The Admiral III

AQUAPHOTON

Faculty of Engineering
Alexandria Univeristy, Egypt
2015

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I. Introduction

Abstract

The harshest environments on earth are underwater. Mankind needs extremely evolved technologies to venture into them, let alone inhabit them. AQUAPHOTON CO. continues to offer ROVs built to withstand the demanding working conditions, allowing man to expand his horizons. AQUAPHOTON CO. possesses the suitable background, history and experience in the ROV industry to make it a worldwide contender.

This year, AQUAPHOTON CO. introduces “The ADMIRAL III”, which is the accumulation of many years of hard work, innovative design, integrity and quality. The ADMIRAL III is an all-new ROV with developed components, proving that our engineers are highly qualified both on the technical and managerial aspects.

The Admiral III is ready this year to invade the polar environment simulated in St. John's. The extreme ocean environment, such as waves, wind, and currents, was taken in consideration in our design phase, resulting in a durable ROV with the capability to accomplish Mate 2015 missions. Inspirational features used in our ROV gave us this capability, which was very clear in our 3 DOF manipulator and custom manufactured thrusters, showing our experience in dynamic sealing. Fast connectors which were our main concern this year to manufacture them with our available capabilities. The vision system of Admiral III has 3 cameras with wide angles, which provide a complete view of the environment and the manipulators using a camera tilting mechanism. Safety precautions are very important for AQUAPHOTON Company for minimum careless accidents and maximum benefit for the project.

Figure 1 - AQUAPHOTON team members

Teamwork:

"A chain is as strong as its weakest link".

Every good team must have a set of defined qualities to allow it to function as a single unit. For example, coordination, communication, motivation, progress monitoring, etc. We strive to instill these in our team because we understand the importance of strong teamwork. We continuously try to enhance the communication and coordination between team members, and to develop a strong level of bonding and coherence. The result is an ambiance that encourages mutual support and effort, and seeks to bring out the unique qualities of every member.

Figure 2 - Team members brainstorming over mission strategy.

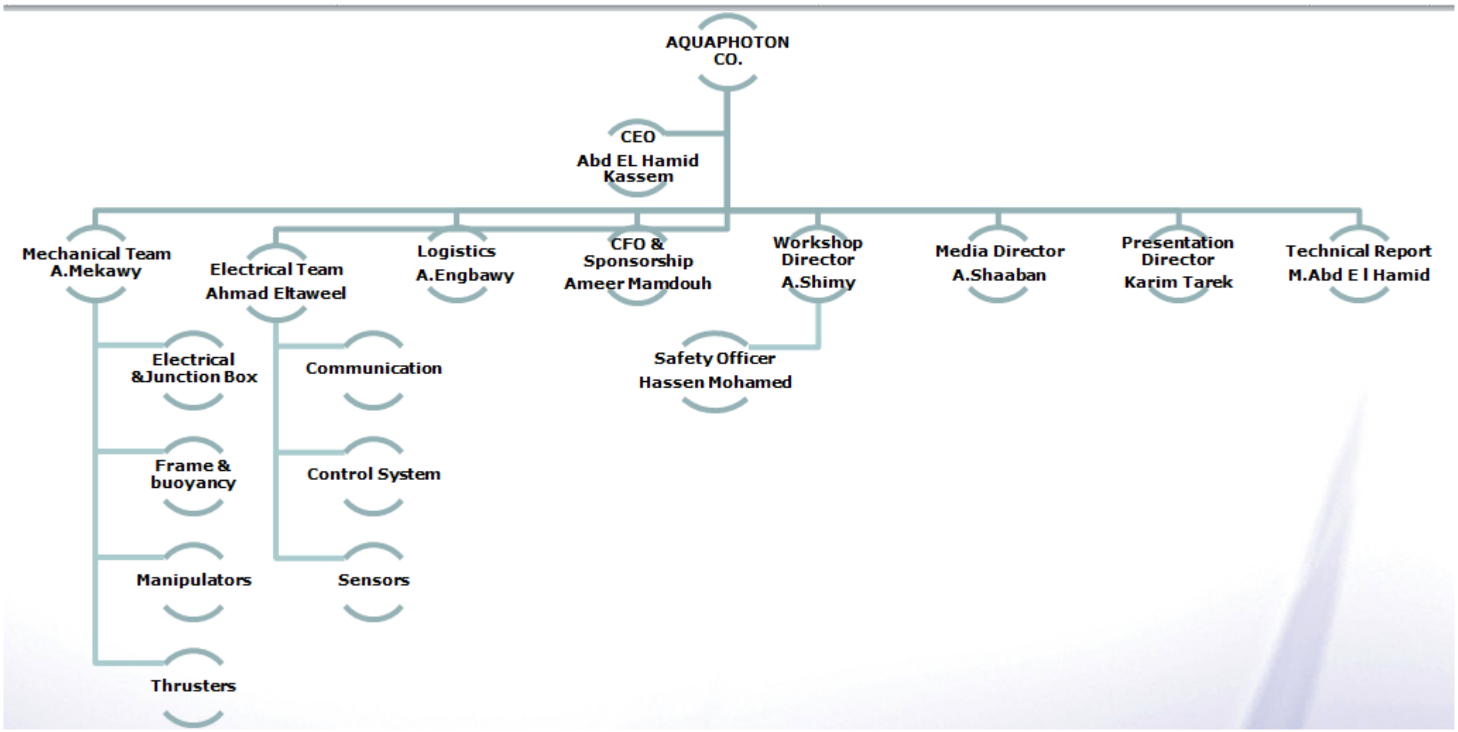

Figure 3 - Team structure

II. Design Rationale

A. Mechanical Design mission

AQUAPHOTON CO. focused this year on accomplishing the Mate missions for the year 2015 without complexity, and on increasing our ROV reliability, performance and cost effectiveness as well as designing and manufacturing every single part in our ROV with our own hands.
AQUAPHOTON CO. always starts the newer version of THE Admiral with an open discussion session evaluating the previous year ROV and the main technical challenges that faced us. Also we discuss our future improvements that we aim to install in our ROV for a better performance this year.

B. Frame

The Admiral III frame has passed through three main phases; 2D sketching, 3D modeling on Solidworks™ and finally implementation by using CNC routing machines shown in figure (4).

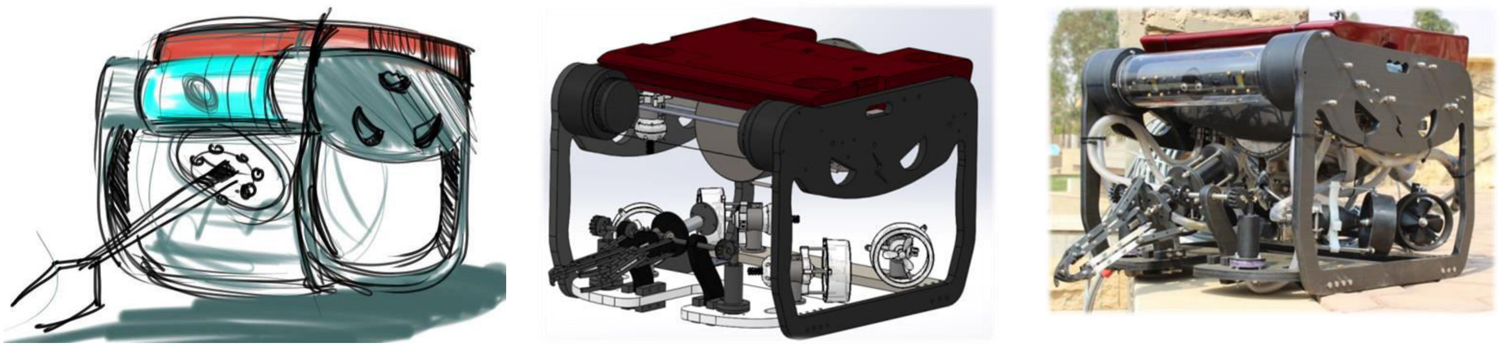

Figure 4 - 2D sketch, CAD design and real design

Material

This material was used for its suitable mechanical properties as good damping capacity, good impact strength, high degree of toughness and good wear-resistance. The sheets were machined by CNC router (computerized numerical control). It provided a very precise fabrication
Our company's engineers designed The Admiral III's frame to be easy to assemble & disassemble, and with easy access to every mechanical and electrical component.

C. Buoyancy

When our company engineers first started working on the buoyancy, they aimed to accomplish a completely balanced and positively buoyant ROV, to allow it to return to the water surface in case of a mechanical or electrical failure. Immediately, two main challenges were met.
The first challenge was to distribute Admiral III's mechanical and electrical components in a way that makes its CG (Center of gravity) and CB (Center of buoyancy) coincident, and we managed to do so as there was a slight difference in the distance between the CG and CB (about 0.015m).

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Admiral III weighed 5.7 kg in water before adding the float. The float - made of extruded polystyrene foam coated with a fiberglass shell- provided 7.5 Kg of buoyancy. We needed a safe margin of excess buoyancy in case more components were later added.

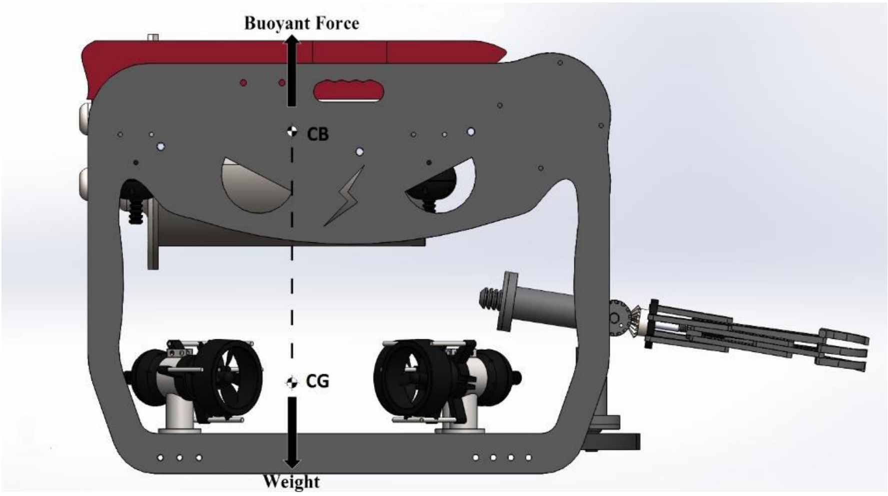


Figure 5 - The Admiral III in equilibrium

Material

The material used in manufacturing the buoyancy is extruded polystyrene foam of density 35 Kg/m^3 and a compressive strength of 300 KPa. This material preserves its quality and properties up to 20m under water. Then we considered covering the foam used for buoyancy with a durable fiberglass shell to provide it with strength and a shiny good look. From here rose our second challenge which was the fiberglass fabrication; its fabrication cost in a specialized company was too high according to our budget. After watching several tutorials, our engineers managed to make their own female mould using foam parts -cut by a CNC laser cutting machine- which were assembled together and glued. After that, the mould was internally coated with a layer of silicon before adding layers of fiberglass and epoxy resin for a better surface finish as shown in figure(6). Curved edges, smooth surface and raised sections around the vertical thrusters were taken in consideration for better shape, least drag force and safety.

Figure 6 - Fiberglass fabrication

D. Sealing

Wire sealing

Our engineers developed an idea used last year in wire sealing which can be an alternative to fast connectors as it is very expensive according to our stated budget.

Last year, we used a system of nozzles and hoses such as those used in gaseous applications. This idea was very effective and was thus used for sealing the wires of the whole ROV. The nozzles are installed in each component of the ROV, all components are then connected to the junction boxes via the hoses, then all the wires are collected in two large hoses and connected to the electric canister. To insure the zero leakage approach, we used jubilee clips on each nozzle.

This year's approach was to manufacture our own fast connectors to ease the assembly of our ROV. We used nozzles & hoses connected with a female threaded part and sealed internally with two rubber rings and to increase the sealing factor of safety, we used two jubilee clips on each nozzle.

Static sealing

AQUAPHOTON company uses either of these two static sealing methods; face seal (used in electric canister, thrusters) or O-rings (used in the lights and camera casings).

Proving its spectacular performance in the sealing process through many years, square cross-sectional surface seals are used in our electric canister, maintained in a groove machined in the housing according to Parker Co. standards.

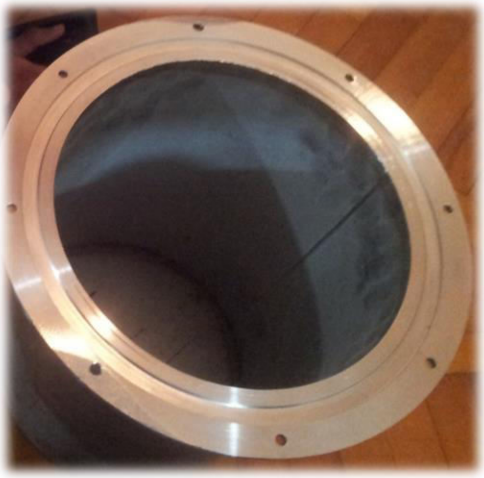


Figure 7 Electric box face seal groove

Dynamic sealing

There is no doubt that dynamic sealing is the hardest type, that's why most other companies use commercial thrusters to avoid the innate problems and complexity of dynamic sealing. But our company insisted that all components used would be our products.

Promoting the success of the method developed last year to seal our thrusters, our engineers used 2RS SKF bearings, and 2 O-rings as a secondary sealing for the shaft. A groove is machined for the 1st O-ring to prevent leakage between the bearing and the casing. Another complementary groove is machined in the shaft for the 2nd O-ring to prevent leakage between the bearing and the shaft.

This year, we decided to manufacture all the grooves and the casings by a CNC milling machine instead of Center lathe machines. Thus, increasing the quality of our components, and offering a 100% guarantee of zero leakage. Parker Co. standards were taken in consideration in designing and manufacturing the grooves mentioned above.

E. Thrusters

Taking an overlook on Admiral III, it is noticed that our ROV is relatively large and can generate a slight increase in the drag force. To begin with, our engineers calculated this force using Solidworks™. Then they chose Brushless DC motors as an alternative to the DC motors used last year for their high power and speed. The size of the casing was also reduced due to the motors' smaller size.

Since our ROV will dive in water with a flow speed range between 0~1 m/s, four vertical thruster were installed to give us more degrees of freedom and remarkable stability

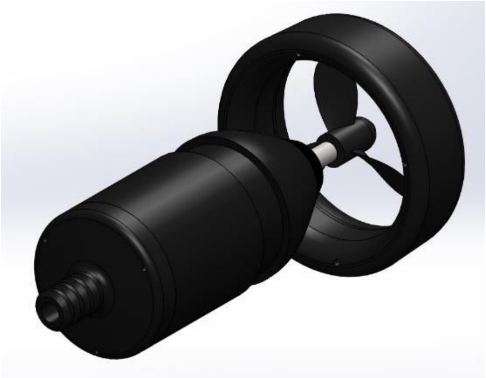


Figure 8 - Thrusters fabricated by AQUAPHOTON CO.

F. Manipulator

Challenges & Design

This year's competition poses new and thought-provoking tasks; almost all of them demand an extra dexterous mechanism.
Our dedicated team of engineers designed a manipulator with 3 degrees of freedom. The idea was inspired from the differential found in vehicles. The integration of 3 bevel gears, specially machined for the manipulator, gave us complete control over the pitch and roll. The gripping motion was accomplished using a power screw. The power screw, coupled with a shaft encoder, provided extremely accurate control of the position and gripping force of the manipulator. The advantage of this mechanism is the high degree of freedom and the strength of the design. The two worms and worm wheels prevent back drive to the motors, while the bevel gears double the torque used to lift and rotate the arm.

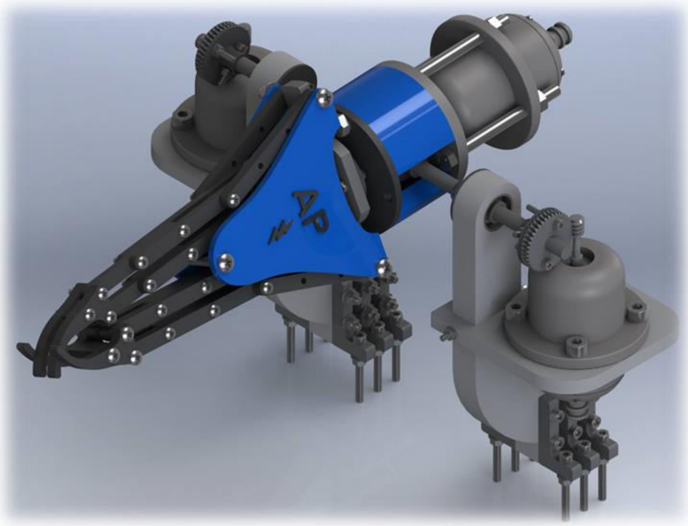


Figure 9 – An early design of the manipulator

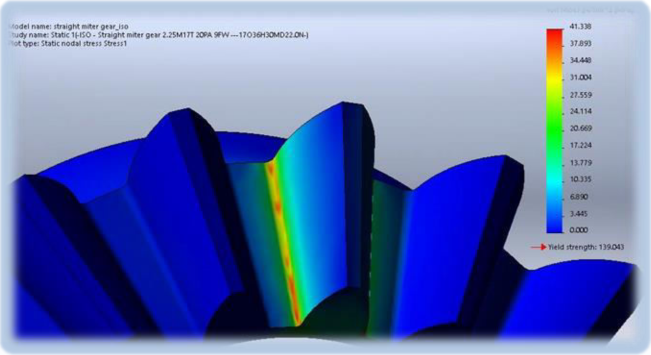


Figure 10 – Stress Analysis using SOLIDWORKS ™

Material

The material selection for the bevel gears was a particularly straining one; our team spent hours weighing out different options. We finally settled on TECAMID polyamide for the whole manipulator due to its rigidity, high machinability and low cost. Stress analysis on the gears' teeth was conducted, with loads far surpassing whatever the gears could encounter in the pools. All the results concluded that the material provided a wide safe margin for operation conditions. Most of the parts were machined from cylindrical blocks of material while the other parts were cut on a CNC router from sheets with 8mm and 6mm thickness.

Motors

The casing of the gripper motors is designed to insulate the motors from water. The sealing techniques used for the motors are the exact same techniques used for thrusters' sealing; a ball bearing for the shaft with O-rings on the inside and outside.

Figure 11 - Motor

G. Cameras

General Description

The Admiral III has 3 HD cameras on board. Two cameras are positioned at the front of the ROV; these are the eyes that give the ROV almost human vision. The system also contains a pair of light sources to make the ROV able to see at night, in addition to a pair of safe lasers to have the option –if needed- for a more accurate image processing system. Our team of engineers fixed the 2 cameras, lights and the laser mechanism to a main plate. This plate rotates freely on a bearing from one side and the other side is coupled to a servo motor shaft which can rotate 180 degrees, thus allowing the Admiral III to look up, down or straight ahead. The third camera is fixed to the bottom plate and provides a view of what's underneath the ROV. Furthermore, the main plate also holds the laser mechanism. The laser mechanism consists of two lasers fixed to a circular plate, which is in turn coupled to another servo. The assembly insures that the lasers always point to wherever the cameras are shooting, and that the distance between the two laser beams is constant, but allows control over the position of the two laser beams with respect to each other.

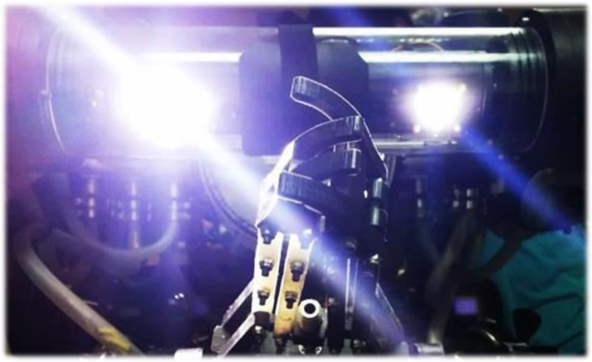


Figure 12 - The Admiral III Cameras & lights

Intuitive Design

The missions at the 2015 MATE competition pose several obstacles in terms of the vision system, for example some distances will be measured and there is in general more space to explore, more scenes to capture an image of and more places to examine inside the tanks.

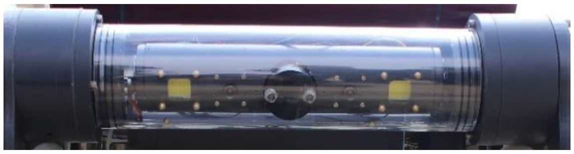


Figure 13 - THE ADMIRAL III Camera & lights housing

Hence, the choice of two cameras was evidently essential for a solid image processing program. Just like the human eyes, the two cameras provide different perspectives of the same object. From these perspectives, different information can be obtained; such as the length, orientation and distance of the object.

Main plate

It is a half cylinder made from Artilon where screw holes for the cameras, lights and lasers are cut using a CNC milling machine. The plate is designed to be easily assembled with the other components; namely the cameras, lights and laser plate.

The Main plate is connected to another two circular plates from each side, one of them is used to house the servo motor, with the motor's shaft coupled to the main plate, and the other is anchored on a ball bearing to prevent vertical motion of the rotating plate and to be balanced (prevent any bending moment).

Housing & Sealing

The two cameras are housed in an acrylic glass cylinder. This cylinder houses the plate which holds the two cameras, two lasers plus the lights. Two caps shield and provide a mean of fixation for the cylinder from both sides, in addition to having machined grooves for static sealing using O-rings, which effectively seal the housing completely from both sides.

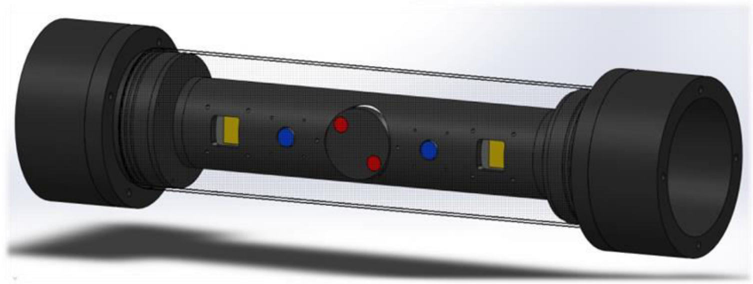


Figure 14 - Camera Housing

The third camera has its own camera housing; a typical cylinder with a clear lens at the front. The casing is sealed using a face seal with two O-rings. All grooves were designed according to Parker Co. standards.

H. Electrical system

System Integration diagram and control flow:

The Admiral III electrical system is completely different than The Admiral II system, in both communication protocol and control theme. Admiral III electrical system components are powered by 12V except for the lights as shown in the SID. Other components are powered either through USB or power control board. The Admiral III's electrical system is controlled using Arduino Mega microcontroller which has enough digital and analog I/O pins to control 8 thrusters, 3 DC motors for the manipulator and plenty of sensors.

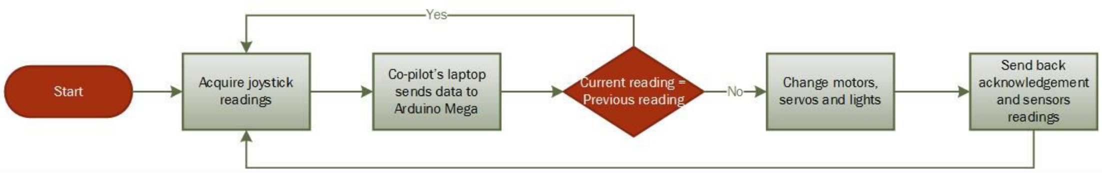
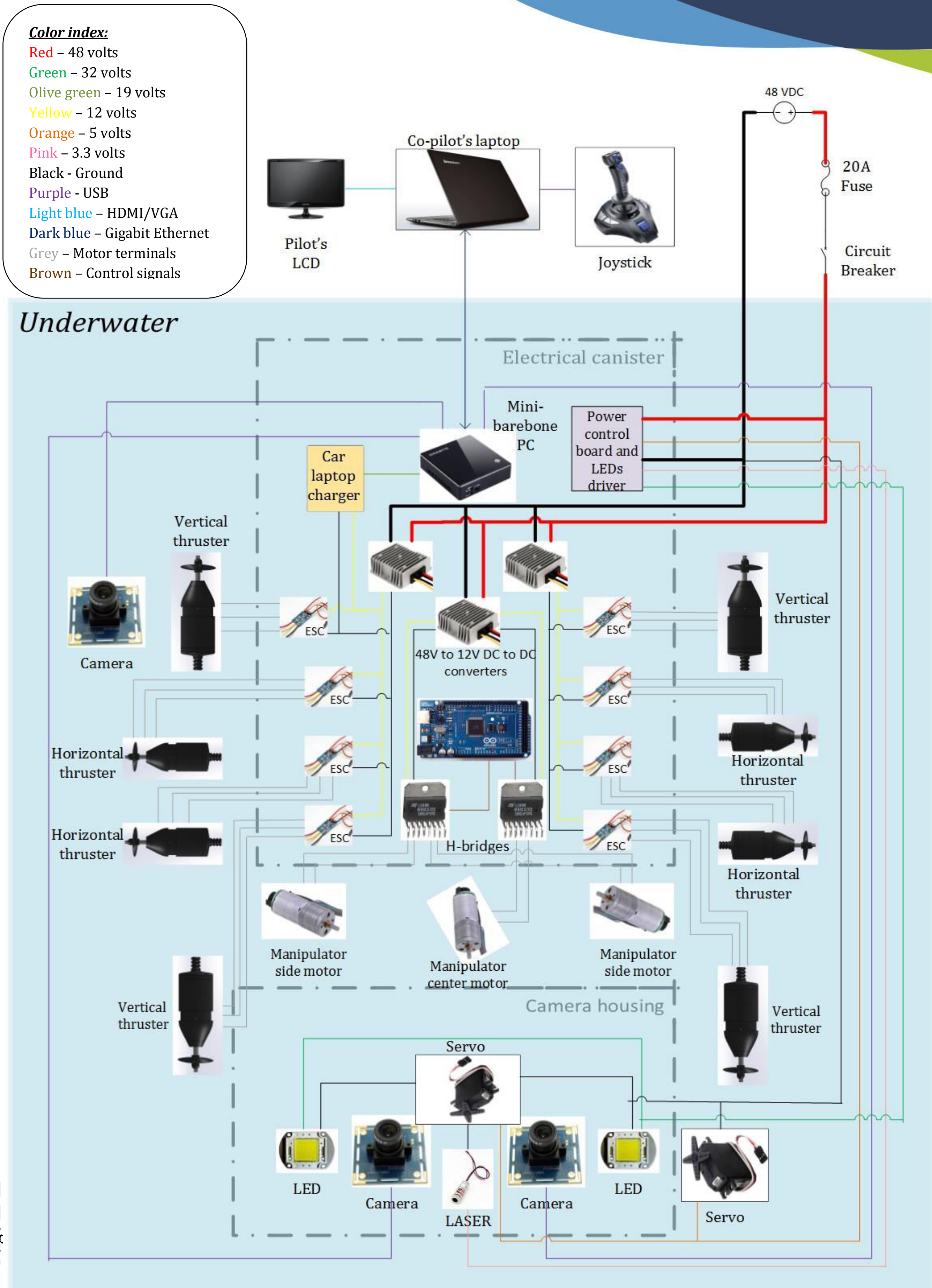


Figure 15 - Control flowchart

Figure 16 - System integration diagram


Color index:
Red – 48 volts
Green – 32 volts
Olive green – 19 volts
Yellow – 12 volts
Orange – 5 volts
Pink – 3.3 volts
Black - Ground
Purple - USB
Light blue – HDMI/VGA
Dark blue – Gigabit Ethernet
Grey – Motor terminals
Brown – Control signals
48 VDC
20A Fuse
Circuit Breaker
Co-pilot's laptop
Pilot's LCD
Joystick
Underwater
Electrical canister
Mini-barebone PC
Power control board and LEDs driver
Car laptop charger
Vertical thruster
Camera
ESC
48V to 12V DC to DC converters
Horizontal thruster
H-bridges
Manipulator side motor
Manipulator center motor
Camera housing
Servo
LED
LASER

Our choice for this year’s motors was 300W/800KV brushless outrunner motor which gives us enough thrust force to move our ROV. We faced many problems using brushless motors as high transient current in starting and overheating.

Motor drivers:

1- Electronic speed controller:

One of the problems we faced was the unavailability of bi-directional ESCs with the needed rating, consequently we bought 30A unidirectional opto ESCs and decided to design our own reversing board.

Another main problem in controlling brushless motors is the very high transient state current so to solve this we used soft start and soft brake settings.

2- Reversing Board:

To solve the reversing problem our electrical system engineers designed and fabricated a circuit using optocouplers for signal isolation and double pole double throw relays to reverse two phases from the brushless motor. Unfortunately, relays with the needed ratings was not available at local suppliers so we used instead two single pole double through instead.

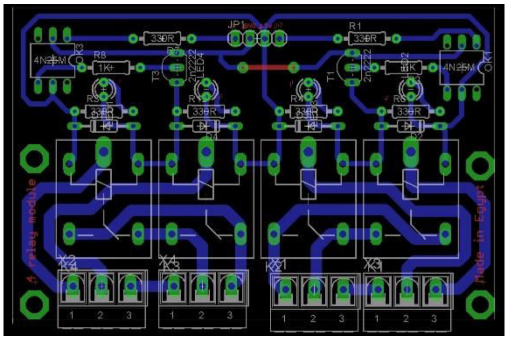


Figure 17 - Reversing board CAD design

3- H-Bridge L298:

Choosing a suitable motor driver for The Admiral III manipulator DC motors we used L298 with paralleled channels for high current applications which can driver motors up to 4A steady state current and our motor stall current is 3A.

Figure 18 - L298N integrated circuit

Cameras:

A main concern when designing the vision system of Admiral III was video quality so we chose board USB CMOS cameras to give us a 720HD video for a great experience with 60 fps to avoid feeling frames dropping in high speed motion situations.

Figure 19 - USB CMOS board camera

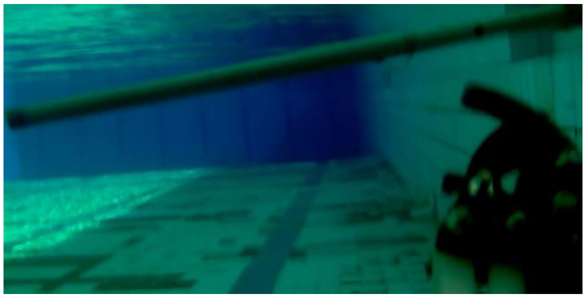


Figure 20 - Snapshot from The Admiral III's front camera

Our next step in the cameras system was choosing our lenses' focal lengths. For the front cameras we used 6mm lens giving a diagonal angle 54 degrees and for the fixed camera we used 2.8mm lens which gives us a wide range view.

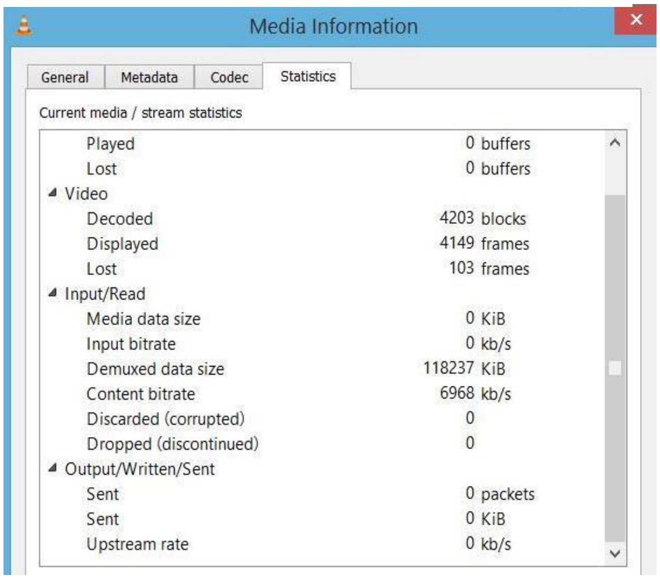


Figure 21 - A screenshot for one of bitrate calculations using VLC

Being able to maintain this good quality was one of our challenges in designing the communication system for this amount of data transfer. To ensure a good performance for our communication system we calculated our cameras bitrate under different conditions.

Firstly, using different online calculators using as fps, codec and video resolution as our known camera parameters. After buying our cameras we re-calculated the bitrate using different programs (ex: VLC) and through recording a video and viewing its details from properties menu on windows OS.

Lights:

For Admiral III lighting system in our front acrylic cylinder, we used two 50W LEDs in our front acrylic cylinder mounted to heatsinks and 12V fans to keep them cool for better performance and less power consumption.
The LEDs driving circuit is based on a npn TIP transistor which was designed by our electrical system engineers and PCB was self-fabricated in our workshop.

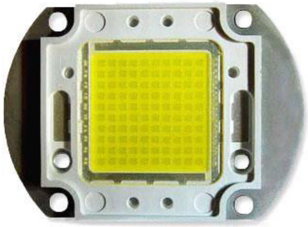


Figure 22 - 50W LED used in The Admiral III vision system

Communication system:

As previously stated, the high bitrate of the cameras was a challenge to handle in our communication system, so our first system design was connecting all cameras and Arduino microcontroller through a powered USB 3.0 hub and using Corning 30m USB 3.Optical cable as our communication tether. This was able to this would provide us up to 5 Gbps communication, but unfortunately we faced some problems in sealing the optical cable.

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We searched for USB to Ethernet adapters but we found none which could fulfill our bitrate needs. Finally, we used a mini-barebone PC (Gigabyte Brix) with a gigabit Ethernet network card connected to the co-pilot laptop through Cat6 Ethernet cable. Firstly, we used RDP (Remote desktop protocol) but we faced a delay problem of nearly 0.6 seconds or less. Changing to another protocol we used USB over Ethernet software, which gave us the ability to share our USB devices over our private network and virtually connect our cameras and Arduino to the co-pilot's laptop.

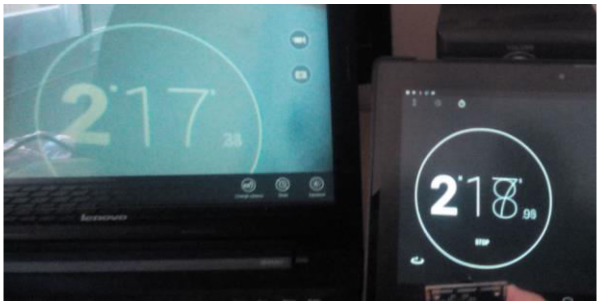


Figure 23 - Calculating time delay in using RDP by taking a screenshot for both screens with a stop watch running

This system was one of our innovations as all our communication system is over 8 terminals only and can be further reduced, and also gives us the flexibility of processing our data on the ROV side with a i3 4010U processor or offshore with our co-pilot laptop and reprogramming Arduino without opening the electric canister.

Figure 24 - The Admiral III communication system core; Gigabyte Brix mini-barebone PC

Figure 25 - Metalstrike 3D joystick

Joystick:

The Admiral III controller is a metalstrike 3D joystick which gives us 3 axes stick, 13 buttons, a slider and a hat button. Our Electrical team engineers developed a MATLAB code to link between the joystick and Arduino through serial communication.

Power management:

i- 48V to 12V DC to DC converter:

Unlike Admiral II power regulation we used DC to DC converters instead of DC choppers as a result for using brushless motors ESCs which should be powered through steady constant voltage and not PWM. 12V converters were used to power all system components except for lights which are powered directly from 48V. This converter has some features, such as waterproof, high efficiency and short circuit and overcurrent protection.

Figure 26 - DC to DC converter

ii-12V to 19V car laptop charger:

To power the mini-barebone PC we replaced its AC adapter by a car laptop charger keeping our electrical system safe. Supplying a maximum current of 3.45A for the mini-barebone PC for high performance applications we chose a 70W charger.

Sensors:

i- Conductivity sensor:

One of our ROV tasks is detecting electric current flow between two certain points underwater, to perform this task we used an analog input pin in Arduino and another ground pin connected to two probes fixed on our manipulator gripper.

ii- Pressure sensor & 9 DOF Inertial module:

We used those two modules to find the ROV orientation and depth, then using PID control we can keep our ROV stabilized, preventing water flow a change in orientation due to change of water flow.

Image processing:

MATE ROV competition this year was more software challenging for the big weight of points for image processing tasks, consequently our programmers developed multiple ways to measure lengths of different objects underwater.

i- LASER:

Our engineers used two point laser sources to produce two parallel beams with a constant known distance between them and using this distance as a reference to measure any target. They developed software using C programming language and OpenCV library to automatically detect LASER and just need two clicks on both end points from the co-pilot to display the length. - LASER specifications are included in safety section -

ii- Stereovision:

The first developed software for stereovision our programmers also used C programming language and OpenCV library but unfortunately they faced some unsolved problems and errors. As an alternative they used MATLAB programming.

Tether:

Improving The Admiral II tether, as stated before in the communication system section, we used 8 terminal Cat6 Ethernet cable which reduced the number of terminals used from 12 terminals of 0.5 mm^2 thickness to 8 terminals of 0.25 mm^2 thickness. On the other hand, we used same power tether 2 terminals of 4 mm^2 thickness.

III. Safety

A. Design & Philosophy:

"A good safety culture is built over time. It is never given."

While designing The Admiral III, safety was a main consideration. Our mechanical engineers designed safe parts with fillets and covers for moving parts. They used dome nuts for no sharp ends and Teflon nuts to keep all components well fixed overcoming vibration and ensuring well sealing. Another safety feature was designing 3D printed kort nozzles for shrouding The Admiral III thrusters.

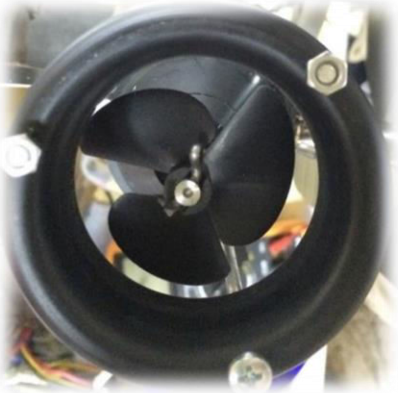


Figure 27 - Kort nozzle

For the electrical system our engineers used safety features in their PCB designs such as fuses and diodes preventing any damage from short circuits or wrong polarity connections.

B. Workshop and manufacturing:

This period was more safety-critical to keep all our engineers safe with no injuries or accidents so we've put some rules to ensure a safe environment.

Tools arrangement:

For optimum safety and time-saving, every set of tools has its own box. Before leaving the workshop, every member must return all tools to their boxes. A penalty is charged to anyone who doesn't adhere to the tools protocol.

Manufacturing:

AQUAPHOTON CO. is an environmentally conscious company, thus our engineers designed The Admiral III with the environment in mind. Only environmentally-safe materials were used and harmful or toxic chemicals were avoided. This way, The Admiral III leaves no trace in the water.

While working with heavy duty tools, our engineers use a C-clamp to securely fix the working piece. Furthermore, safety precautions must be considered at all times. PPE (Personal Protective Equipment), such as gloves, goggles, earmuffs and face masks, must be used.

Figure 28 - Team member using PPE

C. Electrical safety:

Main power fuse and circuit breaker:

As a precaution for short circuits or current overloading, we use a 20A fuse and circuit breaker inline to the 48V source enclosed in The Admiral III surface control unit.

Laser safety:

As The Admiral III has two pointing lasers, our engineers were very careful choosing its specifications. Other important safety procedures are a black shield, safety goggles and a caution sign for overwater testing.

Safety polarized connectors:

A new feature in MATE ROV international competition this year is polarized connectors for no wrong polarity connection. Although not using Anderson power connectors in the local competition neither the regional competition we used XT-60 polarized connectors in our trials to keep The Admiral III system safe.

Figure 29- XT60 connector

D. Testing procedures:

Before assembly our engineers performed multiple tests for each component individually. First step in testing was static sealing test in 5.90m depth for about 15 minutes .Secondly, they tested dynamic sealing for another 15 minutes recording load current readings including transient, no load and full load currents.

E. Safety checklist:

Our safety checklist does not just consider our trials at the pool site; it starts from the workshop till setting the ROV in water.

Handling safety:

Four team members are assigned to carry the ROV; two for the frame itself, one for the tether and another for the control unit. The four team members must wear closed-toes shoes and safety gloves. To avoid any accidents; the front acrylic cylinder and the manipulator are covered with bubble wrap to keep both the ROV and handling members safe.

Pool site safety checklist:

- ✓ Ensure all Fast connectors and hoses are well-fastened.
- ✓ Check components are correctly fixed.
- ✓ Verify tether is not loose.
- ✓ Check for bare wires.
- ✓ Check for short circuits.
- ✓ Verify that gears and moving parts are covered.
- ✓ Check supply no-load voltage is 48VDC
- ✓ A correct rating fuse is connected 30cm or less from the source
- ✓ Dry test
- ✓ Before powering the ROV in water a 15 min sealing test is performed to confirm all components are well sealed.
- ✓ Check LASER switch is well functioning.
- ✓ Finally before setting The Admiral III again in water the laser shield is removed.

F. Avoided accidents:

Personal:

During manufacturing, the blade from an electric rotary cutter accidently hit the hand of one of our engineers. The accident was safely prevented; special gloves protected his hands, resulting in no harms.

Team:

In one of the ROV trials in water, while performing the whole ROV sealing test our maintenance members found a not well fastened fast connector which was leaking a few droplets of water. This leakage test saved The Admiral III from real danger as we don't power the ROV unless all components are not leaking.

IV. Conclusion

A. Troubleshooting Techniques:

The Admiral's III's systems are interconnected, which can cause one leaking component to jeopardize the entire ROV. This year, we added junction boxes. This required a more streamlined process of component testing. In order to swiftly and efficiently detect the source of failure, our team is trained to quickly dismantle or assemble the components required to undergo individual testing. Also, our team uses a process of elimination in order to save time; starting with the junction box (the point of connection for the system components) and then moving on to the more vulnerable components. Thus, heavy prolonged underwater testing was conducted on the ROV before adding any electrical components. During our tests, some water had seeped into the hoses. Immediately, the junction box was disassembled and tested, and it turned out that it was the cause of the leakage. The problem was fixed by replacing some rubber rings which were worn out.

Figure 30- Testing static sealing of the Electric box & junction box

B. Challenges

Technical

This year we faced a challenge with the arrangement of the electrical components inside the electrical canister. The decision to use brushless motors meant we had to increase the number of electrical circuits inside the canister. The initial component layout design proved to be cumbersome and not space-efficient, but luckily our engineers took quick action and completely altered the layout design. They created a multiple-level electric box from Acrylic sheets, with bolts as supporting pillars. Every floor holds a number of electric boards and components with similar size as shown in figure (31).

Figure 31 - Electrical components arrangement

Non-technical

Having The Admiral III's components fabricated by our own company, had a major side effect, as we had to test our methods developed to dynamically or statically seal any component. Thus many prototypes were fabricated; some of them worked and others failed, wasting money. Consequently, AQUAPHOTON sponsors team was always on the move, they sent fund requests to many industrial and commercial companies. Three companies positively replied, providing us with fabrication materials, discounts, access to CNC machines and money.

C. Lessons Learned:

Technical Skills:

Every year, AQUAPHOTON CO. makes sure to design and custom manufacture every component and subsystem on board the ROV. This year is not different from any other year. Living up to its standards, AQUAPHOTON CO. manufactured many complex and sensitive parts. This year our team manufactured for the first time a working 3 DOF manipulator. The amount of hard work and the inherent complexity of the design greatly enhanced our skills. Another first for AQUAPHOTON CO. is the addition of a junction box with fast connectors, which taught us several things such as argon welding and organizing wiring diagrams.

Interpersonal Skills:

This year, the team got updated with fresh recruitments. At one time, the company had 15 members, which is enough to start a small factory. The leaders had to learn how to manage all these members to assign them with required tasks and provide them with whatever they needed. The other members learned how to keep up with deadlines and update the leaders with the progress. We also all learned how to organize data and present them in a professional manner during our weekly meetings. Also, since our project coincided with our education, we had to learn skills such as multi-tasking and strong time-management.

D. Future Improvements:

As we seek further improvement in controlling our ROV, one of our electrical engineers came up with a brilliant idea of adding another mini-barebone PC to our surface control unit, giving us the capability of giving up on our co-pilot’s laptop.

AQUAPHOTON CO. plans to find a way to prevent the systems from being interconnected as it presents a threat to our electrical components if a leakage occurs in our ROV.

Another improvement AQUAPHOTON CO. is planning to design and manufacture new fast connectors without using hoses and develop a sealing method for the wires connected to the junction box.

E. Reflections:

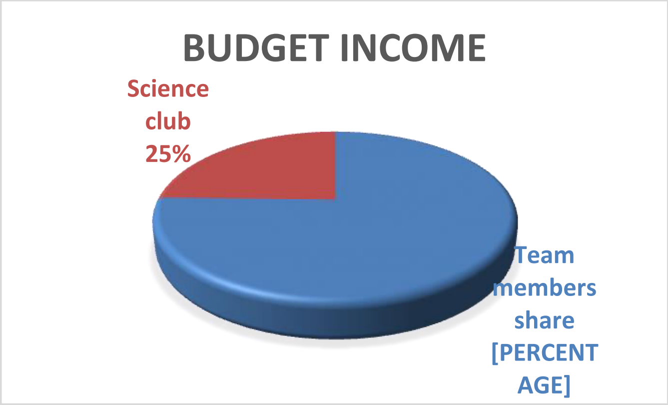
Figure 32- Karim Genena

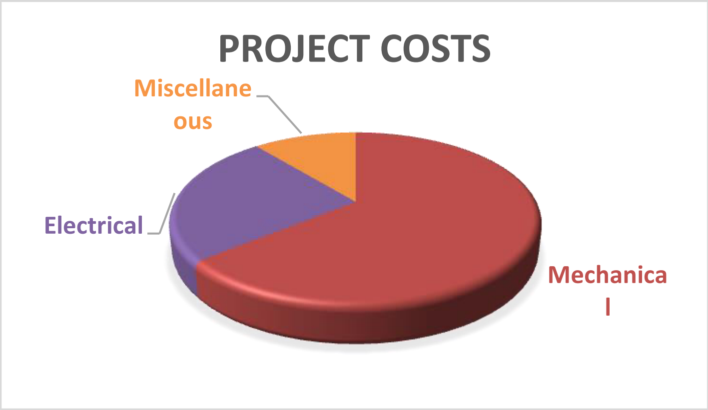
"Working at AQUAPHOTON ROV was like a deep well of experience. AQUAPHOTON ROV provided the necessary and fundamental skills required for an electronics engineer. The cooperation between company members is above fantastic. All in all, it's an experience that others wish to take part in and I consider myself a lucky person."
-Karim Genena,
Electrical Engineer

Figure 33 – Abdelrahman Chaaban

"The chance given to me to work on such a project that tests my skills to design and manufacture complex parts with such talented engineers, was fabulous, interesting and really raised my engineering potentials needed for my future career."
-Abdelrahman Chaaban,
Design Engineer

F. Budget and project costing





Detailed project cost:

	Component	Material	Price/unit	Quantity	Total (EGP)	
Mechanical	Thrusters	Polyamide	785	9	7065	New
	Kort nozzles	Polyamide	100	8	800	New
	Propellers	Plastic	100	8	800	Reused
	Frame	Polyamide	1028	1	1028	Donation
	Electric box	Stainless steel	1250	1	1250	Donation
	Junction box	Stainless steel	335	2	670	Donation
	Fast connectors	Stainless steel	55	28	1540	Donation
	Hoses	Silicon	6 EGP/m	25 m	150	Donation
	Manipulator	Polyamide	3023	1	3023	New
	Buoyancy kit	Fiber glass	950	1	950	New
	Foam	Polystyrene	350	1	350	Donation
	Bilge pump	N/A	185	1	185	New
	Camera housing	Acrylic	1350	1	1350	Donation
	Wasted material	N/A	14368	1	14368	
Electrical	Gigabyte Brix	N/A	3500	1	3500	Donation
	Arduino Mega	N/A	150	2	300	New
	DC to DC converters	N/A	280	3	840	Donation
	Tether	Copper	10 EGP/m	30 m	300	New
	Joystick	Plastic	300	1	300	Reused
	Printed circuit boards	N/A	300	1	300	New
	Cameras	N/A	300	4	1200	New
	LED	N/A	25	4	100	Donation
	DC motors	N/A	120	3	360	New
	Inertial sensor	N/A	650	1	650	Donation
	Pressure sensor	N/A	260	1	260	Donation
	Brushless motors	N/A	124	8	992	Donation
	Servo motor	N/A	150	2	300	New
	Wasted material	N/A	2885	1	2885	
Miscellaneous	Poster	N/A	250	1	250	
	Regional competition registration	N/A	500	1	500	
	Local competition transportation	N/A	500	1	500	Donation
	T-shirts	N/A	100	22	2200	
	Playground	N/A	200	1	200	
	Shipping expenses	N/A	2432	1	2432	
	Tools	N/A	3768	1	3768	
	Total				*55666 (EGP)*	

G. Logistics

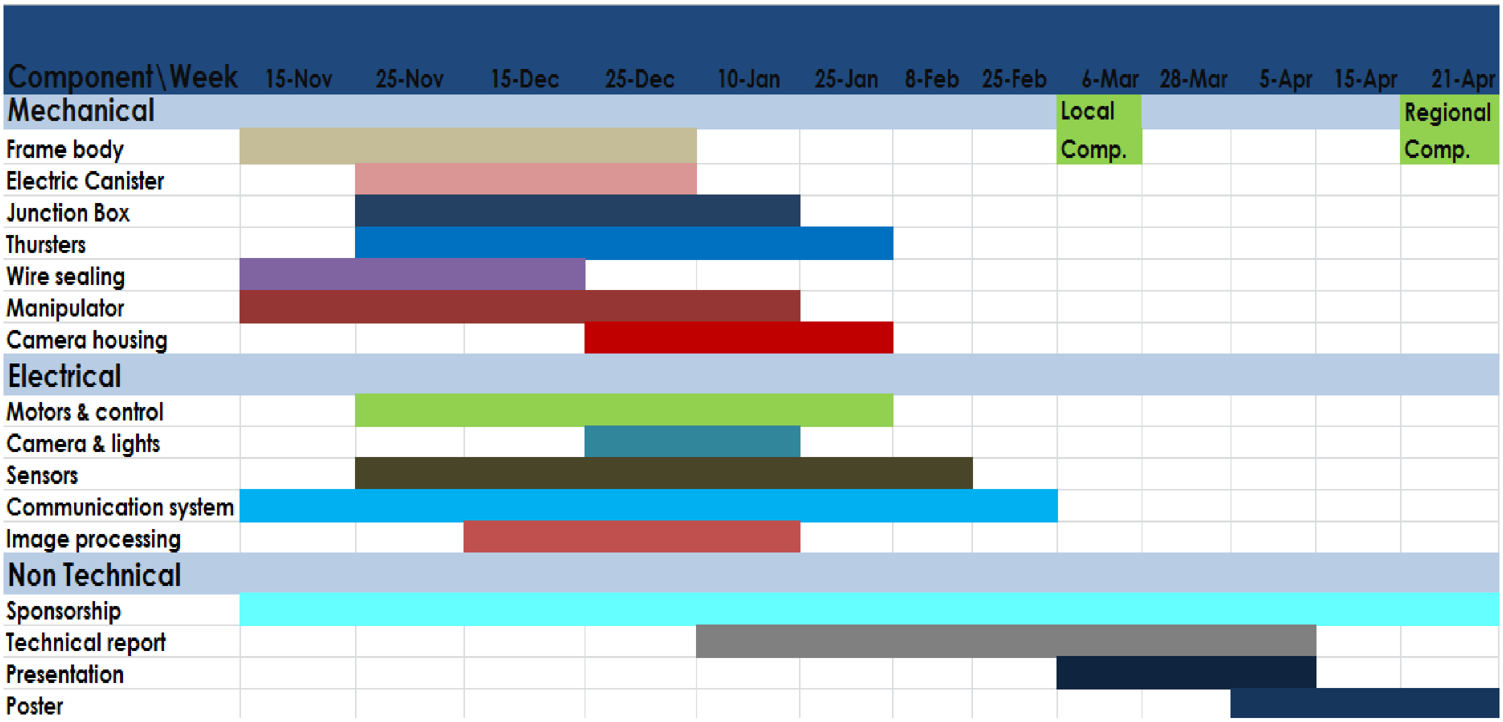


Figure 34- Timeline

F. References

General

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Gripper

http://kurser.iha.dk/eit/i4prj4/ScorBot%20CD/Books/100343-b%20ER_4u.pdf

Buoyancy

Underwater Robotics: Science, Design & Fabrication by Steven W. Moore, Harry Bohm

Thrusters

Design and Control of an High Maneuverability Remotely Operated Vehicle with Multi-Degree of Freedom Thrusters by Daniel G. Walker

Sealing

ORD 5700 Parker_O-Ring_Handbook

Control

Servo library - http://arduino.cc/en/reference/servo
Joystick - http://www.mathworks.com/help/sl3d/joystickinput.html

Image processing

OpenCV - http://opencv.org

Stereovision - http://www.mathworks.com/discovery/stereo-vision.html

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