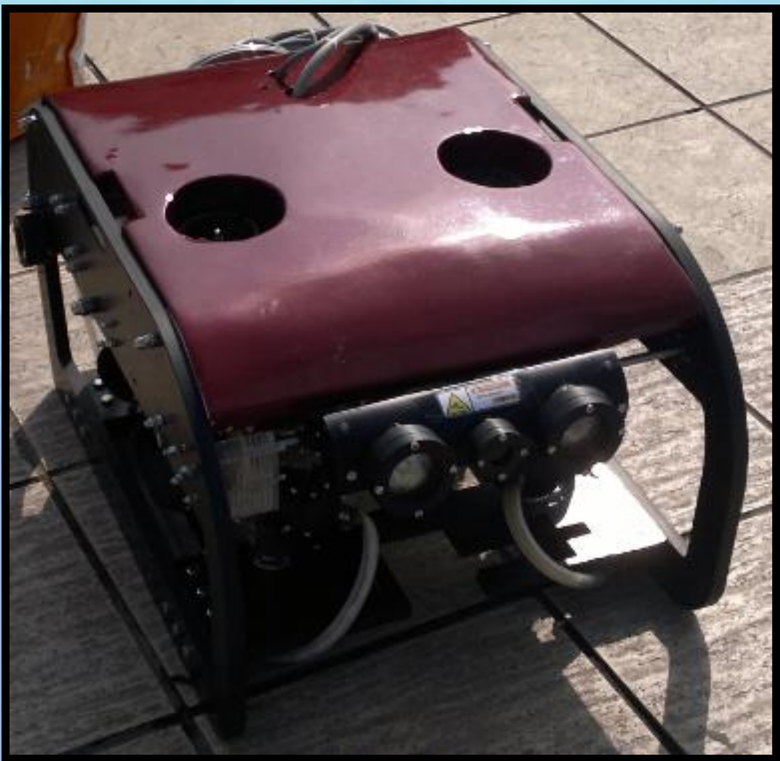
Faculty of Engineering,
Alexandria University, Egypt

AQUAPHOTON

The Systems & Designs of

The Admiral 2



Company members

- Abd Elrahman Samir (CEO, CFO)
- Mostafa Hafez (Mechanical Team captain)
- Ahmed Saeed (pilot)
- Mohamed Mosaad (Safety Officer, Technical Writing)
- Moataz Tarek (Presentation Director)
- Mohamed Farouk (Tetherman, Workshop director)
- Mostafa Abd Elaal (media Director)
- Omar Ibn Elkhatab (Electrical Team captain, Co-pilot)
- Mohamed Hassan (Electrical system designer)
- Mohamed Zaytoon (programmer)

Mentor

- **DR. Mohab Hossam (Faculty Advisor)**

1.2 Abstract

The Admiral 2 is a masterpiece ROV, designed and Fabricated by AQUAPHOTON Company; to compete in Marine Advanced Technology Education (MATE) International ROV Competition, It is the third time for AQUAPHOTON team to participate in MATE competition. All team members are studying Electromechanical Engineering at Alexandria University, and expected to graduate in June 2014.

The Admiral 2 was such a hard ROV designed, built, and tested; to accomplish underwater tasks involved in observing and simulating ocean activities. The ROV brought to life after several designs using CAD programs; to make sure that the vehicle would fit the necessary criteria to accomplish the desired mission.

The hull was well designed; to insure good assembly, perfect shape, and minimum drag force. The Admiral 2 is equipped with six powerful thrusters for smooth propulsion in both the horizontal and vertical plans. Two degrees of freedom manipulator is used; to make sure that the job is done clearly and simply. The vision system of The Admiral 2 has 3 wide angle cameras, which give a complete view of the environment and the manipulators using a camera tilting mechanism. Fibre glass is used to cover the foam upper layer; for the maximum strength and the best shape. An electric canister -made of stainless steel- contains all the electronic circuits, which are custom built for The Admiral 2; thus enabling high efficiency and minimum budget. Safety precautions is so important for AQUAPHOTON Company to ensure maximum benefit for the project and minimum careless accidents.

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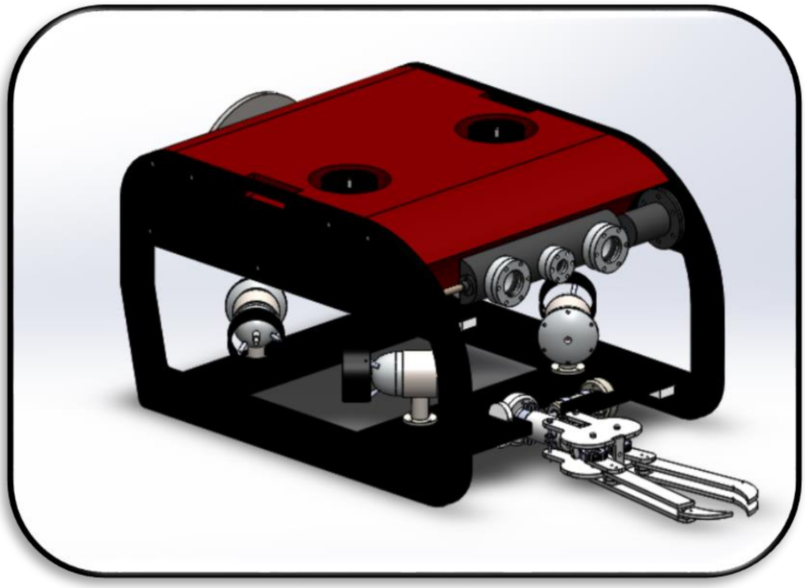
2.0 Design rationale

All the parts of Admiral 2 are designed and fabricated by AQUAPHOTON CO. in order to perform the specific mission tasks. The simplest way, the perfect shape and market availability were our three main criteria for choosing our designs and the result was so satisfying for our Company. The first step in the design was brain storming to get largest number of ideas and choose the most suitable one for us. The company members used the SolidWorks student license CAD software to help them in the design phase. The third step was manufacturing. And the last step was the assembly and testing.



Full CAD Design

2.1 Frame

The frame design is based on providing mechanical strength to the ROV, and to provide a base structure to assemble different ROV systems. The frame shape is streamlined; to ensure minimum drag on the ROV during operation. The design parameters for the frame is the Mechanical strength, low drag resistance to water and ease of assembly

Available materials and manufacturing techniques

1.Aluminum-Fiber composite.

It has the advantage of low cost, but machining process is manual and not accurate

2.Polyurethane.

The raw material is in a liquid form and is poured in a mould and left to cure. This choice was very good as the material provide high mechanical strength; the only disadvantage is the high manufacturing cost as it needed a mould to get the required shape.

3. Nylon sheets - TECAMID PA6 GF30 polyamide. (The chosen material)

Semi-crystalline thermoplastic with good damping capacity, good impact strength, high degree of toughness, and good wear-resistance. The machining process for the sheets is CNC router (computerized numerical control). It provided a very precise fabrication.

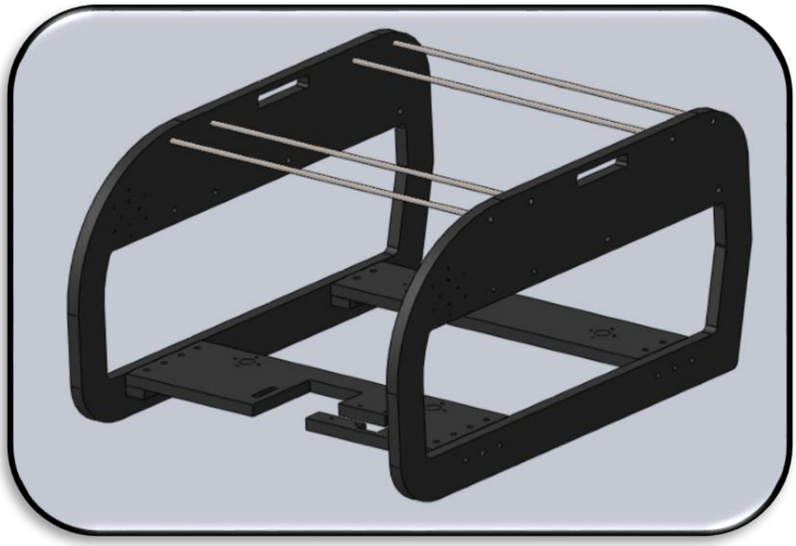


Fig.1 CAD design of the frame

Material properties in dry/wet conditions:
Modulus of Elasticity= 8500/6000 MPa
Ultimate Strength = 140/110 MPa (brittle)
Elongation at break = 2.5% / 5%
Hardness (ball indentation) = 147 MPa
density = 1350 Kg/m³
Water absorption at saturation = 6.6%

Fig.2 dissembled parts of the frame

Advantages of the frame shape

1. It was designed in such a way that allows putting the ROV on 5 of its 6 faces to provide easy access to all ROV mechanical parts; thus providing easy maintenance.
2. Easy handling of the ROV.
3. Ease of assembly. It is assembled with one tool because all fixation bolts are the same size.
4. Elegant shape; because of the appearance of the material, and the stainless steel fixation bolts to avoid rust

Using these date, stress analysis on the frame was done to see points of maximum stress and ensure safe design. (Using SOLIDWORKS)

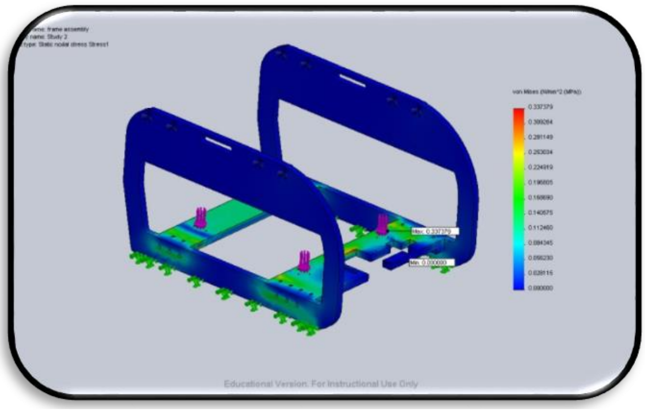


Fig.3 Stress plot for the bottom plates of the frame

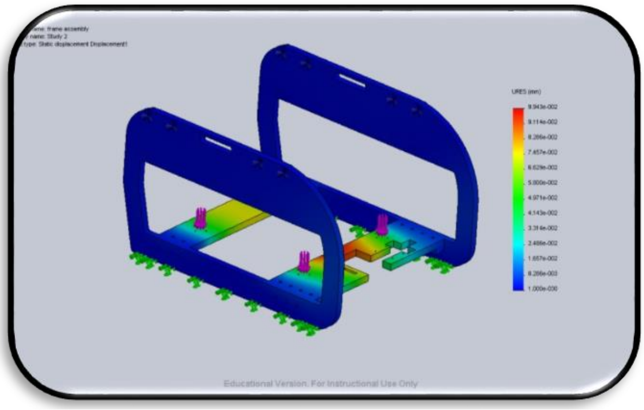


Fig.4 Displacement plot for the bottom plates of the frame

2.2 Thrusters

The thrusters are the ROV's Mechanical power source, which allows the ROV to move in all direction with the minimum losses of drag force. The thrusters enables the ROV to move smoothly in both the horizontal and the vertical plans. AQUAPHOTON Company decided not to buy a thruster of another company and started to build her own thruster. All thrusters used are full designed and fabricated by the company.

Available materials and manufacturing techniques

1-Stainless steel Material
it has the advantage of high rust resistance, mechanical strength good appearance, so it was used as a shaft's Material but it was excluded as main case material due to its high cost.

2-Aluminum
It was excluded due to its reaction with water forming salts on its surface.

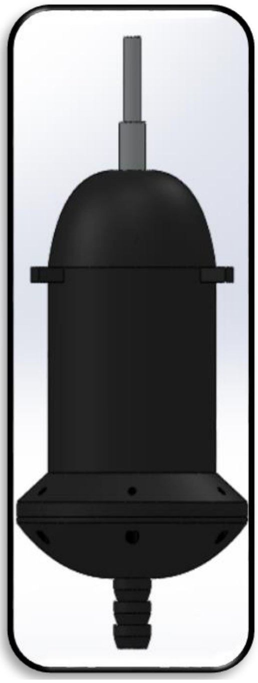


Fig 5 CAD design of the thruster

3. **TECAMID PA6GF30 polyamide. (The selected material)**
It is a Thermoplastic material, so the rust is totally avoided, high mechanical strength beside its easy machining process.

this Design has many advantages of low drag force, small size, ease of maintenance and high power to weight ratio. Machining methods used are Centre lathe machine, gasket casting and welding for fixations

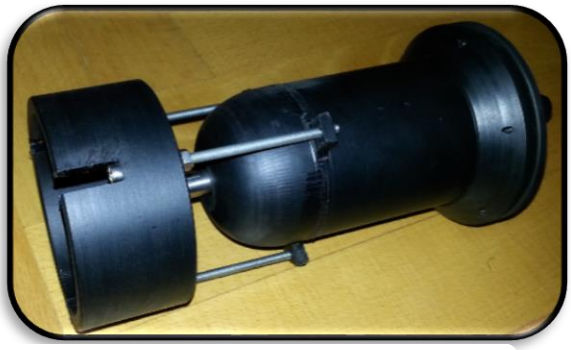


Fig. 6 thruster

Motor specification
Type: Canon brushed DC motor
Voltage Rating: 24 V
noload Current: 0.4A
Load current: 3A
Full load current: 8A
Power : 72 Watt
RPM : 1350 rpm

Propellers' specification

Pitch: P1.4.
Diameter: 70mm.
The shaft size: 6.35mm

Fig. 7 used propeller

2.3 Electric cylinder

The goal of this design is to make a totally secured cylinder for electric boards which give the maximum safety considerations and prevent any leakage with the minimum drag force

The available material and manufacturing techniques

1-plastics
we avoided choosing the plastic cylinder for the bad machining, high cost and a fragile material

2-stainless steel (The selected material)
this material is used due to its High surface finish, can withstand impact loads and high pressures.

Most of electric canisters have two shapes, box shape or a cylinder shape. We used the cylinder shape because it produces low drag resistance to water and easier in machining compared to the box shape. Also the cylinder shape can with stand higher pressures than that of the box shape. The dry housing designed was a perfect fit for all of the electronic circuit and leaves no wasted space.

According to our design we have two options in machining the electric canister, using CNC machining which is so expensive according to our budget, the other solution was centre lathe machine which is characterized by acceptable surface finish and low cost.

Fig. 8 Electric canister

Sealing method: To give the best sealing standards and prevent any leakage we decided to use 2 square cross-sectional surface seals in sealing the cap of the canister and a group of bolts to insure a full contact between the surface seal, the cap and the cylinder's flange. For sealing the wires, one of our Engineers came with a great idea. We used nozzles and hoses system used in gaseous application. This idea was so effective and used for sealing the wires of the whole ROV. The nozzle is welded to the lateral area of the canister to connect the motors, lights and tether to the circuits

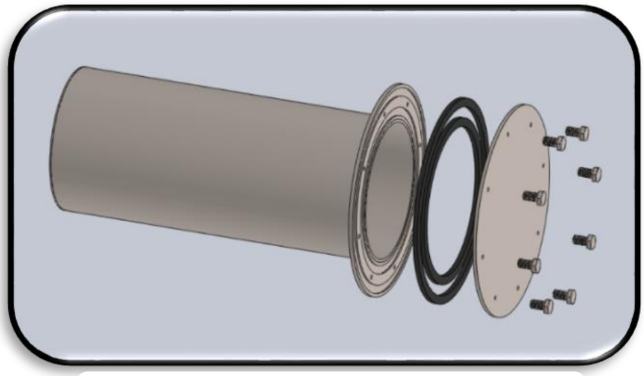


Fig 9 disassembled electric canister

Fig. 10 nozzle

2.4 Vision System

The goal of the cameras is to provide clear vision to the pilot and help him locate and navigate the ROV at subsea levels. The admiral 2 has 3 cameras for a complete view of the environment and the manipulator, the first camera is installed on a tilting mechanism enabling the pilot for a wide range of vision, this main camera is used to show the pilot his target and measure the shipwreck dimensions. There is two powerful light spots installed on the tilting mechanism for a better vision underwater.

Fig. 11 tilting mechanism

The second camera is used to show the platform under the ROV to help the pilot interact easily with the manipulator. The position of this camera can be changed according to the mission needed to accomplish. The third camera is installed for the rear view of the ROV as part of the mission may requires backward motion. The casing is made of a Thermoplastic material called polyimide characterized by low cost, good shape and ease of machining. A surface seal is used in insulation of cameras and lights casing. For the wire insulation, the same idea of nozzles and hoses is used.

We used USB DVR which allows us to monitor our 3 cameras simultaneously on Laptop screen, with a live view. This DVR is used to Record a live video or take snapshots.

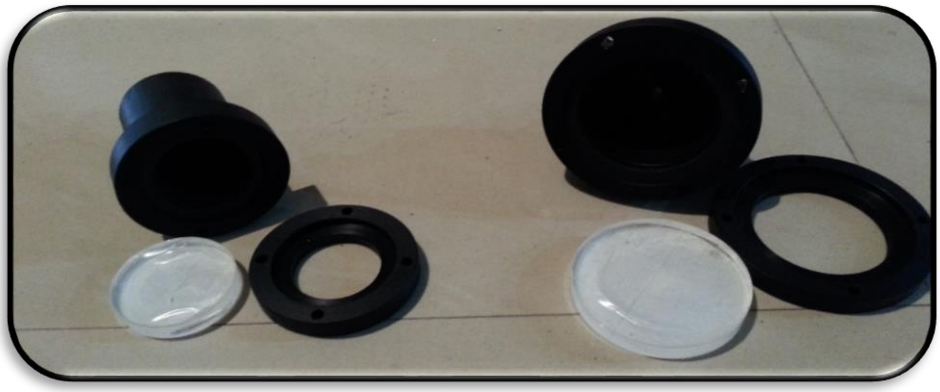


Fig. 13 cameras casing

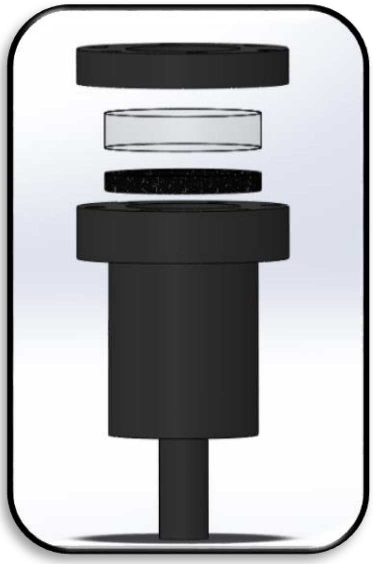


Fig. 12 camera CAD design

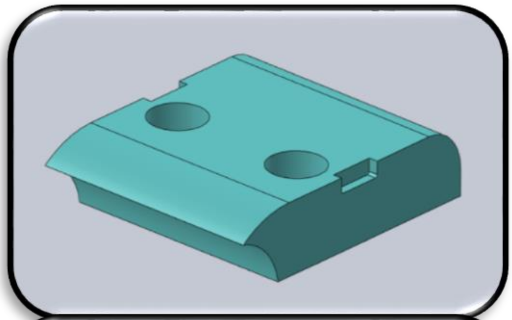
2.5 Buoyancy

The design requirement was to make slightly positive buoyant ROV; in order to be easier in flying and manoeuvring, and to allow the ROV to return back to the surface in case of electric or mechanical failure. This was done by calculating the overall weight of the ROV, including the weight of the foam; in order to calculate the amount of foam needed to reach the design goal.

ROV total weight = 48 Kg
Foam Volume needed = 0.020766 m^3

According to these calculations, using Archimedes law. The total weight is slightly lower than the buoyant force resulting from the volume displaced by the ROV; thus making the ROV slightly floating.

Fig.14 overall shape of the foam



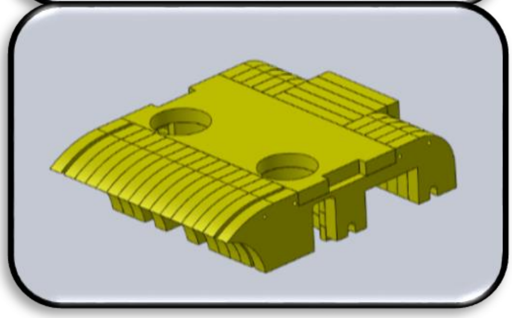


Fig. 15 CAD assembled Foam parts

Material used in manufacturing the Buoyancy is Extruded Polystyrene foam with density of 35 Kg/m^3 and a compressive strength of 300 KPa. This material saves its quality and properties to 30m depth under water.
We used a unique method to manufacture the buoyancy foam with the designed shape. The total volume of the foam was divided into small parts so that we can cut the foam parts using CNC laser cutting. These small parts were then assembled and glued together to form the integrated shape of the foam. The foam was then covered by a layer of fiberglass for more strength, and to give a good looking shape to the ROV. The mould for the fiberglass was made of Acrylic; to give the fiberglass a better surface finish.

2.6 Balance Box

The main goal of the balance boxes is to easily shift the Cg (centre of gravity) point to the desired place between the two vertical thrusters. We made 2 balance boxes fitted on the 2 sides of ROV along its length to shift the Cg forward and backward and 1 balance box fitted along the width of ROV to shift the Cg left and right for any asymmetry

The balance box consist of washers and a shaft between them so if you want to increase the weights, all you have to do is to increase the number of washers, if you want to shift the weights to shift the Cg you have to move the washers on the shaft. We chose steel washers to give us maximum weight to volume rate. As an initial start in the balancing terminology we start by a small percentage of the total mass of balance boxes which is 306 gm. of the total mass =865 gm. This allow us to have additional backup weights in case the ROV in floating or not stable in the balance experiment. These balance boxes are small, simple in building and considers as a quick release masses

Fig. 16 3 balance boxes

2.7 Manipulator

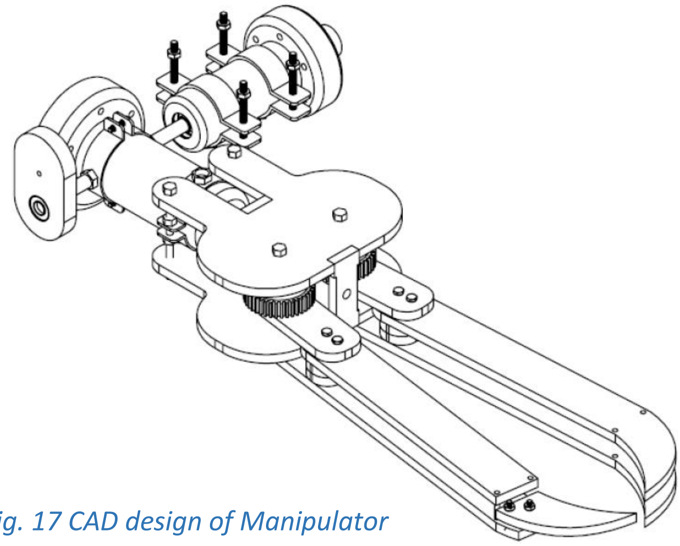


Fig. 17 CAD design of Manipulator

The Admiral 2 has one Manipulator with two DOF (degrees of freedom), moving up &down and gripping. This two motions allows the pilot to easily interact with any part on the playground. This unique design is custom built for the Admiral 2 to accomplish all needed tasks easily. The Gripper material, Gripper motor casing and arm motor casing are made of Nylon sheets TECAMID polyamide (Artinol) where this material has the strength needed and it can be machined easily. The gripper is made of 6mm thickness sheet and assembled with set screws. CNC Router is used to fabricate the desired part for the manipulator assembly.

The casing of the two motor are designed to insulate the motors from water. The insulation techniques used for these motors are the exact same techniques used for thrusters' insulation.

The gripper mechanism consist of a worm and 2 worm gears to transfer the motion from the rotating shaft to the two end effectors. The end effector has a special design to enable the pilot catch the plate inside the shipwreck

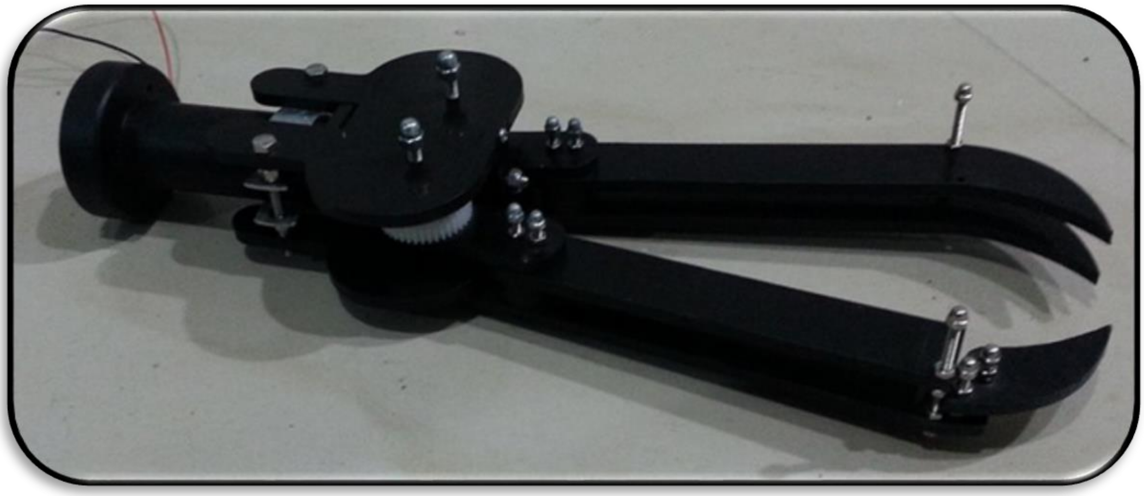


Fig. 18 assembled Manipulator

Gripper Motor Specification

Rated Voltage: 12 Volt

Speed: 200 RPM

Load current: 0.4 ampere

Full Load Current: 1 ampere

Arm Motor Specification

Rated Voltage: 12 Volt

Speed: 35 RPM

Load current: 0.4 ampere

Full Load Current: 1 ampere

Fig. 19 Gripper motor

2.8 Electric system

The Electrical circuits are enclosed in a stainless steel electric can fixed over acrylic sheet. It includes 2 types of circuits; communication circuits and power control that will be illustrated later. Fast connection plugs were added inside the electric can to avoid high cost and shipping problems of buying fast connectors. These plugs allows fast assembly and disassembly for the electronic boards for maintenance and troubleshooting problems

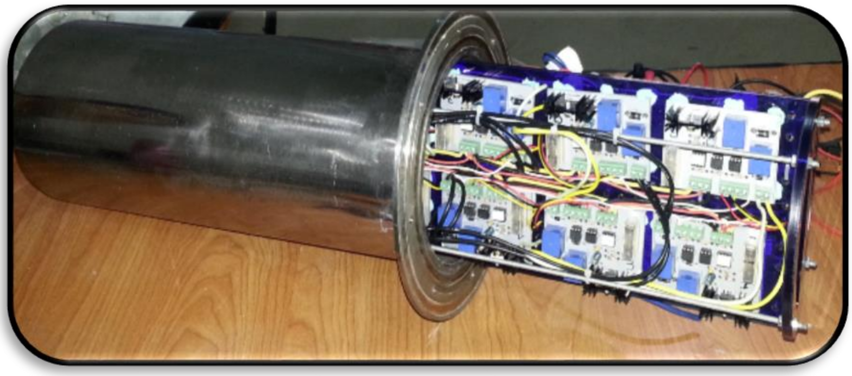


Fig. 20 electric circuits in the canister

Communication

We tried first to use RS485 communication between PICs, but unfortunately that communication was unstable. So we had to use Arduino. Five pins were used to transmit data from Arduino UNO (surface controller) to Arduino MEGA (underwater controller), and this provides us with the ability to give 32 commands while our needs is 18 commands. That communication was stable. We were able to interface the Arduino UNO with Laptop through serial communication through Putty software. As a backup plane we used PS2 controller by using PS2X library for Arduino UNO.

Electronics System Flow

A Laptop sends serial data to Arduino UNO that sends data to Arduino MEGA (underwater controller) to control motion of motors (used for thrusters, agar sample collecting mechanism, arm, gripper and camera motion) and Lights. Arduino boards are easy to interface and have stable operation.

Motors

We used Brushed DC Motors with sufficient speed and torque. We had problems with surges at start and stop especially for thrusters' motors, so we added soft starting and soft braking to prevent damage of our circuits, or damage of the fuse added to protect the circuit.

Motor Driver

We had problems with high current, so we used MOSFETs (Metal Oxide Semiconductor Field Effect Transistor) with heat sinks installed to dissipate heat. We also had problems with the MOSFET H-Bridge drivers available, so we had to give up the idea of making H-bridge with 4 N-Channel MOSFETs. So we used 2 relays with 1 N-Channel MOSFET to provide us with the desired operation. A freewheeling diode is used to provide a path to current. 48 volt is input to the circuit .PWM (Pulse Width Modulation) and direction signal are input to the circuit so that 24 volt is output voltage to the thrusters. We don't have control over speed; instead a fixed PWM is assigned to each motor to give adequate smooth motion underwater.

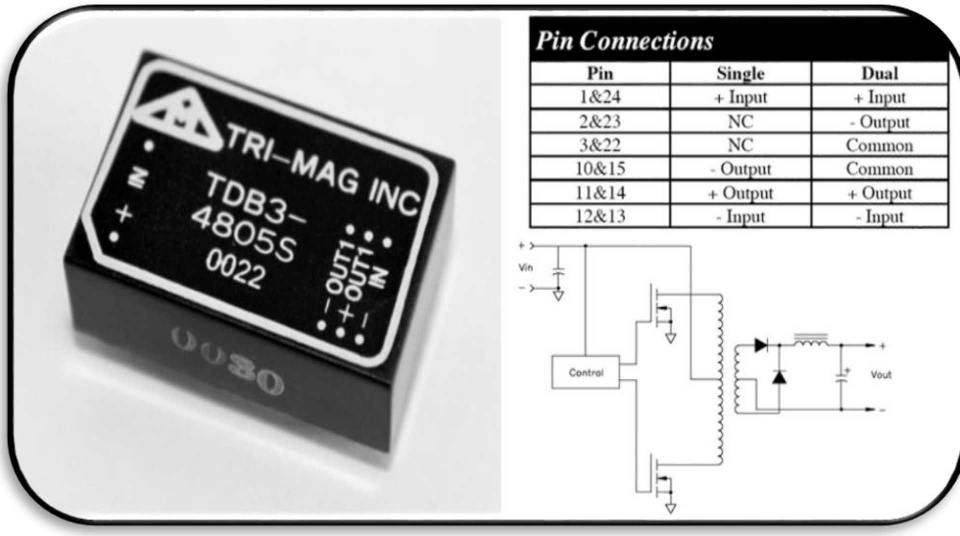
Light Circuit

Based on a 1N-Channel MOSFET, to its gate PWM is input to control voltage over the Lights to give adequate light intensity.

Voltage Regulation

There was many options for voltage regulation part but our choice was to buy a DC to DC converter to regulate the 48 volt to 12 volt as a power source for cameras. This converter is characterized by stable output voltage, suitable current rating for our application (5A) and protected by a 5Ampere fuse.

Another 48 Volt to 5 volt converter is used as a power source for the Arduino. This converter is characterized by isolated ground.



Pin	Single	Dual
1&24	+ Input	+ Input
2&23	NC	- Output
3&22	NC	Common
10&15	- Output	Common
11&14	+ Output	+ Output
12&13	- Input	- Input

Fig. 21 48/5 DC to DC converter

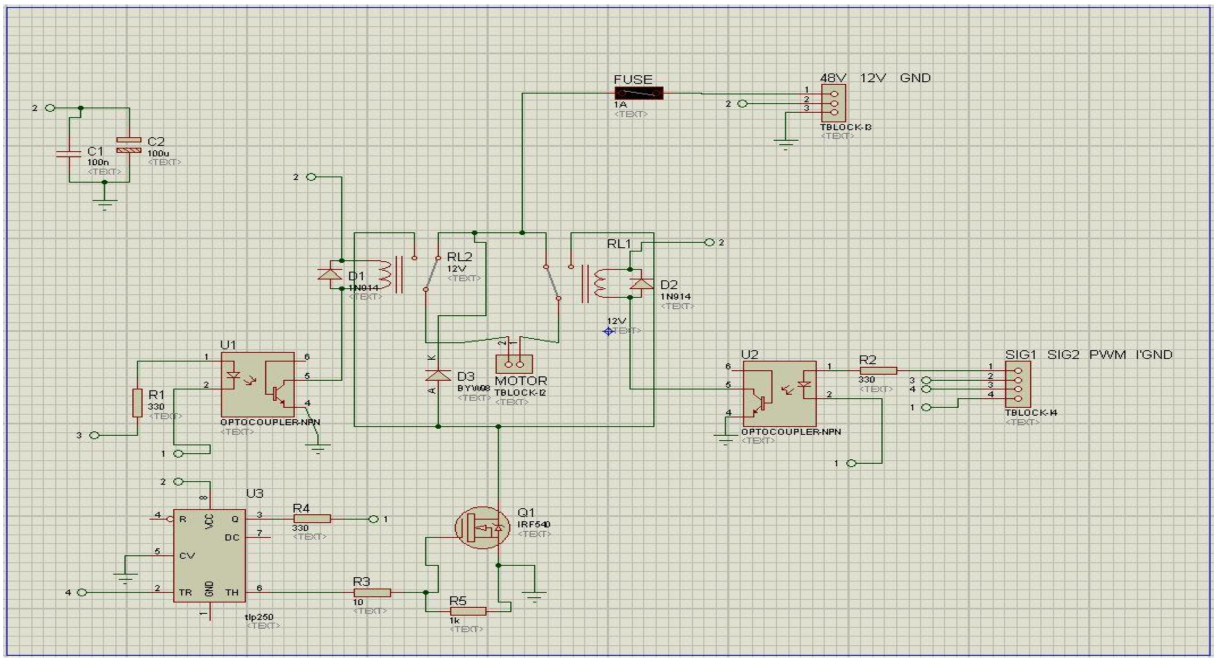


Fig. 22 electric schematic of motor driver

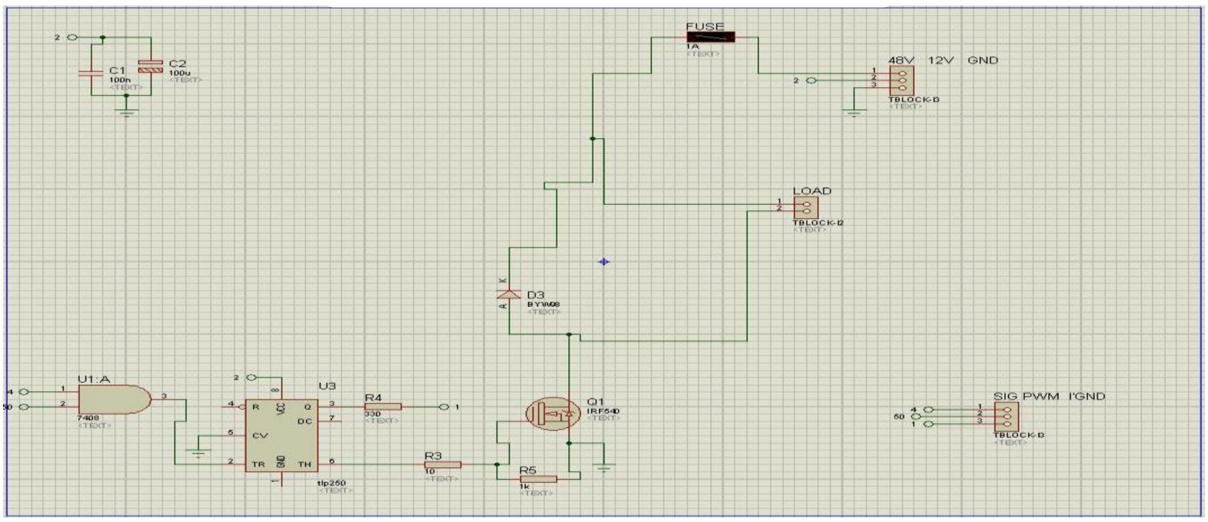


Fig. 23 electric schematic of Light circuit

Tether

One of our defects in the Admiral 1 in 2013 was the heavy tether, last year we used a 25 terminals tether, each tether is 1.5mm thickness made of copper which was really heavy. This year, The Admiral 2 has 2 tethers, the first one consist of two terminals 4mm thickness used for power transmission to the ROV. The second tether is a 12 terminals 0.5mm thickness, 6 of them is used for the vision system (2 terminals for each camera), while the other 6 terminal used for the communication between the surface control and the ROV.

Fig. 24 The Admiral 2 and the tether

Surface control

The surface control of the Admiral 2 consist of 3 main component. The first component is the control box. The control box is made of Acrylic sheets and fabricated using a laser machine. This box consist of the main feeder circuit breaker, a 20 ampere fuse, emergency shutdown button, power source input, tether output and LCD. The second component is the computer with control the movement of the ROV. The last component is the DVR with transfer the camera signals to the computer.

Fig. 2 The Admiral 2, the tether and the control box

3.0 Payloads

The Admiral 2 is supported with extra tools to help completing tasks in the minimum possible time.

Zebra mussel quadrat

It is required to estimate the total number of zebra mussels on shipwreck which is difficult to counted due to long dimensions, so it is required to fabricate a quadrat with dimensions 0.5m*0.5m which will be placed on the top of shipwreck's hull to know the number of mussels in this area by using our front camera &so it will be easy to estimate the total number by using the shipwreck dimensions.

Conductivity sensor

One of the important tasks this year is to design and deploy a sensor to accurately measure the conductivity of the venting groundwater which will be more conductive than the ambient pool water.

Simply it is 2 copper plates (electrodes) parallel to each other with a small gap between them, a resistor is connected in series with one electrode; 12 volt DC is input to the sensor, voltage across the resistor changes according to the water salinity.

Fig. 26 conductivity Sensor

4.0 Safety first philosophy

AQUAPHOTON promotes improvements in quality, health, safety and environmental standards through the publication of information notes that are mix between popular guidelines & our trials in raising the safety rate. Members are self-regulating through the adoption of these guidelines as appropriate. They commit to act as responsible members by following relevant guidelines.

Safety includes three main branches:

1) **Workers' safety** concerning health of workers and avoiding injuries from manufacturing tools, safety clothes is a must which consists of gloves, eye goggles, face mask and ear protection headphones.

Safe working practice dictates that personnel should not work alone when dealing with Heavy lifts. The skill sets of the ROV team must be carefully chosen to ensure a safe efficient operation, a minimum crewing level of three persons is necessary in order to have proper complementary skill sets to operate safely and efficiently and sufficient competent personnel available at critical times to launch and recover the ROV.

Fig. 27 Moataz Tarek wearing the PPE (personal protective equipment)

2) **ROV safety features**

Admiral 2 is designed to meet safety guidelines by mechanical & electrical means. As for mechanical features; it has no sharp edges that can hurt while handling or operation, propellers are shrouded which reduces the possibility of getting in contact with the propeller, all gears are covered by guards which secures contact during operation, safety labels are sticked on propeller's casing to give attention for rotating propeller which may cause severe hurt, also on gear's guard to prevent contact during rolling.

While for electrical features; all cables inside the hull are secured inside hoses & well attached to components, tether is well attached to the surface control unit, there is a single inline fuse for the whole system which saves all components if current exceeds the maximum operating value; however each power driver circuit is guarded with separate fuse, a main circuit breaker is provided at the beginning of the control unit as on/off switch to start& end operation safely, also an emergency switch is provided to shut down the system rapidly if any unexpected conditions occurred suddenly.

3) **Environmental considerations** our ROV is free of any chemical substance or pollutants that can mix easily with water.

Pre- and Post-Dive Checks

A visual and physical inspection should indicate potential or existing problems prior to turning on electrical power. The vehicle should be examined for cracks, dents, loose parts, unsecured wires or hoses, dirty camera lenses and obstructions in the thrusters. If possible, vehicles should be washed with fresh water after a dive. All command controls should be briefly operated and the vehicle response checked.

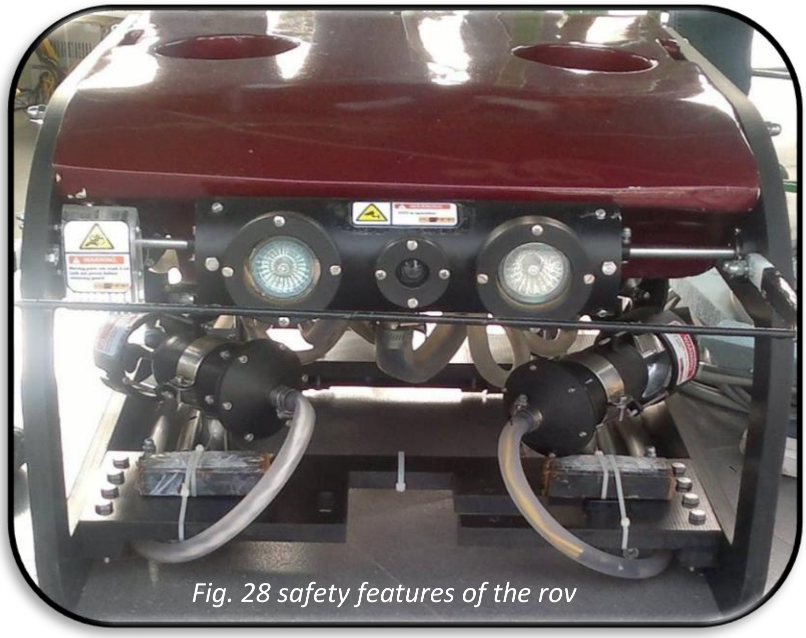


Fig. 28 safety features of the rov

5.0 Challenges

5.1 Technical

AQUAPHOTON team faced two major challenges this year; the first one was the fiberglass fabrication. When the team members wanted to fabricate the fiberglass in a specialized company, we found that the cost was so high according to our budget. THEREFORE, the company decided to self-learn the proper way of fabrication by watching a plenty of tutorials and succeeded in fabricating the perfect one for us with an efficiency not so far from the big company one.

Fig. 29 Moataz and Ahmed making the Fiberglass

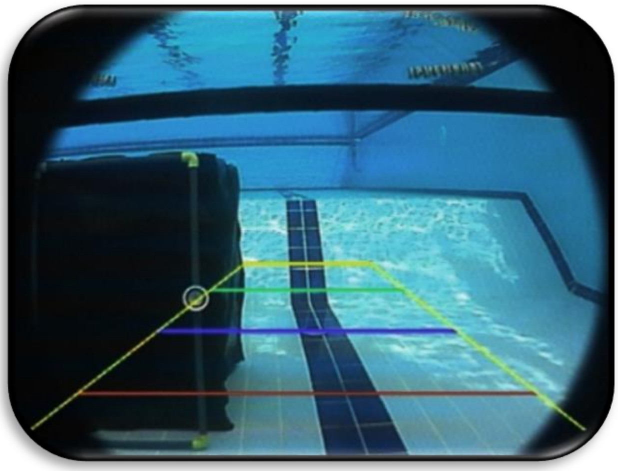


Fig. 30 front camera screenshot

The second technical challenge we faced is to find an underwater ultrasonic sensor to accomplish on of our missions of measuring the parameters of the shipwreck but we failed to find the suitable one in the local market. As we know great ideas can come out of tragedy, one of our members found a special camera used in cars to help the driver in parking by mentioning the distance to the other cars. After we calibrated the distance under water, the idea was successfully working with a negligible error.

5.2 Non-technical

When the electrical team captain travelled abroad for about a month and another electrical team member was not able to work for a while. Great responsibilities and great amount of tasks was for only one electrical member in a short time. SO, two of the mechanical team members overloaded with extra work and started to share tasks with the electrical team and successfully finished them.

6.0 Troubleshooting

It is a must to face some difficulties in critical moments when you are working on great projects, so troubleshooting is a basic technique for any one working in such a project.

After our local competition we found that there is a leakage in sealing hoses &because our sealing system is interconnecting between all components via hoses which means that water may go to electronics' canister &cause failure of the whole system.

It takes time to know where the leakage comes from, so First of all, each component should be isolated separately to inspect where fault has occurred. After this process we found that the leaking comes from one of the vertical thruster. Such a problem should be solved rapidly. We found that the flat seal wasn't installed in the right position & so the thruster's cap isn't closed correctly.

This problem can be solved by replacing the flat seal with a new one to avoid any deformation occurred in the old one &then reclosing the cap carefully.

After this action the thruster should be tested separately to make sure that the problem is solved, then install the thruster in its position to check the whole vehicle.

7.0 Lesson learned

7.1 Technical

One of the most important lesson learned is the criteria of the proper static and dynamic sealing. During the past two years, we got used to seal by silicon gasketmaker as a one-use sealant, which was so expensive and not effective at all. However, this year for the static sealing we designed and fabricated gaskets that meets our needs, and for the dynamic sealing we used O-rings. The result is zero leakage.

7.2 Interpersonal

In the non-technical side, all company members learned set of soft skills through the process like presentation skills, effect of team chemistry on the technical side and a little of feasibility study. However, the main lesson we learned was the time and task managing techniques especially how to make time balance between personal and professional life.

8.0 Future improvement

- Thrusters is a very important component that should carefully selected to match the design of the whole vehicle to produce the smooth propulsion. AQUAPHOTON CO. aiming to increase the thrusters' efficiency in two different ways, first by designing and fabricating propellers that meets our needs using advanced technologies in design by simulation programs and in fabrication using 3D printers and CNC machines. Second by improving the design of thruster out casing for less drag force.

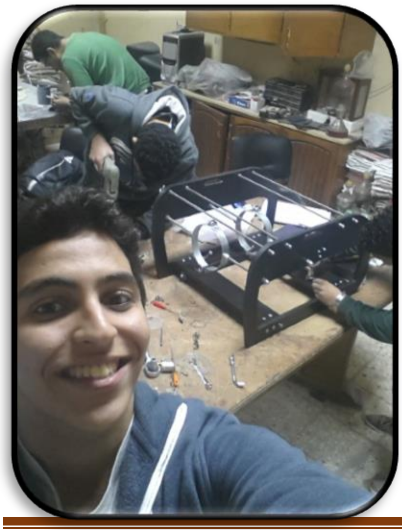
Another improvement AQUAPHOTON CO. planning during the next year is to have fast connecting system inside the electric canister for ease of maintenance and to separate the Tether from the body

9.0 Reflections

"*As a Mechanical Team member I learnt how to think practicaly using my academic Knowledge and I learnt the basic design steps that must be accomplished in order to get the best product, in adition to Teamwork. As a Teamleader I learnt how to lead a discussion in a diplomatic way to make the right decision , how to think in steps with critical thinking , I learnt self –control and I Understood the true meaning of responsibility*"

Abd Elrahman Samir, Mechanical Engineer, CEO

Fig. 31 Abd Elrahman Samir in the pool testing the ROV



"*Looking back at what has been accomplished throughout our design process, many improvements have been made. Not only have we all learned a great deal of knowledge, but we have also built on our technical skills in the fabrication process for our ROV.*"

Ahmed Saeed, Mechanical Engineer, pilot

Fig. 32 Ahmed Saeed in the Workshop

10.0 TeamWork

"Do it with passion or not at all"

The above quote says it all. The admiral 2 was designed, built and tested by 10 Passionate engineers having one target, winning the international competition, June 2014. From the first day, all AQUAPHOTON CO. members decided that nothing would be acceptable less than the perfect. We chose the way of success to be our destiny and we believed that this way must be well organized, so we started to plan for a reasonable timeline to stick with it, prepare our Workshop and equip it with needed tools, and finally we started our beloved project. Since day one, every single member knows his duties. While spending many hours together the engineers learned to work as a team, think creatively, and be open minded to each other's thoughts.

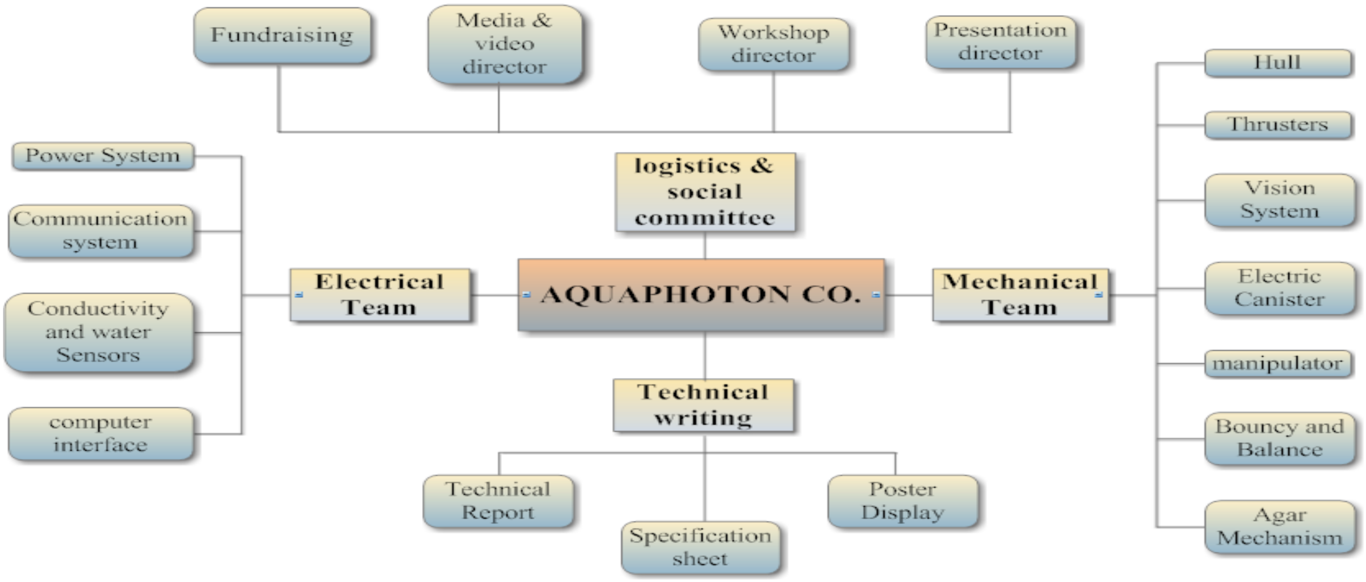


Fig. 33 task management chart

The above diagram illustrate the task managing of the company. Every single part of the Admiral 2 is designed by the company members. Even the technical report and the poster display was the company effort.

Fig. 34 three mechanical engineers working together on thrusters fixations

11.0 Behind the competition

AQUAPHOTON Company has many activities related to ROV besides MATE competition. Our engineers give sessions in many big events in Alexandria University to raise awareness of ROV industry and importance. In fig (36) Mostafa Hafez, Mechanical team captain giving a lecture for the newcomers about the admiral 1 and the participation in MATE competition,

In figure (35) Moataz Tarek and Ahmed Saeed in a session in the opening ceremony of RAS (Robotics & Automation Society), IEEE (institute of electrical and Electronics Engineers) student chapter. February 2014

In April 2014, Aquaphoton CO. aiming to make a group of workshops about “How to build your ROV” with the association of Alexandria University Student union

In addition, our company participated in many project fairs; one of our Achievements is winning the first place in IEEE project fair, March 2013.

Fig. 35 Ahmed and Moataz in IEEE session

Fig. 36 Mostafa Hafez in the Newcomers Event

Fig. 37 AQUAPHOTON members in IEEE project fair

12.0 Budget

Component	Price / unit	Quantity	Total Cost
Thrusters	456	6	2736
Thruster Fixation	25	6	150
Electric Cylinder	1525.5	1	1525.5
O-ring Grease	150	1	150
Balance Box	113	1	113
Foam	440	1	440
Fiberglass	563.5	1	563.5
Frame	1171.5	1	1171.5
½ inch Hoses	3.5/meter	10meter	35
1 inch hoses	9 / meter	2 meter	18
Control Box	357.5	1	357.5
Manipulator	454	1	454
Camera1	175	1	175
Camera2	200	1	200
Camera3	75	1	75
Cameras casings	221	3	663
Tool box	85	1	85
Camera Mechanism	398	1	398
Junction Box	260	2	520
Transportation	290	-	290
T-shirts	80	10	800
Competition Registration	500	-	500
Safety tools	73.5	-	73.5
Lights	133	2	266
Tether	15 / meter	20 Meter	300
MEGA Arduino controller	330	1	330
UNO Arduino controller	140	2	**280**
H Bridge circuit	65	10	650
PCBs’ Fixation	100	-	100
Keyboard	25	1	25
Power Supplies	55	4	220
48/5 DC to DC Converter	80	1	80
48/12 DC to DC Converter	100	1	100
Wires	2 / meter	20 meter	40
DVR	550	1	550
Conductivity Sensor	180	1	180
Wasted Materials	121	-	121
		Total Cost	**14,735.5 L.E.**

Sponsors

Science club 8000 LE

Engineers Syndicate: 1000 LE

13.0 References

Safety

AODC 032 ROV intervention during diving operations
AODC 035 Code of practice for the safe use of electricity under water
IMCA C 005 IMCA guidance on competence assurance & assessment – Guidance document and Competence tables – Remote Systems & ROV Division

Electric box

http://en.wikipedia.org/wiki/Gear_pump

Electronic

www.arduino.cc/playground/Main/PS2Keyboard

www.pjrc.com/teensy/td_libs_PS2Keyboard.html

Frame

http://www.ensinger-online.com/en/materials/engineering-plastics/polyamides/#c608
http://www.lairdplastics.com/product/brands/tecamid/856-tecamidatrade-nylon
http://www.plastral.com.au/page_sheet.php?id=34&categorie=Engineering%20Plastics%20-%20Ensinger
http://www.ensinger.com.br/upload/download/pt/arquivo_MzAw13095302670.pdf

Buoyancy

http://www.atlasest.com/uploads/XPS_-_CATALOG.pdf

Thrusters

http://www.propellerpages.com/?c=nozzles&f=How_Nozzles_Work

http://www.seabotix.com/?gclid=CNv79b-867wCFUjItAod218Alw

http://openrov.com/forum/topics/thruster-layout

14.0 Acknowledgements

AQUAPHOTON CO. would like to thank the following individuals, organizations and companies for their assistance, support and guidance in building our masterpiece the Admiral 2

. Parents- motivating us and Moral supports

.DR. Mohab Hossam- guiding us and technical support

. MATE- giving us such a terrific chance

. Hadath-organizing both the local and the regional competition

. Arab Academy for science, Technology and Maritime transport- organizing the regional competition

. Alexandria University science club- providing funds, workshop and transportation to the local competition

. Engineers Syndicate- providing funds

.SolidWorks- providing AQUPHOTON CO. with 11 Student licenses.

IEEE Student branch- providing us with posters, flyers, T-shirts and Business cards.

15.0 Appendices

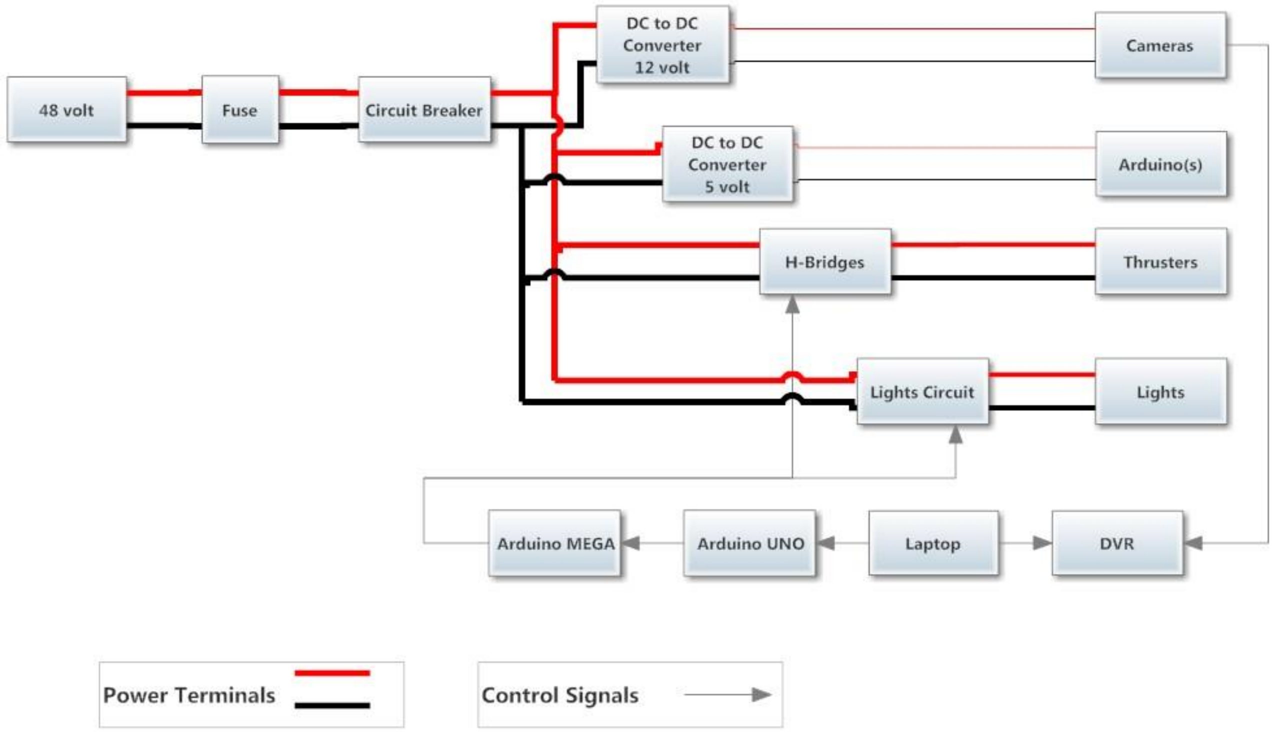
Appendix A (Gantt-chart)

Number	Task	Start	End	28/10	4/11	11/11	18/11	25/11	2/12	9/12	16/12	23/12	30/12	6/1	13/1	20/1	27/1	3/2	10/2	17/2	24/2	3/3
1	company elections and system	1/11/2013	7/11/2013																			
2	competition orientation & task managing	7/11/2013	12/11/2013																			
3	Mechanical Team phase one (design & brain storming)	12/11/2013	12/12/2013																			
4	Mechanical Team phase two (fabrication)	12/12/2013	20/1/2014																			
5	Mechanical Team phase three (testing)	20/1/2014	28/1/2014																			
6	Mechanical Assembly	28/1/2014	6/2/2014																			
7	electrical Team phase one (learning and brain storming)	12/11/2013	12/12/2013																			
8	Electrical Team phase two (communication system)	12/12/2013	30/12/2013																			
9	Electrical Team phase three (power system)	30/12/2013	16/1/2014																			
10	Electrical Team phase four (sensors)	16/1/2014	21/1/2014																			
11	Electrical team phase five (testing)	21/1/2014	28/1/2014																			
12	Electrical Assembly	28/1/2014	6/2/2014																			
13	pilot training, maintenance & local competition preparation	6/2/2014	22/2/2014																			
14	Technical Report	23/2/2014	28/2/2014																			
15	Poster Display	23/2/2014	6/3/2014																			
16	presentation preparation	23/2/2014	6/3/2014																			
17	Regional competition	7/3/2014	9/3/2014																			

Appendix B (safety checklist)

Item	check
-camera's glass is clear	
-ensure that there is no sharp edge	
-gear's guards in place	
-Rust free Control container	
-well closed Control container	
- Stock and tools stored in an orderly and secure manner in workshop container	
-tether is securely attached to ROV body.	
-no exposed wires	
-main fuse in place	

Appendix C (One-line Diagram)



Appendix D (Software Flowchart)