reaching about 6 times the normal operation at the start of motor operation.

This table shows the H-bridges PWM Technique output power percentage, at ROV full power operation:

			Dolphin ROV H-bridges										
			Bilge Pump				Bilge Pump				Grippers		
			1	2	3	4	5	6	7	8	1	2	3
Dolphin ROV Motion	Horizontal	Forward	100	-100	100	-100	0	0	0	0	0	0	0
		Backward	-100	100	-100	100	0	0	0	0	0	0	0
		Lateral R	100	100	-100	-100	0	0	0	0	0	0	0
		Lateral L	-100	-100	100	100	0	0	0	0	0	0	0
		Rotating R	100	-100	-100	100	0	0	0	0	0	0	0
		Rotating L	-100	100	100	-100	0	0	0	0	0	0	0
	Vertical	UP	0	0	0	0	100	100	100	100	0	0	0
		Down	0	0	0	0	-100	-100	-100	-100	0	0	0
		PitchingF.	0	0	0	0	100	100	-100	-100	0	0	0
		PitchingB.	0	0	0	0	-100	-100	100	100	0	0	0
	Grippers	Gripper 1	0	0	0	0	0	0	0	0	100	0	0
		Rotation	0	0	0	0	0	0	0	0	0	100	0
		Gripper 2	0	0	0	0	0	0	0	0	0	0	100

Table 4: PWM Output

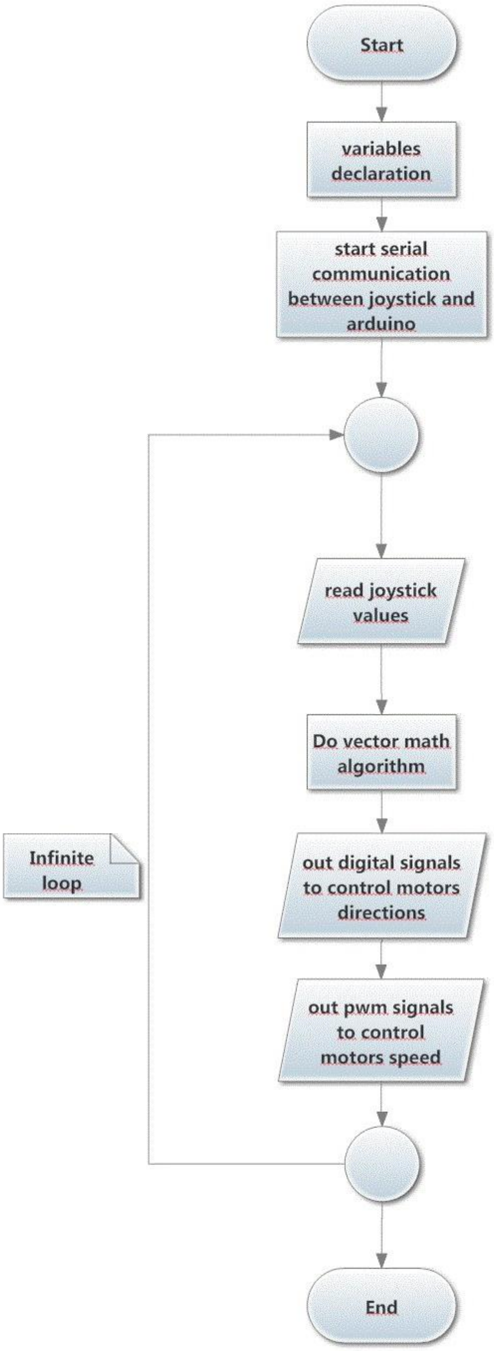
4.2. Software

Dolphin ROV software is simple but effective; it consists of two main parts; the base-station software at the pilot side and the on-board underwater software. Base-station software uses input from a joystick the Logitech Extreme 3D Pro Joystick (Figure 20), written with open source available Arduino software.

Figure 20: Logitech 3D Pro Joystick

On-board electronics consist mainly of an Arduino Mega ADK board. This exact brand of Arduino microcontroller was chosen although it was expensive compared to its counterparts as it has a powerful processor ATMega 2560and it features an ATmega8U2 programmed as a USB-to-serial converter. Its length and width are 10.2 cm and 5.3cm respectively operating7-12 input voltages and DC current of 40 mA having 54 Digital I/O pins, 15 of which provide PWM (pulse width modulation) output, and 16 Analog input pins and equipped with a boot-loader to upload new code to it without the use of external hardware programmer.

Software Layout:



This table that shows the impact of a full-scale deflection of the joystick:

		Joystick input (full deflection)		
		X	Y	Z
Dolphin ROV Horizontal Motion	Forward	512	612	128
	Backward	512	0	128
	Lateral Right	612	512	128
	Lateral Left	0	512	128
	Rotating Right	512	512	260
	Rotating Left	512	512	0

Table 5: Joystick Readings

5. Payload Tools

5.1. Algae Sample

In task one "**SCIENCE UNDER THE ICE,**" it is required to collect sample of algae. After many discussions between the team members, the company decided to build a device that will be fixed on the top left side of the vehicle's body frame. The device consists of a hollow plastic cylinder which has three flexible members fixed inside it with 120 degree spacing between each other which act as one-way gate. Once the sample is pushed inside the cylinder it will never be able to get out of it.

5.2. Pipeline Attachment Device

Figure 21: Hair Clip

In task two "**SUBSEA PIPELINE INSPECTION & REPAIR,"** it was a problem to find a solution of lifting the corroded section of the pipeline, we came up with an idea which is using a large plastic hair clip as an attachment device. This clip will be connected to the shore station by a rope that will help the station crew to lift the corroded section after attaching the clip to it.

5.3. Testing Anodes Device

For the task "**OFFSHORE OILFIED PRODUCTION & MAINTENANCE**," our team designed a small waterproofed sensor that can test the grounding of anodes. This sensor consists of a small LED in series with a resistance. By connecting the sensor across the testing point and the common ground, the LED will light up if there is voltage difference between them.

5.4. Moving water through the pipeline system

Figure 22: Rule™ Bilge Pump

In task three "**OFFSHORE OILFIED PRODUCTION & MAINTENANCE**," it is requiredto verify that oil will flow through the correct pathway by moving water through the pipeline. Our company decided to use a 550 GPH bilge pump to perform that task. The pump is fixed on the vehicle's body frame. The bilge pump will pump water through the 1 ½-inch PVC coupling of the pipeline. Our team chose the 550 GBH bilge pump because of its cheap price and efficiency to perform the required task.

5.5. Water flow rate sensor

Figure 23: Water flow rate sensor

Water flow rate sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor, when water flows through the rotor, rotor rolls. Its speed changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse signal. In the third task it is needed to measure the average flow rate of water through the flume tank, our company will use the sensor to accomplish that task.

IV. Safety

We consider safetyandhealthofallemployeesto be themost importantaspectof ourwork. Thecompany will comply withall workplacesafety requirementsset forthandasafety managerwill beresponsibleformaintainingallsafety issues. Hewill use the company's safety check listdailyto conduct routineinspections (refer to appendix A.)He willalsoensureemployees are equipped withnecessary protectiveequipmentandthat theyare usingtools inasafeway.Furthermore,hewillenforcethesesafety rulesand investigateaccidentstoprevent them fromoccurringinthefuture. Safety is divided into two categories as follows:

A. Workplace Safety:

- Safety labelsthroughouttheworkshop (Figure24).
- Employeetraininginworkshopsafety.
- Gogglesused duringcuttingandweldingof mechanicalparts (Figure26).
- All chemicals such as epoxy and NeverWet® (Figure25) liquid repelling treatment are handled using safety gloves.
- Lifejackets arerequiredduringROVtestinginwater.

Figure 24: Safety labels

Figure 25: NeverWet®

Figure 26: Following Workplace Safety

B. Dolphin ROV Safety Features:

- Safety electricallabelsonvehicle.
- Kort nozzles surround each propeller (Figure 27).
- Heat shrinks usedextensively (Figure 28).
- Sharp edges had been sawed off and covered by wax.
- Curved androunded edgedframe.
- Housing is made from polyethylene which is non-conducting
- Fuse board-withstanding10Ainserted before each motor drivers.
- LED indicatorson theArduinoshield.
- Ahighsensitivity waterdetection sensormoduleof model 1SEN11304P(2.0 cm*2.0cm) is used todetectliquidleakage.

Figure 27: Kort Nozzles

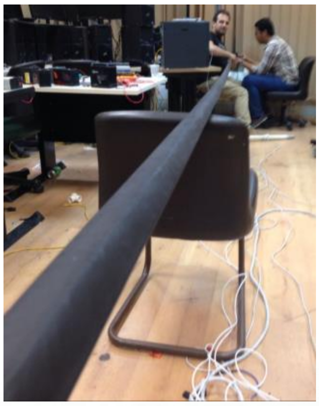


Figure 28: ROV Cables, in heat shrink

V. Company Structure, Teamwork& Project Management.

Dolphin ROV is a product resulting from teamwork and interaction between all the team members of the company. A team hierarchy was established at the very first meeting. Each member was designated to a specific role of CEO, financial manager, electrical team leader, mechanical team leader etc. The CEO would divide tasks between different departments and hand these tasks to team leaders who, in turn would work on the tasks with the team members. The technical report and the poster are also a group effort as a head was assigned to mentor their completion by requesting certain sections from different teams.

Weekly meetings were held where team members would report the progress of their specific assignments and a schedule was set toaid in building the vehicle. Sometimes there were a few time delays and straying from the schedule but we managed to finish the work within the set time frame. To ensure that Dolphin ROV is prepared to compete in the competition our team used various ways such as a Gantt chart (Figure 29), Critical path method (CPM) and Program Evaluation and Review Technique (PERT) to guide their decisions regarding resourcesand time. We also decided to employ a heavy usage of flowcharts and networks to plan and coordinate activities. (Figure 30) shows the TORBINI team job diagram.

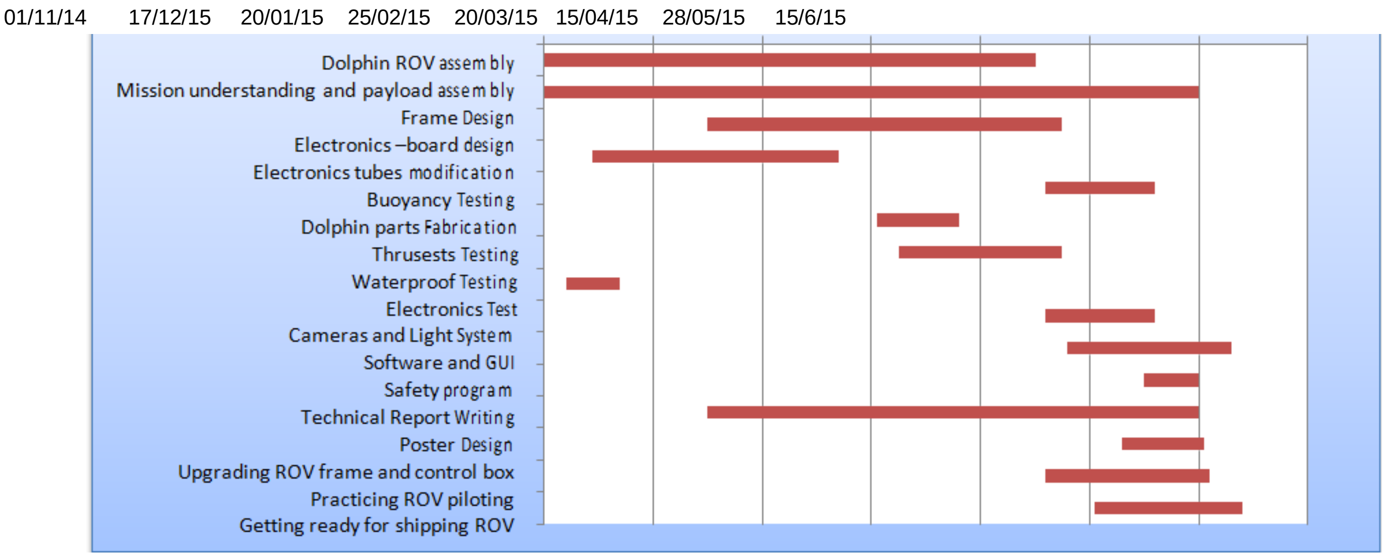


Figure 29: Gantt chart

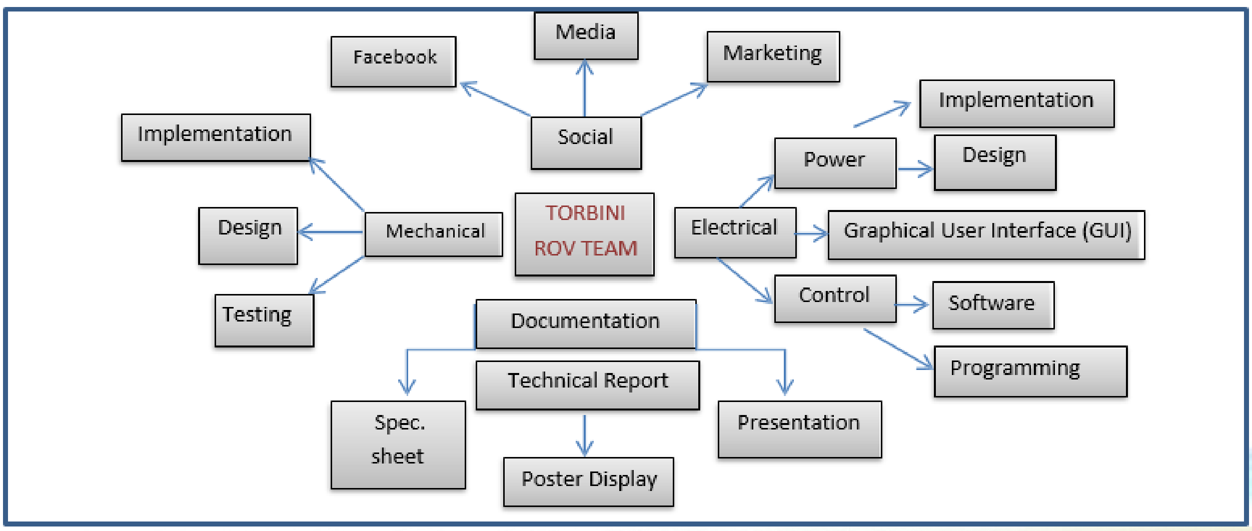


Figure 30: Torbini Team Job Diagram

VI. Challenges

A. Technical Challenges:

The biggest constant challenge that faces us each year is sealing the ROV (Figure 31). We learnt a lot from our past experiences with sealing and reached the best sealing technique. This year a new method was used after many trials and errors and testing underwater using materials ranging from Epoxy, gasket sealing, silicon, and foam. Our new method which has proven to be 100% effective consists of using the polyethylene tube enclosures and O-rings in between while using **Epoxy** and the commercial product **Rust-Oleum®NeverWet®** liquid repelling treatment extensively.

Figure 31: Sealing Test

Another challenge was to figure out how to program the Arduino to read the analog signals sent from the joystick controller to control the ROV's movements. Refer to the software section page. We also had to find out easy and affordable ways to solve our missions such as holding the algae sample and opening and closing the valve.Through brainstorming during our weekly meetings we found out ways to solve the missions easily.

B. Non-Technical Challenges:

One of the biggest non-technical issues was that we didn't have a place to work in since the college lab was unavailable for us to work in. After delaying the work for a while, a team member provided an empty apartment to work in. In addition to the sudden lack in number of team members, since most of our team members had to travel and some were busy doing their graduation projects so we ended up a being team of four people working, work wasn't divided the right way, we were pretty late on schedule but we managed to get the job done.

VII. Trouble Shooting

Troubleshooting is an important process that was utilized by our team during the project. Each part of the ROV was tested after it was produced and then when the whole vehicle was built, it was tested under water numerous times. Whenever we were faced by a problem we used the technique shown in (Figure 32). We identified the problem correctly then we developed alternative solutions and chose the best alternative. Finally, the chosen solution was implemented.

One of the problems faced was that after we installed the cameras in our ROV and fixed them tightly, two cameras experienced problems in video streaming as the image quality was distorted and accompanied by noise, one camera even broke down during the regional competition. We used our technique of problem solving: Alternatives

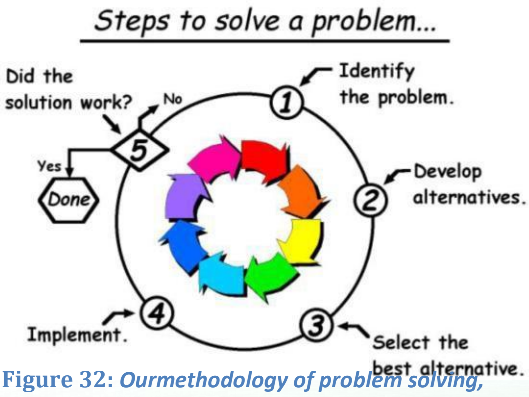


Figure 32: *Ourmethodology of problem solving, courtesy of*www.thecollaboratory.wikidot.com

were considered and we bought new cameras, sealed them using epoxy around the electrical wire entering the cameras from the back to seal them completely. We tested the cameras under water and they worked perfectly.

VIII. Future Improvement

Dolphin ROV is subject to continuous changes and improvements whenever needed that will include:

1) Our ROV is operating on an open-loop control at the moment, later it will be converted to **closed-loop control** giving accurate feedback through a gyroscope and an accelerometer. Providing a PID algorithm to our ROV will be highly stable and this will help us a lot in accomplishing the required missions.

2) Replacing traditional copper cables with **Fiber-optic cables** to transmit information over a much larger distance and with a much higher bit rate. Digitized information is placed onto light pulses for transmission using a laser and travels along the glass fiber at the speed of light. We will install two fiber-optics; one for transmitting information and one will be used as a spare.

IX. Lessons Learned

A. Technical lessons learned:

At first our mechanical department designed and constructed the ROV to operate using six thrusters. Two thrusters were installed for vertical motion and four thrusters for horizontal motion. Power was calculated and the team thought that the resulting power, number and layout of thrusters were enough to drive Dolphin ROV and give it all the degrees of freedom it required.

However, after testing Dolphin ROV underwater it became unstable and did not move smoothly. We had to change the number and way of installing thrusters completely. The new setting was using four thrusters for vertical motion and four thrusters positioned at 45°for horizontal motion. We learnt from this example that we should not depend on our calculations and take them for granted. We should always test our progress step-by-step before finishing, so that we do not need to repeat the work again and waste valuable time.

B. Interpersonal Lessons:

The project of building Dolphin ROV gave us lots of interpersonal skills. We were a micro-society consisting of old and new members from different majors, backgrounds and genders. We learnt a lot from each other, gaining skills of time management, organizational skills, and presentation skills. Technical aspects were passed over from older, more experienced members to the newer members. If there is one thing that can be modified next year that would be adhering to a stricter time frame so that we do not find ourselves loaded with tasks as our exams and the competition deadline drew near.

X. Team Reflections

"Working on the mechanical parts helped me in my field of study, but what benefited me the most is learning all electrical, electronic and software aspects related to our ROV. I've gained essential skills that will aid me in any future projects I embark. ROVs garnered my interestso much that I am considering pursuing an ROV-related career later".
Mahmoud Badra-CFO and Pilot

Figure 33: Mahmoud Badra

Figure 34: Yousef Awad

“As a Mechatronics Engineer I have gained all the knowledge that I need to learn from both the electrical and computer departments in just a couple of weeks. The hands on experience that I’ve gained will benefit me for a life time. I hope I continue participating in more projects in the ROV field in the future”
Yousef Awad- Operations, Mechanical Team.

Outreach

Our team was always keen on spreading scientific knowledge especially ROV knowledge with fellow students and colleagues all year-round. Starting with a pre-workshops session (Figure 34) given at our college (The Arab Academy for Science and Technology and Maritime Transport) in order to educate students as much as possible about remotely operated vehicles, continuing with other sessions spread throughout both semesters (Figure 35).

Figure 34: TORBINI Team tutorial sessions

Figure 35: Sessions for all semesters

XI. References

1) Harry Bohm and Vicki Jensen (1997) "Build your own underwater Robot and other wet projects".

2) Robert D-Christ and Robert L.WerlniSR (2007)"The ROV Manual: A User Guide for Observation Class Remotely Operated Vehicles".

3) MATE – Marine Advanced Technology Education**"www.marinetech.org"**

XII. Acknowledgments

We would like to thank the following organizations and individuals:

• **AAST** (Arab Academy for Science, Technology and Maritime Transport) for the financial support, hosting the regional competition and allowing us to use the pool for ROV testing.
• **Prof.Dr.Ossama Ismail** for mentoring and providing technical support.
• **Engineer Islam Wageed** for facilitating the working environment and co-coordinating our logistical issues.
• **Engineer Mohammed Fouad** for providing engineering consultations and for providing us the Mechanical work shop.
• **Industry Service Complex** at AAST for being such a great machining resource
• **MATE Center** for organizing the international competition and bringing together so many competitors and organizations in one think tank.
• **Hadath** organization for helping and organizing the regional competition.
• Our mentors **Engineer Ahmed Ramy** and **Engineer Mohamed El Bana** for their continuous help and support.
• Our colleague **Mai Faramawy** for her help on the technical report
•Our colleagues Khaled Hamdy and Amr Elgohary for their help .

XIII. Appendices

A. Safety Checklist:

Date of Inspection: / / Time of Inspection:

		Workplace Safety	
Lab	1	No loose or entangled wires	
	2	Electrical Equipment tested prior to usage	
	3	People working with electrical equipment have been given proper training	
	4	Are all power points, light fittings and switches in a safe place	
	5	Staff are using safety goggles	
	6	Medicine cabinet is adequately filled with all necessary first aid kit	
Fire	7	Are all escape routes free from obstacles, including furniture and electrical equipment	
	8	All Team members have been given full instructions and training in escape and assembly points, and fire precautions	
Pool 9		All team members wearing life jackets	
	10	Appropriate shoes are worn	

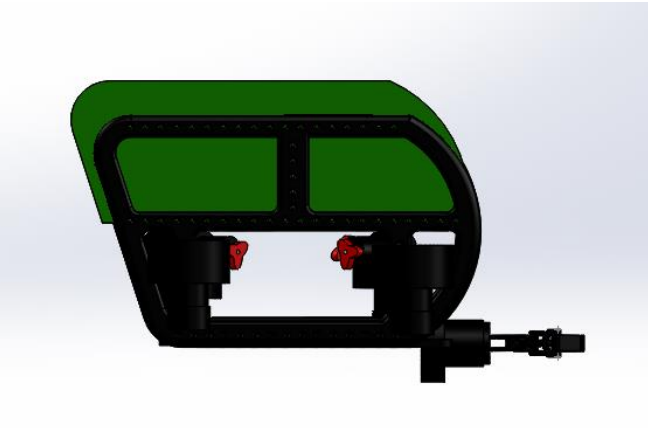
		ROV Safety	
	1	Safety Labels	
	2	Propeller Kort nozzles fixed	
	3	Fuses in place	
	4	Connections are secure	
	5	No leakage	
	6	No live wires	
	7	No sharp edges	

Safety Manager:………………….. Signature

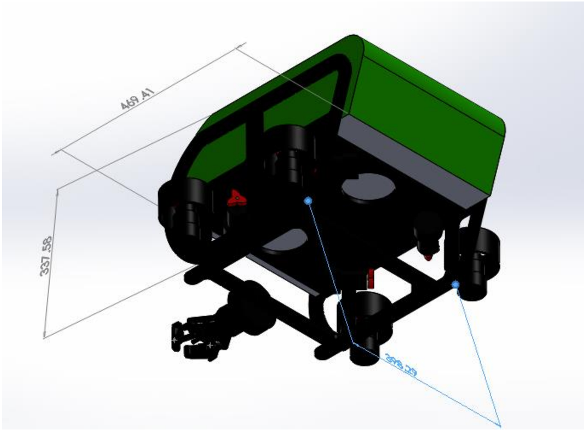
B. Budget

	Required itmes	Total (USD)
Electrical	Electrical Tools	39.00
	Motor drivers	228.80
	Control unit	45.50
	Thrusters	416.00
	DC/DC Converters	130.00
	Joystick	91.00
	Electrical Connectors	26.00
	Light system	6.50
	Sensors	78.00
	Tether	52.00
	Electronics components	13.00
Mechanical	Cable Galands	19.50
	Fiberglass cover	91.00
	Enclosure	32.50
	Buyouncy foam	3.25
	Sealing Tools	6.50
	O-ring	6.50
	polyethylene sheets	78.00
	Pipe Attatchment Device	6.50
	Hand tools	13.00
	Machining/CNC/Drilling	130.00
Printings	Technical Documentation	13.00
	Marketing display	39.00
	T-shirts	195.00
Travelling	Transportation to Regional	130.00
	Transportation to Internationa	10000.00
	Meals	260.00
	Total	12149.55

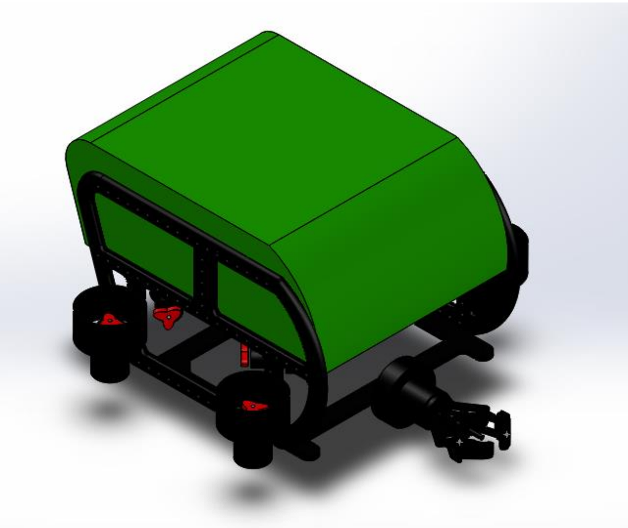
C. Dolphin ROV SolidWorks™ Design Views



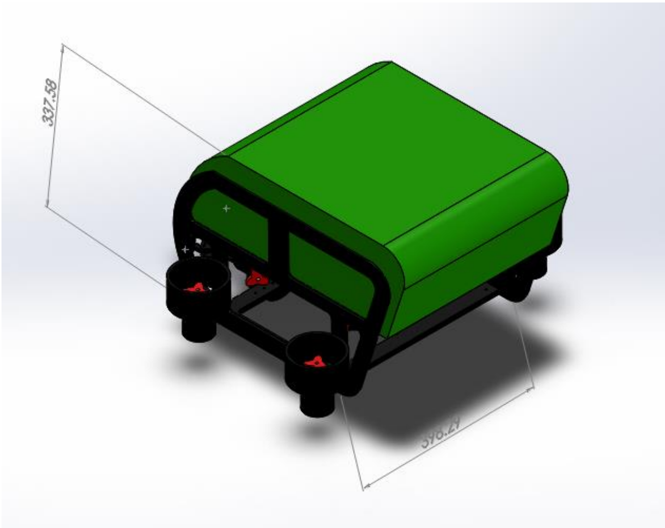
3D assembly Side View



3D assembly Back View



3D assembly Front View



3D assembly Top View