Mechanism

Atlantis ROV

Technical Report

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Note: Our team has no mentor

Abstract

For the Second time to participate, Atlantis Inc. this year decided to take part in the Egyptian regional competition again, which are hosted by "MATE" Marine Advanced Technology Education center and Hadth Company. Our purpose is not only to participate in the competition but also to be a good step in the ROV manufacturing career. Atlantis ROV was designed to help in investigation of shipwrecks and do several tasks relevant to this issue.

Our ROV body is made of Stainless steel rods, including one well isolated tube including our drivers to control our thrusters; it also includes our camera and sensors. Our ROV has 8 thrusters in different directions to enable the ROV to move in all direction with good maneuvering. Our ROV has many sensors, which facilitate the driving; tilt sensor and compass, pressure (depth), temperature and water sensors. The pilot controls the ROV with a key board. He also can see our cameras on the computer screen, which also includes all the reading of all our sensors. During this process, company crew learned essential technical skills and utilized “outside-the-box” brainstorming techniques to ensure a quality product. The design and fabrication of the ROV cost approximately 17500 EGP.

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I. Budget

ITEM	PRICE(EGP)
Driver & motors	3000
Propellers	1350
Camera	315
Doom	225
Plugs	1000
Electrical Components	2000
Pressure sensor	750
DC-DC converters	1165
Batteries	500
Wiring	400
Equipment	380
Mechanical Structure	1340
Artilone & Acrylic	700
Machining	1000
Mechanical Sealing	300
Molding	2000
3D Printer	1000
Total	**17425**

We took 2000 EGP as a donation form mechanism center

II. Design Rationale

This year, Atlantis Inc. adopted a different approach. We wanted to make our ROV a multifunctional and strong underwater platform to carry out deep-water missions. After some research and our own experiments, we found that the most important function of the ROV required for the tasks of this year is capturing photos and video and this was very clear when talking about task 1 and 2, that's why we developed some systems in our ROV to ensure achieving these mission, here are what we developed:

- Front Camera with a wide lens 2.1 mm placed in a doom and moved in 4 directions with 2 servos.
- Our GUI can get the true length of the shown figures captured or displayed by the camera.
- A communication between the pilot laptop and copilot's one, where every image is captured is automatically sent to the copilot's laptop for processing.

We also found that a lot of the tasks involved the movement of an object from one location to another by the ROV. This meant that we had to have a manipulator system that is agile and easy to maneuver. We also found that it will not be enough to have one manipulator because there are lots of things to be carried in a short time, that's why we built two powerful manipulators able to carry all objects in the tasks.

We found that in one of the tasks we have to enter a ship wreck and then get out of it, and by comparing the size of the shipwreck and the size of our ROV, we found that it is nearly impossible to turn in this shipwreck, so we have to move backwards in order to get out of it, That's why we placed a backward camera with a good resolution to help the pilot to go backward and exit the shipwreck.

Furthermore, we also required powerful thrusters, because in the tasks of the competition, we have to carry very heavy objects. So we put 8 powerful thrusters which are able to carry heavy weight, They are put in positions to enable 6 degree of freedom which will provide high maneuverability to our ROV.

Finally we had to measure the conductivity of ground water, we began searching on the ways to measure water conductivity, we found a lot of ready-made products which can measure conductivity with high quality, but it was very expensive, also the competition doesn't encourage purchasing ready-made systems. That's why we decided to manufacture this system, by ourselves.

Conductivity meter:

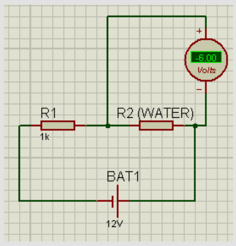

Figure 1: Conductivity meter theory

We found if you made a potential difference in a very short distance in water, a current will pass this current is directly proportional to the conductivity of water and this is the basic theory of our device. We made a simple circuit were we connected the two terminals of a normal source of 12 V by two elements in series, one of them is 1KΩ resistance and the other is 1 cm^2 of water, as shown in fig (1), we then calculate the voltage drop caused by the 1KΩ resistance and by means of ohms law we can calculate the current passing through water. By multiplying by constant we can get the conductivity of water. We have made a circuit containing the resistance and an Arduino Nano microcontroller board to measure the voltage drop and send it to the computer, where we put this circuit off shore and we extend two wires form it to the water, each wire is soldered to a 1 cm^2 piece of copper and are fixed with a 1 cm between them, we placed both of copper pieces in a small T shaped tube where it can be handled easily by the ROV manipulator and placed in the hole. We also devolved a computer program which can plot the reading of water conductivity over time on a GUI interface to be able to monitor changes in conductivity easily, thus we can measure water conductivity.

III. Description of Sub-Systems

Our ROV consists of three main Sub-Systems, Mechanical Sub- System, Electrical Sub- System and Software Sub- System. Here are the details of Each Sub- System:

A. Mechanical Sub System

1. Frame:

As it is the second experience for our Company Atlantis Inc., we manage to upgrade our ROV and give it special maneuvering in order to facilitate any task or mission needed by our ROV.

So we upgrade our body to a symmetric one made by (1/2)" stainless steel tubes grade 304. We use stainless steel as it is a very hard material and it is not affected by water at all and also it can be formed easily and give good shapes. Our frame with dimension (55cm*25cm*70cm) as shown in fig (2)

Figure 2: ROV Frame

We as Atlantis Company were keen on following the right steps of designing a product. After putting the CAD design we passed it by various simulations to prove its performance and to find out all the faults of our design.

So we passed our product before manufacturing by a CFD (computational fluid dynamic) and we get perfect results.

Our body has very low drag as there is no large surface area facing or opposing the movement, also our frame has high stability as the tubes gives the frame low resistance and equal distribution of forces.

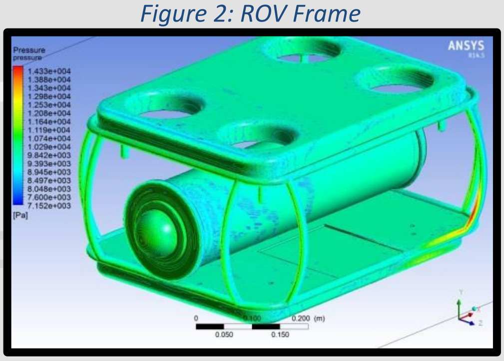

Figure 3: Pressure forces on the ROV

Fig (3) represents the pressure forces on the ROV body at speed 1m/s and it shows the pressure magnitude affected on the body. The magnitude is low compared to the high thrust force of the motors used.

Fig (4) represent the stream lines acting upon our vehicle as it shown there is no sign of backflows or any turbulence that decreases our vehicle power.

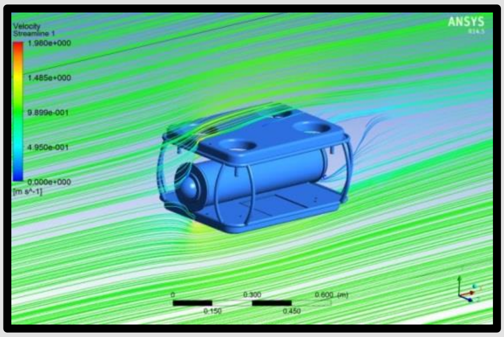

Figure 4: Stream lines acting upon our ROV

2. Pressure hull:

In the past year, Atlantis Inc. has used several electronics tubes connected by a series of wires and tubes. However, the company learned that this system has many flaws including an increased number of connection locations that could leak, an increase in complexity of the design, and an added difficulty in maintenance. This year, a single pressure vessel was used to house all electronics and connections. A tube of 6 inch diameter is placed in our ROV's frame in its center to complete the equilibrium and not to affect the symmetry and the maneuvering, the tube is closed with two end caps the first one with an

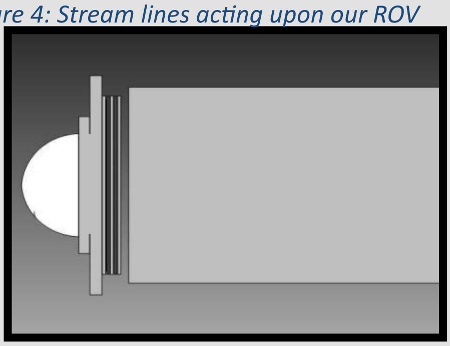

Figure 5: Pressure Hull

acrylic dome holding the camera with artilone housing and 2 O-rings to act as waterproofing as shown in fig (5), and the second one is completely artilone and fixed in it the plugs to prevent the water to enter the tube.

3. Propulsion system:

Our ROV is propelled by 8 thrusters which enables the vehicle to move in all direction with 6 degrees of freedom with acceptable speed. The vehicle contains 4 vertical thrusters and 4 vector horizontal thrusters.

The 4 vertical thrusters are responsible for 3 degrees of freedom, it allows our vehicle to heave, pitch and roll as illustrated in Fig (6).

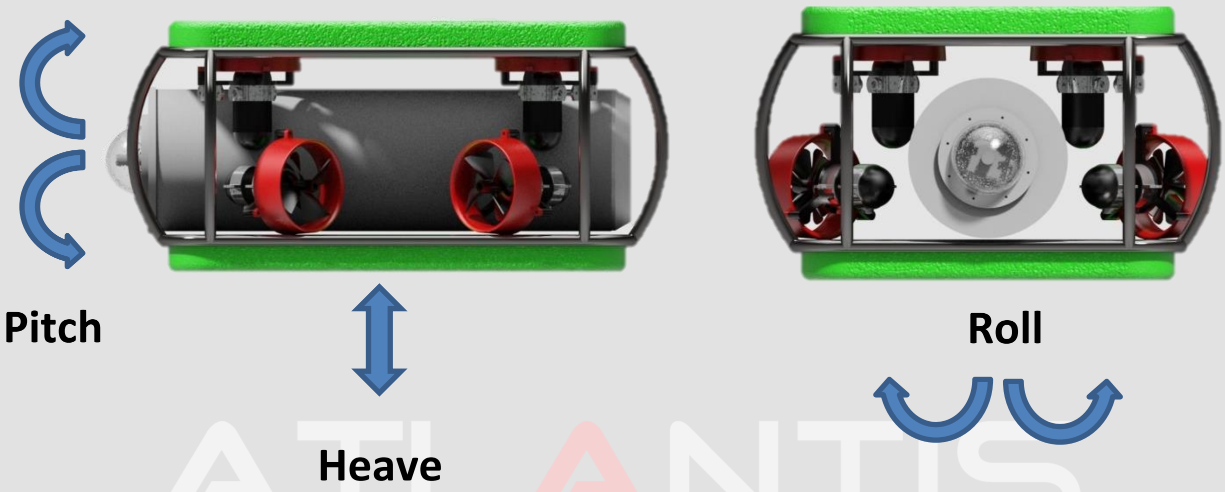

Figure 6: Heave, pitch and roll movements

The other 4 horizontal thrusters are responsible for the other 3 degrees of freedom, it allows our vehicle to yaw and surge and sway, as illustrated in Fig (7)

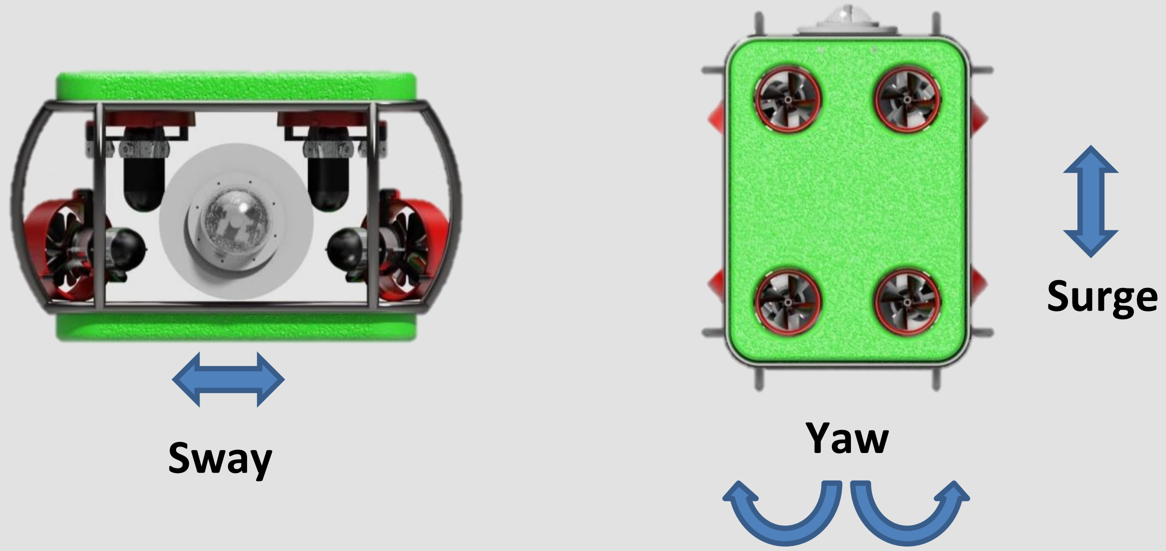

Figure 7: Yaw and surge and sway movements

With this motors setting our vehicle is allowed to move in all directions and it gives the vehicle so high maneuverability that allow the pilot to drive it easily.

Thrusters:

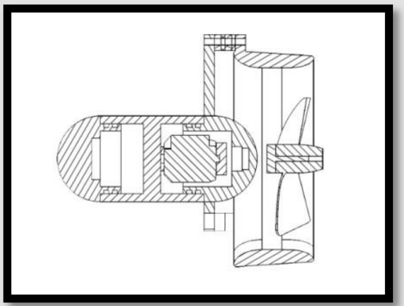

Figure 8: Our Thruster

In this ROV we attempt to produce our thruster by our company not unlike our previous 2 ROVS that was propelled by bilge pumps which are already sealed, and not only producing a normal thruster but we insisted on producing a different thruster with a perfect performance and an aerodynamic shape that nearly has no resistance in water, and this costs us a lot of time starting by molding polyester to get non-uniform plastic shapes and ending with 3d-printing and machining.

Our company produces a reliable thruster as shown in Fig (8) that was manufactured by the mechanical team. It consists of two caps (front cap and end a cap) and between them lays a housing that encloses our motor.

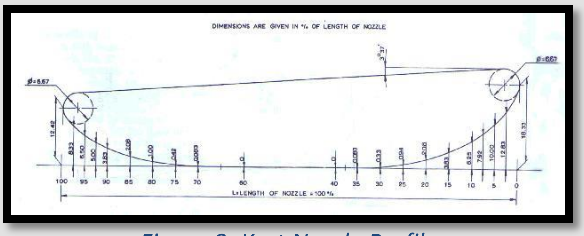

Figure 9: Kort Nozzle Profile

The two caps were sealed by O-rings to prevent any water leakage, and our copper shaft was sealed by the means of oil-seal.

Our thruster operates with a 4-blades 95 mm propeller enclosed inside our company kort –nozzle which is 3d-printed to give us our desired profile which is profile No(37) as shown in Fig (9) which nearly equalizes the forward thrust with the backward thrust and this profile really fits the ROV requirements.

Figure 10: Our Brushless Motor

Our thruster operates with a 300 watt 800 KV turingy brushless motor as shown in Fig (10) which is a highly reliable motor that can work in bad circumstances and also its specialized by its small size when compared to its power.

4. Electrical connectors:

Figure 11: The Electrical Connectors

As we desired to produce a robust system so we focus on making our vehicle to be easily assembled and disassembled, so we use these sealed electrical connectors. We use it for our motors and lights and manipulator and also we use it for the main power cable to our vehicle and our tether too.

These connectors are composed of 2 main parts each part of them composed of 3 parts; each is connected to the other by the mean of screw which is sealed by O-rings. The wire terminal is sealed by a rubber gland as shown in fig (11).

By using these connectors we can easily maintain any part of our vehicle either the motors or the electronic tube or any other part.

We fixed these connectors on our electronic tube end cap as shown in Fig (12) which enables us to disassemble our vehicle in nearly 5 minutes and take out our electronic tube to maintain it.

Figure 12: Connectors fixed on the end cap

5. Buoyancy System:

We thought of many ways for the buoyancy for our new ROV, we found the best way is to use polyurethane foam. We started to calculate the required volume that prevent the ROV from sinking and divide this volume into two parts one on the top and the other on the bottom. That's the best way we managed to implement. Neutral buoyancy equation was used for buoyancy calculation

Upward acting buoyancy: (volume x density of water)

Downward acting buoyancy: weight of ROV

Total net buoyancy: upward - downward

Then we could manage to make the ROV to be suspended in the water by controlling the volume of the foam for both parts the one on the top and the other on the bottom of the ROV. The idea of making two parts of foam one on the top and the other on the bottom is if the ROV gets upside down or roll over to be balanced and to reduce problems with buoyancy

Finally the two parts will be covered by fiber in order to protect the foam from being damage which could lead to malfunction the buoyancy we already calculated and this fiber will be colored to make the ROV have a better look.

Figure 13: DC motor used in the manipulator

6. Mechanical manipulator:

Our manipulator this year differs from the last year; we make an optimization between the cost and the requirements of this manipulator that fits the missions of the competition.

We find out that we only need a simple clamper that can fit the requirements of the missions and we decided to use 2 of this clamper.

Our clamper is composed of housing with an end cap that encloses our dc powerful motor as shown in Fig (13), the wire terminal is sealed by a rubber cap and the shaft is sealed by oil-seal, also a mechanism to convert from rotational motion to linear motion was designed by the mechanical team as shown in fig (14).

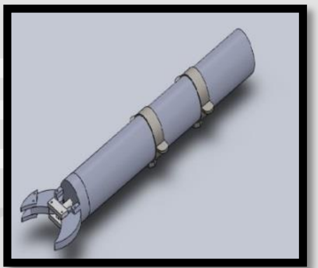

Figure 14: Mechanical Manipulator

B. Electrical Sub System

Our Electrical Sub System Consists of two main parts: ROV control, Surface Control, in addition to imaging system, Lighting system and tether.

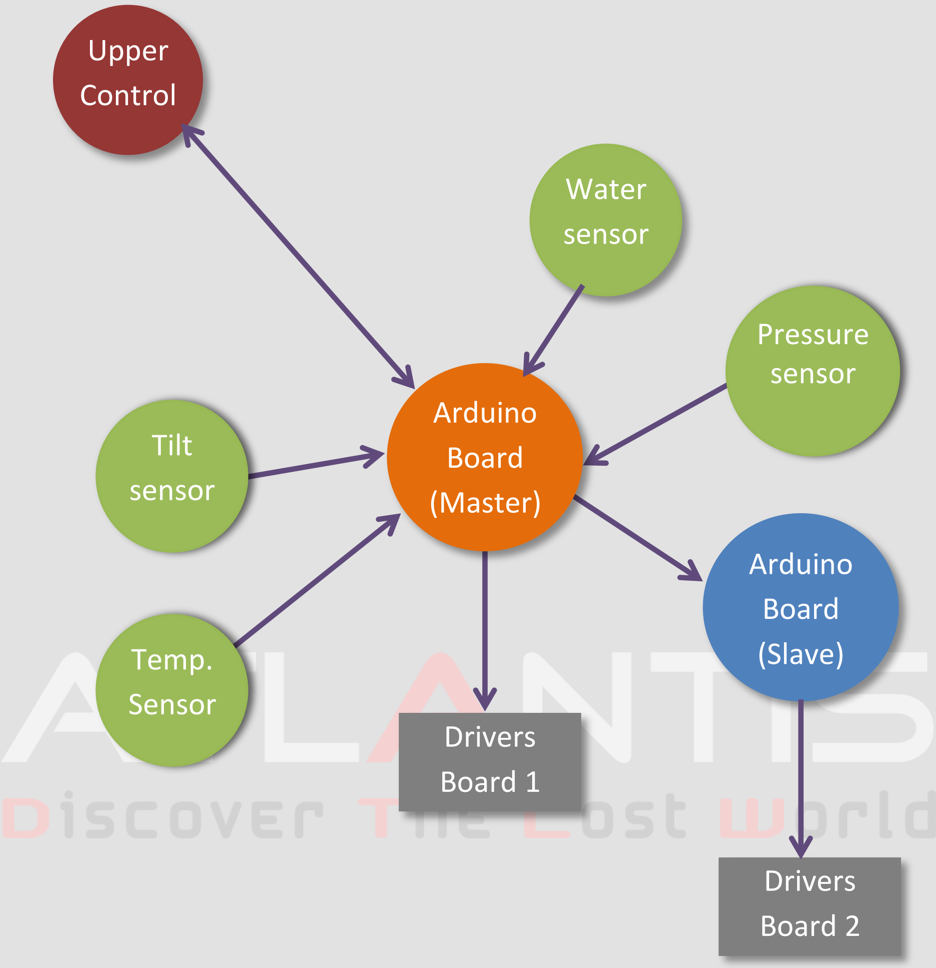

Figure 15: Electrical Sub-System

1. ROV Control

It is placed in a well-sealed PVC tube. It consists of 4 electric boards as shown in fig (15):

a) Arduino Board (Master)

It receives all the data from the tether. It contains an Arduino MEGA microcontroller board which is based on the ATmega2560. We are using 2 of its serial ports, the first to receive data from the tether and the second to transmit part of the data to the Arduino Board (Slave). We are using 4 of its PWM outputs pins to operate the ESC drivers in (Driver Board 1). We are also using 4 of its digital output pins to operate the relay systems in (Driver Board 1).

We are using other digital input/output pins, analogue inputs pins to control the sensors. All the sensors transmit their readings to the Arduino Mega which transmit it to the surface control through the tether.

Here are the details of each sensor used:

1. Pressure sensor (Depth sensor)

A Pressure transducer (PX2 A N1XX 200P A AB) from Honeywell International Inc. was used in the ROV. The sensor has an analogue interface. This sensor is used to measure the depth of water by means of measuring external pressure. As this pressure, reading is converted into depth in the software, taking into consideration the configurable water density. The sensor is placed inside the tube, where part of it is exposed to water to measure pressure and the other part is isolated to transfer the signal. The sensor can detect pressure until 200 psi, which is nearly equivalent to 140 m depth. Its accuracy is 0.25% FSS (Full Scale Span), while its response time is less than 2 ms, as shown in fig (16).

Figure 16: Pressure Sensor

2. Temperature Sensor

A temperature sensor DS18B20 from Maxim Integrated, with digital interface type was used in the ROV. The sensor is capable to measure range of temperature from −55 to +150°C, with an accuracy of ±0.5°C from -10°C to +85°C. The DS18B20 digital thermometer provides 9-bit to 12-bit temperature measurements. This allows the pilot to monitor temperature and shutdown or reduce demand on the ROV in the event that overheating occurs, as shown in fig (17).

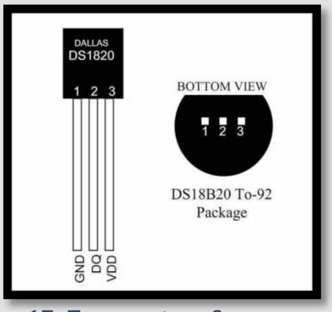

Figure 17: Temperature Sensors

3. Water sensor

A water sensor with analogue interface type was used to detect the leakage of water (if occurred) in the ROV. This allows the pilot to monitor the leakage of water in any part of the ROV, where he can make the decision of immediate stop of the ROV if leakage occurs, as shown in fig (18).

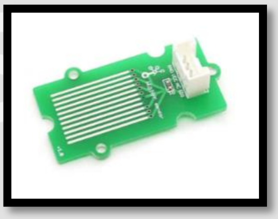
Figure 18: Water Sensor

4. Tilt sensor and compass

A Tilt sensor and compass (LSM303DLH) from STMicroelectronics was used in the ROV. The sensor has an I2C interface type. This instrument is a 3-axis accelerometer and 3-axis magnetometer, which is used to define the device body coordinates and three attitude angles: pitch, roll and heading. The sensor was put away from the converters and relays to ensure that varying magnetic fields caused by them, do not disrupt its function. The Sensor is supplied by a clock signal from the microcontroller. The measurements of the sensor are sent to the Arduino on the board then to the control unit through tether, as shown in fig (19).

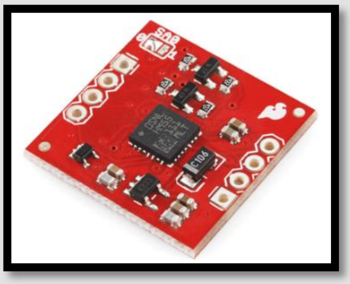
Figure 19: Tilt Sensor

b) Arduino Board (Slave)

This Board receives the data from Arduino board (Master) then send it to the (Driver Board 2). It contains an Arduino UNO microcontroller board which is based on the ATmega328. We are using 4 of its PWM outputs pins to operate the ESC drivers in (Driver Board 2). We are also using 4 of its digital output pins to operate the relay systems in (Driver Board 2).

c) Drivers Board 1 & 2

They are two Identical Boards. They receive signal from Arduino Board. Each of them consist of 4 ESC Drivers and 4 relay systems

1. <u>ESC Driver</u>

Last year we used relays to control our thrusters but this year, Atlantis ROV theme is high manoeuvring ability, So we decided to use make more powerful thrusters that's why we used Brushless motors and used ESC Drivers in controlling them.

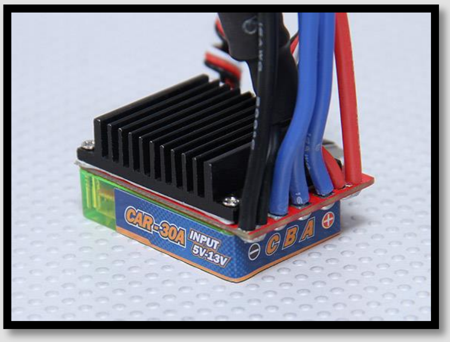

Figure 20: ESC Driver

We used Hobby King Brushless Car ESC 30A w/ Reverse shown in figure 2, it's a standard car escalator providing forward and reverse with a large number of motor compatibility for up to 240,000 RPM. It has full protection feature, including low voltage, over-heat, throttle signal lost, start-up protection and self-check, as shown in fig (20).

So by using these 8 ESC drivers (4 in each Board), we can control 8 brushless motors, whether forward or backwards in any speed

2. <u>Relay system:</u>

We also needed to control our grippers and our light system, that's why we added 4 relay systems (two in each board) where two of them to control each gripper, one to control light system and one as a spare part.

Each relay system consists of two relays to each of them is connected by a freewheeling diode to prevent back EMF and connect to a 1K resistance in series with an LED to be able to ease troubleshooting.

The signal of each relay is given from the Arduino board but it passes first on an opto-isolator to protect the Arduino then the signal is amplified with a PNP transistor then operates the relay

2. Surface Control

It is responsible for connecting the computer with the ROV control, where it consists of a small board containing USB to serial module which is the simplest way to connect TTL interface devices to USB. This module converts the data from the computer to serial data to be transmitted through the tether to the ROV control. It also receives serial data from the ROV control and sends it to the computer. Our surface control contains also an easy cap module to convert the camera signal to USB to be easily received by the computer, as shown in fig (21).

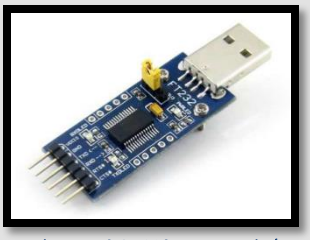

Figure 21: USB to serial module

3. Camera

Cameras are of a great importance, because they are the only way for the pilot to see the surroundings of the ROV, and to ensure the success of each task. The camera depends on the clarity of the feed of the cameras. Atlantis ROV has two cameras one on the front and the other on the back

a) Front Camera:

The Front camera is placed in a doom and controlled by two servos to move the camera right, left, up and down. We used a 700TVL camera which has very high resolution compared to what we used last year, also attached to its board a mini Sony Effio-E DSP. And the best thing about this camera is that it's 2.1mm Wide Lens which allows the pilot to see a wider view of the surroundings. It transmits

Figure 22: Front Camera

coloured videos with high resolution allowing the pilot to see clearly, as shown in fig (22).

b) Back camera

The back Camera is placed at the back of the ROV and it is in a waterproof housing made of artilone accompanied with O-rings to prevent the leakage of water to it. The camera sensor of type CCD and resolution 420TVL of output signal PAL /NTSC as shown in fig (23).

We also add video & image processing feature to our navigation system in order to submit computation requirements under water such as distance measurement as required in task 1, where we developed this feature using a c# developed software that is interfacing the underwater cameras.

Figure 23: Back Camera

4. Conversion Unit

As known, if you want to transmit power with high current for long distances, you should lower down the voltage to prevent power loss, so in ROV industry, ROVs are always supplied with 48 volts, while most of the control systems are designed to be supplied with 12 volts. In Atlantis ROV we made our conversion unit to convert from 48VDC to 12 VDC. Our Conversion unit consists of 4 DC to DC converters. Two of them can resist till 20 A, so one of them is used to feed the 4 thrusters at the right side of the ROV, while the other is used to feed the 4 thrusters at the left side of the ROV. The other two converters can resist till 5 A, so one of them is used to feed the two grippers and the lighting system, while the other is used to feed both of our cameras, the Arduino board (Master) and the Arduino board (Slave).

5. Tether

The tether is the bridge that connects between the surface Control system and the control board on the ROV. Our tether is made of 2 main power lines (VCC & Ground), those two lines carry the main power of 48 volts to the ROV voltage regulators, and those two lines are made of 1.5 mm thick wire to sustain the power flowing through them. The tether also contains an Ethernet cable with 8 terminals for transmitting signals, these cable is provide with more thick shield to prevent the cable from being broken and it also prevents other external magnetic field from interfering with the data transmitted in the cable. The most important feature of this cable that each terminal consist of a bundle of tiny copper threads instead of one thick thread, This makes the terminal more strong and resist bending without being cut. We are using 6 out of the 8 terminals of the Ethernet cable, two for the RX and TX signals used two transmit data from the surface Control to the ROV control. Two wires are used as the signal and the ground shield for the front camera and two as signal and the ground shield for the Back camera.

6. Lighting system:

Our ultra-bright light system is used in the ROV to ensure clear image to the ROV pilot even at deeper water or at night. Our ROV has two light torches each located in the Top corner of ROV.

Each torch consists of 8 Ultra Bright LED each 4 are connected in series and both groups are connected in parallel. Each LED has 120o viewing angle, Color temperature from 6000 to 8000K, and luminous intensity from 4000 to 5000 mcd. It consumes 3 volt. Each one is fixed in housing from artilone and each one consists of two main parts; the cap and the cone and they are attached by threads and O-rings in between also a

Figure 24: Lighting System

transparent disk of acrylic is attached from the front in the cap by rubber gasket, and to make sure that no water will enter the housing we fix inside the cone a rubber cap to prevent the water to enter from the cable, as shown in fig (24).

C. Software Sub System

The control system of our ROV is meant to give the pilot an easy and intuitive way of controlling the vehicle.

Our ROV is controlled by an Arduino Mega 2560 which receives user data from a surface computer equipped with a program designed to facilitate graphical interface, was used to receive input from the keyboard and display sensors reading received from Arduino. The output pins on the Arduino are directly command by the program to control the driver motor controllers.

The communication between the program and the Arduino is achieved through serial USB connection, which is the Link between computer on board and the Arduino and its sensors.

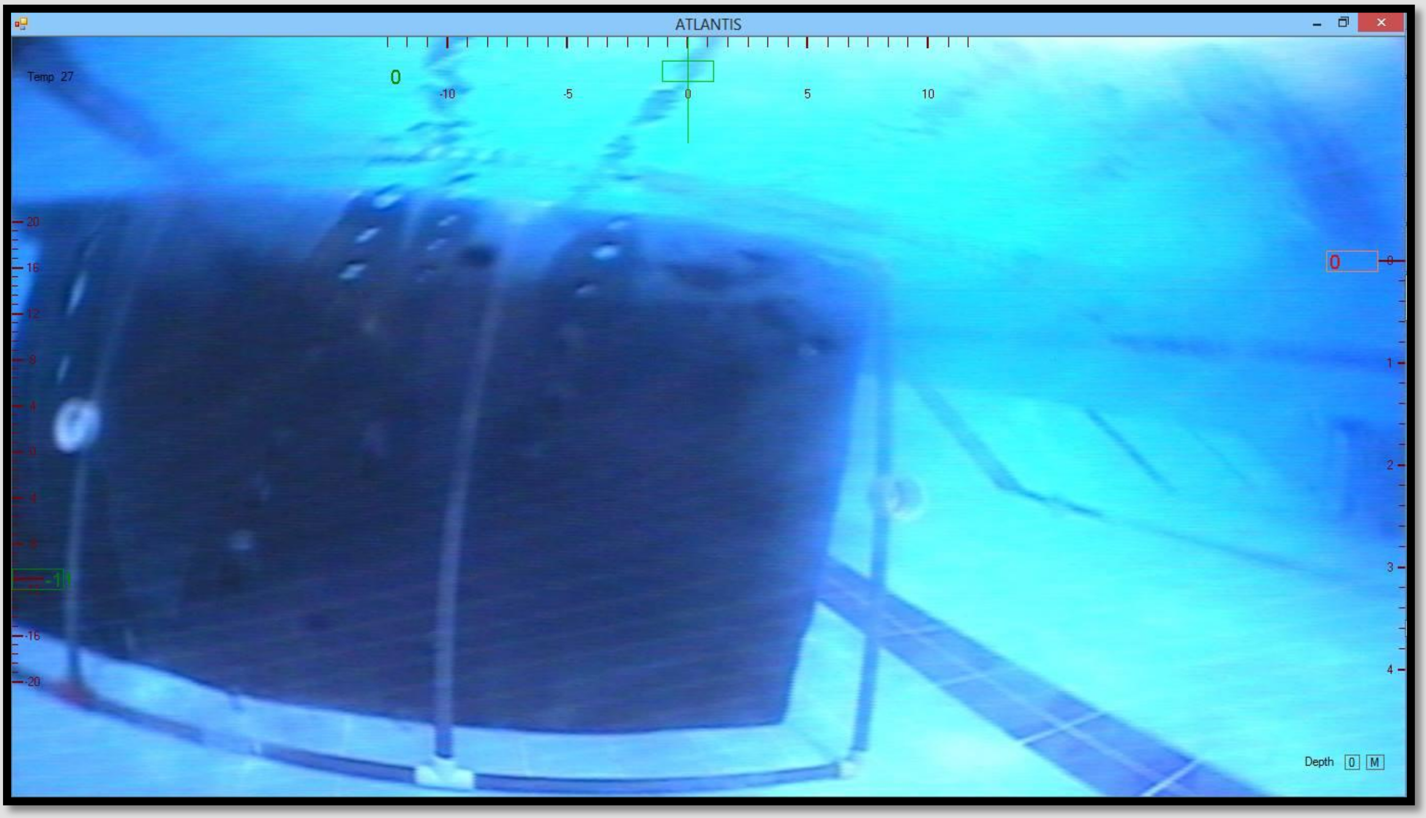

Figure 25: The GUI displaying the camera and the sensors reading

The program on board is written in C sharp, it displays the ROV's Camera, receives data of the sensors through Arduino code which is written in C++. All sensors' data received is displayed on the graphical user interface as show in fig (25). The GUI displays a meter for the roll and pitch of the ROV (Roll meter at the left of the screen, pitch meter up the screen) of the ROV, it is fed form the tilt Sensor, it also displays another meter for depth (at the right of the screen), fed from the pressure sensor. The GUI also displays the temperature in (^{o}c). Our software also enables the user to control the ROV using the key board of the computer, where it provides each motor with three desired speeds in each direction (clockwise and anticlockwise).

Our control will have the privilege to show both the pilot and the co-pilot the same displayed data from sensors reading, camera and captured photos both on different device (laptop), our GUI can get the true length of the shown figures captured or displayed by the camera.

IV. Safety Systems

At Atlantis Inc., we give care much about safety. Safety has become part of our routine from the design process up to the implementation of the final ROV. In order to achieve better coordination and to make sure that all the safety concerns are addressed completely, we had classified the safety protocols into 4 different categories as shown below:

A. Mechanical Safety

- All rotating parts have been labeled.
- All propellers are guarded by Kort nozzles which prevents direct contact with the propeller and the propeller are covered using a bright red guard to prevent people from putting their fingers through it.
- All sharp edges have been sawed off to prevent cuts and accidents during transportation.
- The end caps of the electronics can are isolated by a layer of thick wax as the motors' wires pass through them.
- O-rings are incorporated into the end caps to maintain complete isolation at very high pressure
- A firm handle is used to safely handle the ROV.
- A safety rope is tied to the ROV to pull the ROV in water when needed.

B. Electrical Safety

- Diodes are added to prevent back currents from damaging other equipment
- Capacitors are place to stabilize the voltages and to prevent sudden spikes in the supply.
- The electronics tube is made of PVC, a non-conducting material.
- Emergency switch is also included to allow quick and easy cut off of power in the case of an emergency.
- The power supply itself has a failsafe mechanism in which it cuts off itself in the case of a short circuit.
- 40A fuse connected to the power line of the tether.
- Indicator LEDs are added to the circuits to see which one are on power and which one are off.
- Temperature sensor monitors the temperature of the circuits and if the temperature exceeded 90^{o}C, the system gives an alarm and shuts down automatically.
- Water detection alarm is operated if any leakage in the electronics can is detected.

C. Water test safety

Every time before a water test, an elaborate power test is done to see if all the voltages are correct. Then a safety checklist (included in the appendix) is run through to ensure that all the safety protocols have been completed. Once the power goes on the Control Station, Master shouts "Power is on Hands off" to alert the people around the launch area.

D. Crew safety

Atlantis Inc. staff managed to follow some safety precautions in order to avoid injury and stay safe throughout the whole working duration:

Figure 26: Amr during cutting a tube

- Wearing eye goggles during cutting and building the mechanical body.
- Using fixed tools like the drill station instead of the drill to avoid any injuries.
- Wearing gloves and lab coats while printing and welding the electric boards.
- Wearing ear plug during using the saw station to block its high sound from the user.
- The workshop contains a first aid box for any injuries.
- All the electric batteries are stored separately from each other and from the electric boards to prevent any short circuits.

V. Challenges

A. Technical Challenges

One Challenge faced us was the isolation of the tube containing the electrical system of the ROV we first tried to isolate by epoxy and glue it leaked as we found that this is a handmade operation and it is not accurate. We also tried to isolate with silicon but we faced the same results. Therefore, we left all the chemical isolation methods. We then started searching again and collecting information from several professors and experts in this field on how can we isolate this tube. We found the best solution is using plugs, which is well fitted with O-ring in addition to rolling Teflon around. We put plugs instead of wires in the end cap and fitted it also with O-rings .This solution had a great result and it prevented and water from entering the tube.

We also faced another challenge, as when we began to design our body before the competition we didn’t put any restriction on the size of our ROV, but after seeing the missions; we found that our ROV must pass in a hole of 75 cm X 75 cm. At this time our ROV width was 70 cm, which means that it will be very hard for the pilot to pass from this hole with only 5cm clearance that’s why we had to change our design without getting rid of much of the parts that we already have manufactured and also leave enough space to put our motors and tubes. At the end we managed to reduce the width of the ROV with minimum replacements.

Figure 27: Ahmed Adel during working on the Design

B. Non-Technical Challenges

One of the main changes that we faced this year that part of our company left and we recruited some new members. This formed a big challenge in organizing our work and jobs as it was their first experience in MATE ROV. To overcome this problem, the old staff members held training sessions at the beginning of the working process to introduce the competition to the new staff and to teach them all the technical experience the old staff gained from the previous years of participation to make sure the same quality of work is maintained and to ease the work. Also when dividing the tasks we made sure an old member would work with a new member in order to help him understand the process. We also re-allocated some tasks which were the responsibility of company old crew which cause over load on all members. Soon, all the crew became closely experienced in the job and each individual started producing outstanding work. Furthermore, it is now a lot easier to divide the tasks upon all the members as they are well experienced.

VI. Troubleshooting techniques

The main problem that we always faced was in the electrical system, as it happened many times when we finish all our connections, plug the power and start to move, nothing responds. This was a big problem to us, but after some while we began to make our own trouble shooting technique. First we make sure that all LED indicators are lighted which means the power is going in all boards. Secondly we use the buzzer in the Multi-meter to make sure that the USB to serial module is connected is connected to the Arduino. Then we make sure that all the ether net cables are connected in the right way. After that we make sure that all the tracks of all boards are connected. If the problem is not solved yet, then It will mostly be whether the Arduino is broken or any other IC is burned.

Another problem we faced and it was very hard to solve it, was after building the ROV, when we started testing the isolation in a swimming pool at depth 5m. A very little water leakage in the electronics tube was detected. So it was very hard to detect which plug is draining water, we started thinking how to solve this problem we found the best solution is using a compressor to resemble the 5m depth, while we used some soap which will make bubbles in the place of leakage. We found that one of the plugs wasn't well fitted, so we replaced it and no water leakage occurred after that.

Our software was supposed to be made by java. But there were many problems because it doesn't contain embedded libraries to control the camera and the serial port connection. So after making a graphical user interface (GUI), which can capture and record videos, we faced many problems sending serial data with key Listeners using java, so we had to be flexible and to get usage of the Microsoft technology. That's why we turned to use C sharp, which was more user friendly and had more options than java.

Figure 28: Ahmed Ayman during fixing some problems in the code

VII. Lesson Learned

A. Technical

We consider what we have done this year as a breakthrough in Atlantis Inc. History. Our ROV this year was a very rewarding experience to every member in our crew. Starting with the newcomers to underwater robotics, this work has added up a lot to their technical knowledge and practice. For instance, the electrical department is now well-trained to design and finish up high-quality electric boards using Altium software in a very short period of time. In addition to that they

Figure 29: Mohamed making ANSYS Simulation

are well trained to manufacture PCBs with a very high quality, starting form etching to drilling and soldering. Simultaneously, the mechanical department has developed very wide knowledge in designing using various software as Inventor, Solid Works and Catia. In addition, they have managed to learn several programs in order to simulate every step of building our ROV such as Solid Works and ANSYS. They were also

For the programming department, it was a new experience to build a GUI using C Sharp software for displaying the ROV's status for the pilot and to measure the length of the designated location. For the sake of reducing mission time, an idea was presented to utilize a non-mechanical method of measuring the distance to determine the dimensions of the shipwreck. By flying over the designated location, the front camera captures an image of the designated location. The image is then processed where the user selects 2 points on the screen with a known real distance between them and then selects other 2 points which bound the required length. The pixels location coordinates are subtracted from each other to get the number of pixels between the 2 points. By getting a relation between the number of pixels and the real length, the distance is calculated accurately with an error of few millimeters.

C. Non-Technical

The project gave a lesson of interpersonal interaction to each member of the crew. In the beginning every member in our crew was only working in his field, but when the assembly started, we had numerous problems. It turned out that programmers and constructors do not know exactly what electronic devices are used in the vehicle, because electronics engineers had to change electronic unit during their work. So, constructors had to design new container for electronics unit and programmers had to change microcontroller firmware. From this case, we understood that it is important for working groups to know general development process and stay opened for other groups in interdisciplinary project.

VIII. Reflections

Figure 30: Ahmed Tarek during soldering the electric boards

"I used to work in different projects in the past, I also was used to work in different research groups, but Atlantis Inc. was my first under water robotics experience in my life. I can say now that joining Atlantis Inc. is really a different experience, I also can say that, it is really a life changing experience and I consider it a turning point in my life. As I was exposed much to technical experience, as the head of electrical department, where I was much exposed in designing and manufacturing electric boards. I was also exposed to leading experience as the CEO of Atlantis Inc., it was not my first time to be a leader of a team, where I was a leader for some groups and teams in the past, but it was really different experience to me as leading a robotics team is much harder than any normal team. I might not have been the best leader. However, I am sure of one thing, I have the best team! All members are extremely passionate about Robotics, have a good working attitude, and are capable in handling the problems in the ROV even in our most dire state. We have much room to improve but this is huge step in our journey in the field of underwater robotics. Good job Atlantis Inc. crew"

Ahmed Tarek (CEO & Head of Electrical Department)

"This experience is the most rewarding experience I have ever had. Apart from having so much fun during our coursework, I have learned a very important lesson that reflected on my whole life and decisions: Implement your ideas. Working in the mechanical department, it was my first time to put my ideas for the ROV's design into action and observe the consequences. I have made many designs during my college study and I have made designs during online courses, but these designs are different, as you make the design and then manufacture it. So you should be very sure about the applicability of manufacturing with the allowed technology and within the budget of the company and this is a very hard thing. In addition to that during my work I learned that mistakes waste money and time, and we can't always bear this, so I must revise my designs many time to make sure that there isn't any mistake. Now, I can say that I have a wider vision and that I can expect the consequences of a certain idea and most probably get them right"

Mohamed Abd El-Aziz (Head of Mechanical Department)

"It has been a fun and enjoyable thrill ride being in Atlantis Inc. crew. It was really a very good experience working as CFO in Atlantis Inc., as I gained much experience in accounting and a managing budgets, I also gained a lot of experience in buying online products, as it is not easy to select a the seller and make sure that he is trusted. I also gained much experience as an HR, where it was very hard to deal with new comers and mix then with the team and change the team attitude to them from treating them as strangers to be one unifying family of Atlantis Inc. This has brought us closer and had helped us to overcome all challenges."

Mazen Wael (CFO & Head of Human Resources)

"I really appreciate my teammates and I'd like to thank them for making our company what it is today. I have learned so much about leadership, presenting, machining, CADD, electronics and programming through this competition. I was introduced to programming through the MATE competition last year. It has become my favorite hobby and I now want computer science to be my career. I have countless fond memories of writing code during cold winter nights and testing our ROV in the pool during very cold nights. I am sure now that my experiences will help me as I move on into the future".

Ahmed Ayman (Head of Programming Department)

IX. Future Improvement

Our Company is planning to improve its working strategy and use new and advanced technology in manufacturing our ROVs, from the improvement we are planning to implement in our new ROVs:

- Optical fibers: We are working in our R&D section to use optical fibers to avoid magnetic noise problem that affect our control systems also to avoid mutual induction problem between wires.
- Fiber glass: We tend to use fiber glass material in our mechanical structure in next operations, since this material offers low resistance to water flow and is environment friendly and is used in boats and marine crafts easy to be shaped.
- Auto safety system: We are going to use an air bag in the ROVs of our companies so that the ROV would float on water if it faces in technical problem underwater and it was out of control.
- Sonar imaging systems : We tend to support our ROV with sonar system so that we are going to have a more effective vision of what is going underwater as surrounding water current velocities and temperature so that we won`t be in need to cameras

X. References

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XI. Acknowledgements

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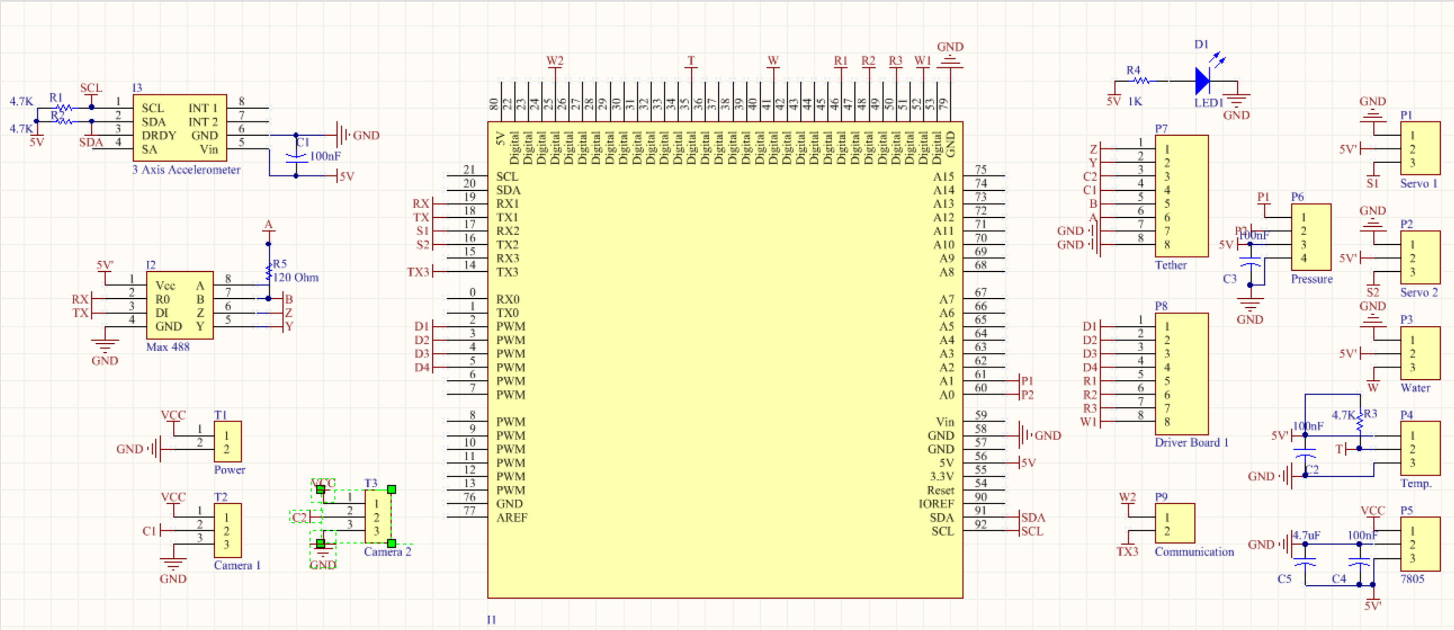
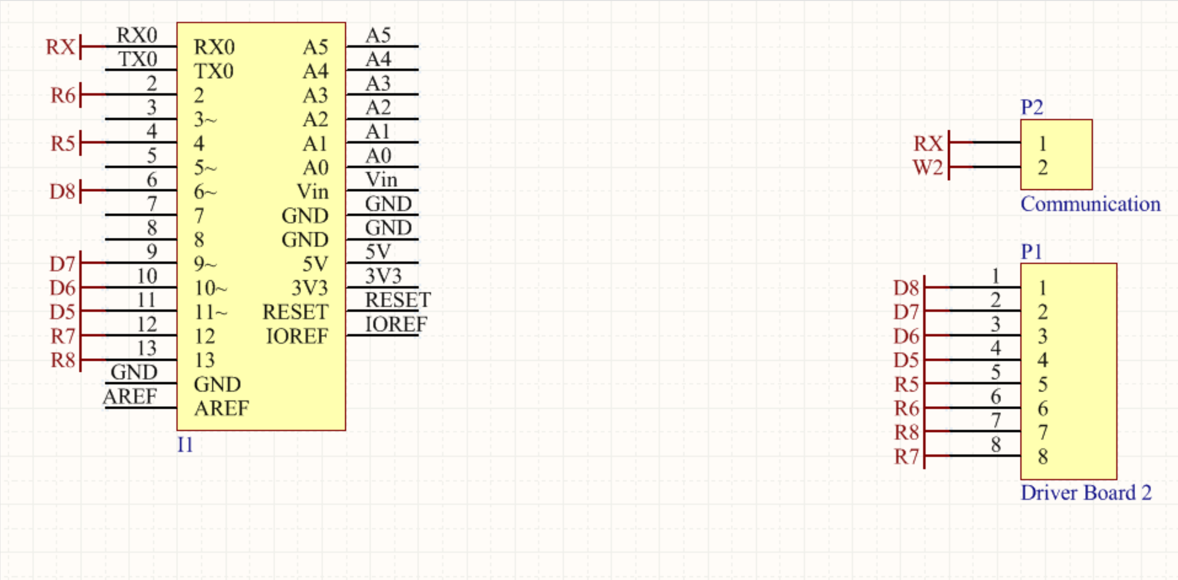
XII. Appendices

A. Electrical Schematics

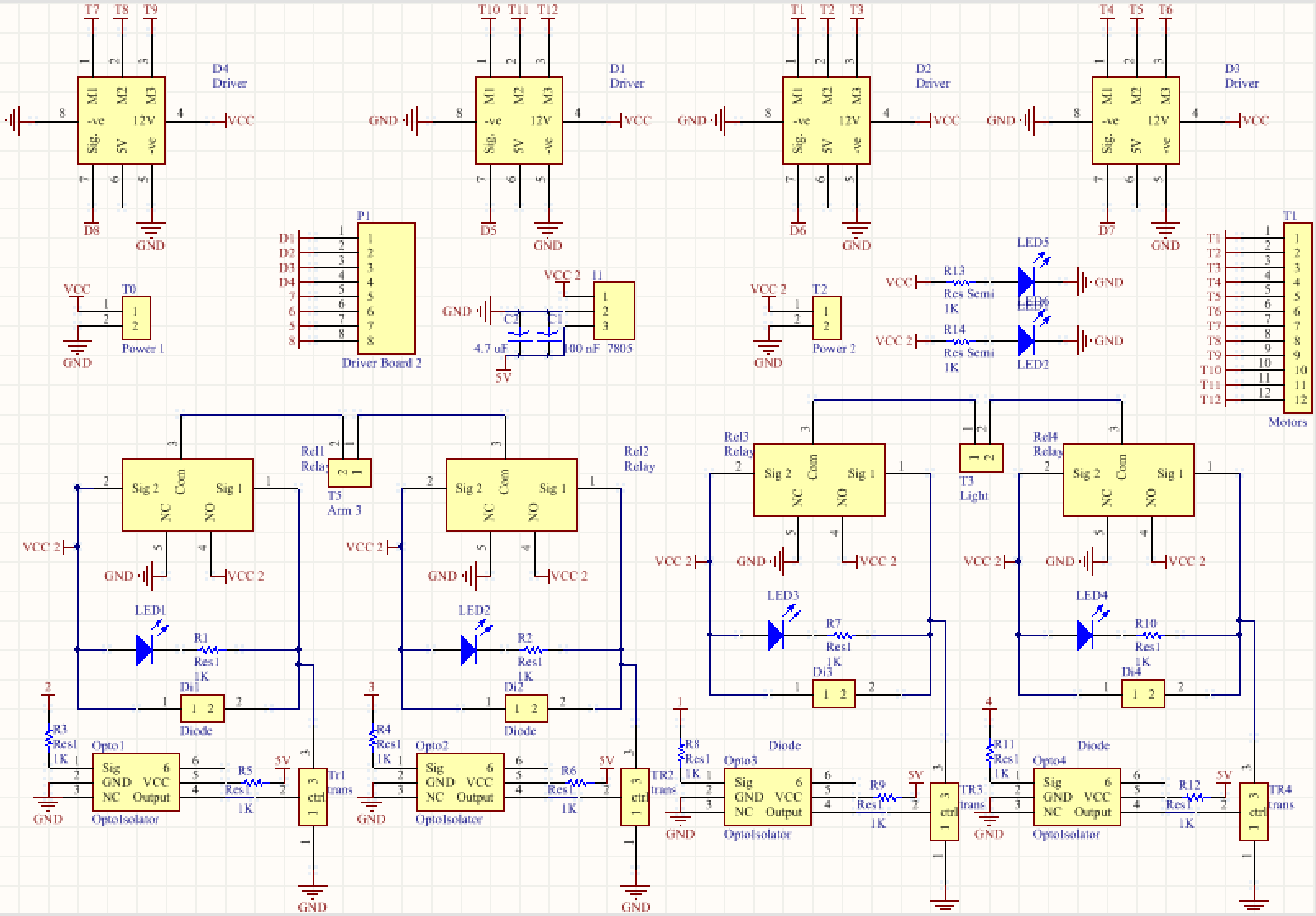
1. Arduino Board (Master)



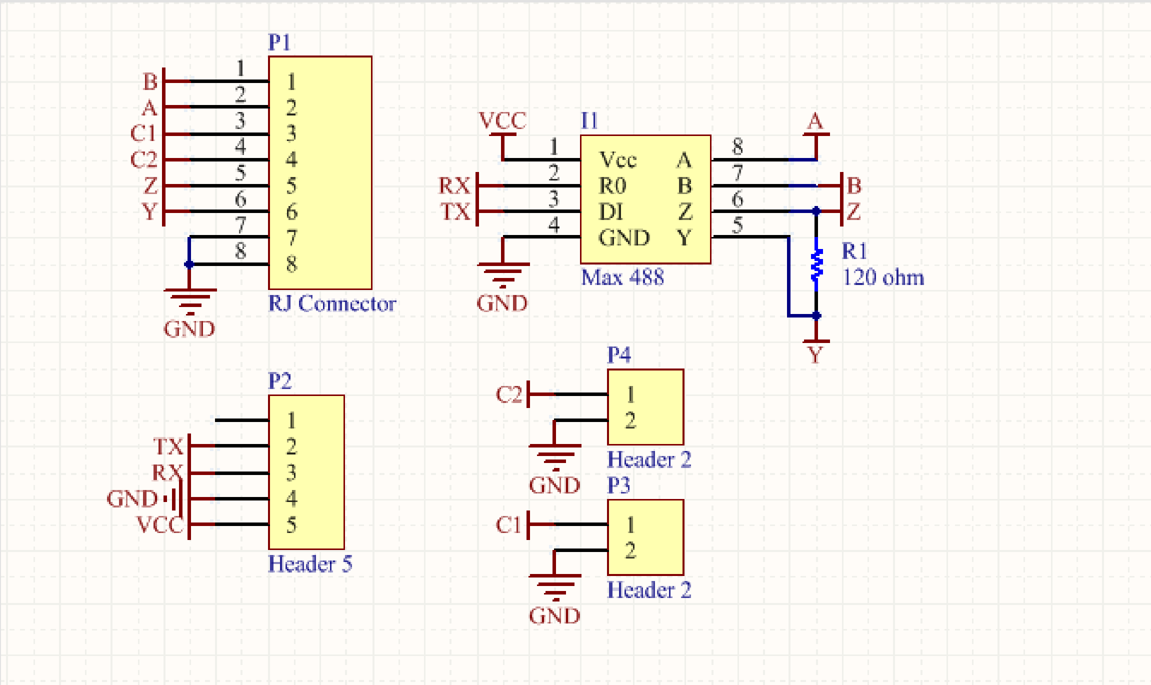
2. Arduino Board (Slave)



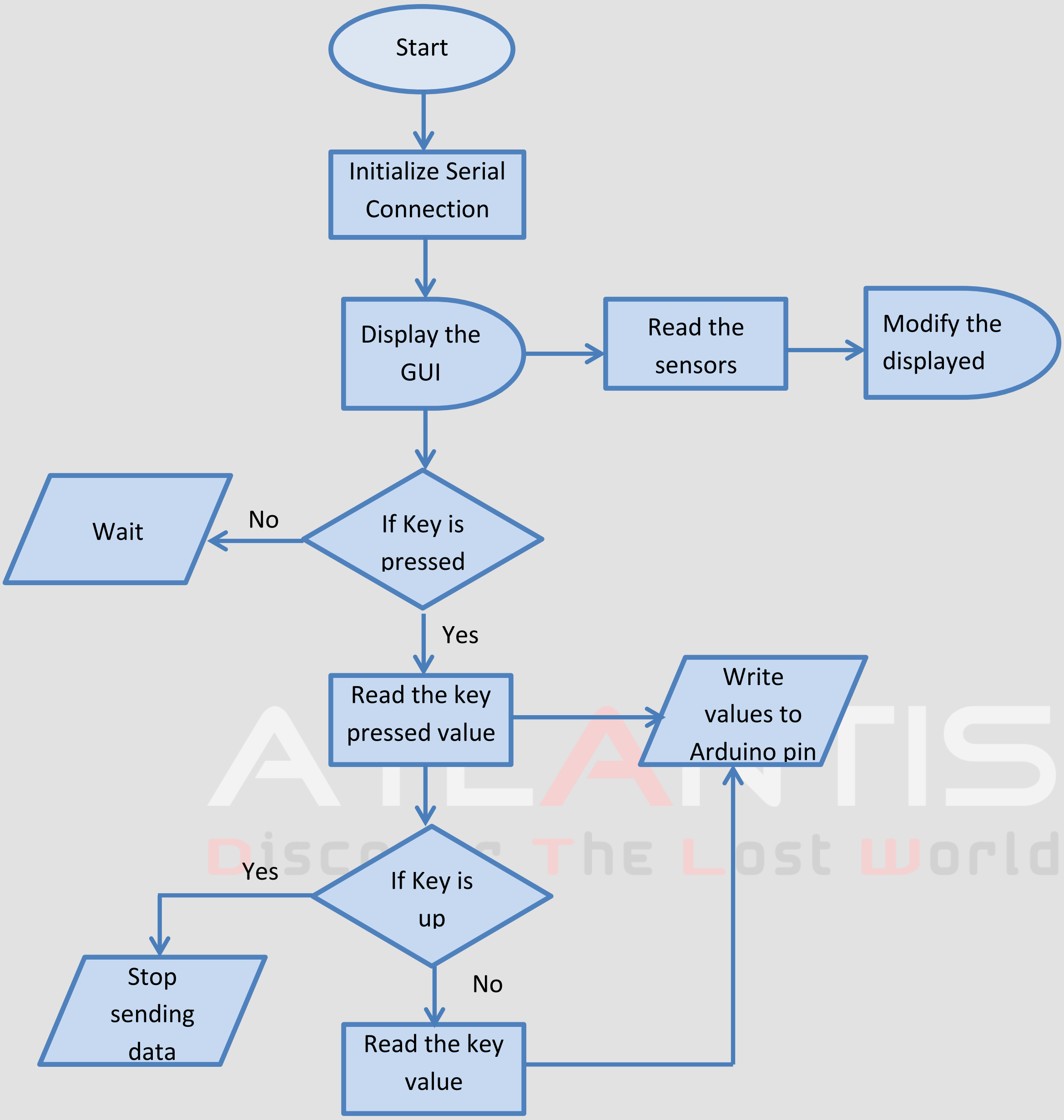
3. Drivers Board 1& 2



4. Surface Control



B. Software Flow chart



C. Safety Checklist

No.	Safety procedure	Checklist
1	Connect the tether to the ROV	
2	Check if there are any sharp edges in ROV	
3	Double check all waterproof plugs whether it is tightened or not	
4	Check whether all of the cables had been properly sealed	
5	Using Digital Multi-meter, check whether the 48V input and ground is connected or not	
6	Check the fuse in the emergency button	

7	Connect power supply with the tether	
8	Check whether all of the motors can be rotated	
9	Clear the area around ROV before test the motor on the ground	
10	Turn on the power and see whether the ROV is functioned properly	
13	Put the ROV in the water	
14	Check the electronic tube water proofing	
15	The ROV is ready for the mission	