MATE Center
ROV Competition
2018
Alexandria, Egypt

Technical Report

The Kraken

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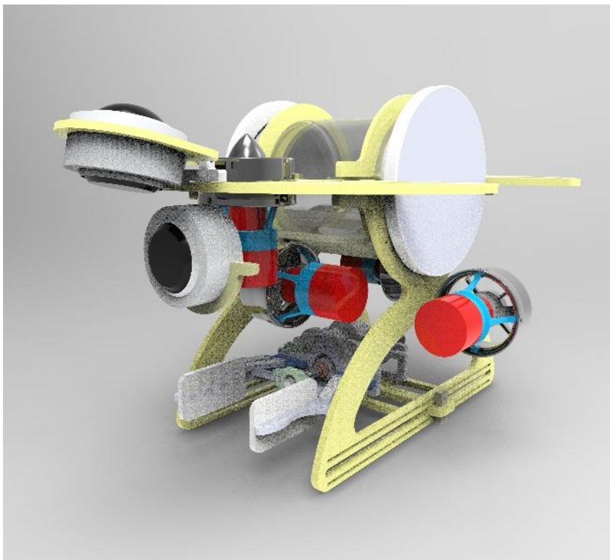
I. Abstract

Robo-Tech is a marine company dedicated to development and manufacturing of ROVs to tackle multiple challenges environments. The latest Remotely-Operated Vehicle from our company **“The Kraken”**, it is specialized to do several tasks under water, in order to build it we were split into four teams (Administrative, Electrical, Software and Mechanical), to be more organized, ensure our development and fabrication of our product. The design was based on leaving free space to facilitate handling errors Moreover; the ROV’s flexible design enables adding or removing any extra hardware or required software.

We took into consideration the size and weight to ease our mission under water. Software was developed and coded from scratch via C# and Arduino allowing the user swift correction of any error. Electronics were assembled, modified and tested extensively to ensure the system stability. The safety for environment and people is a priority in our product so we made sure that safety labels have been added, shrouded thrusters, no sharp edges, electronics housing wiring was as compact as possible also electronics system is protected from any unexpected increasing in current by adding a safety fuse. This report will show the technical information about the mechanical design, software and electronics as well as the safety considerations and the future improvements.



(Fig. 1: Computer rendered 3D model of this year ROV)

(Fig. 2: Robo-Tech Co. The Kraken members)

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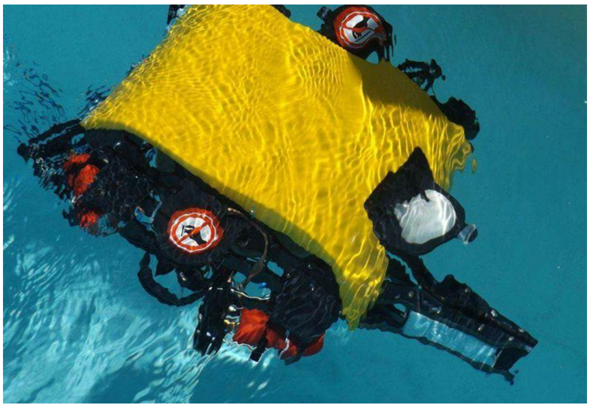
III. Design Rationale

A. Design Evolution

Since 2016, We have built two ROVs, first let's talk about last year ROV seen in (Fig. 3) and the problems encountered us, we had two motors for up and down in sides which made us unable to do pitch and made the maneuver in missions so difficult.



(Fig. 3: Last year ROV)

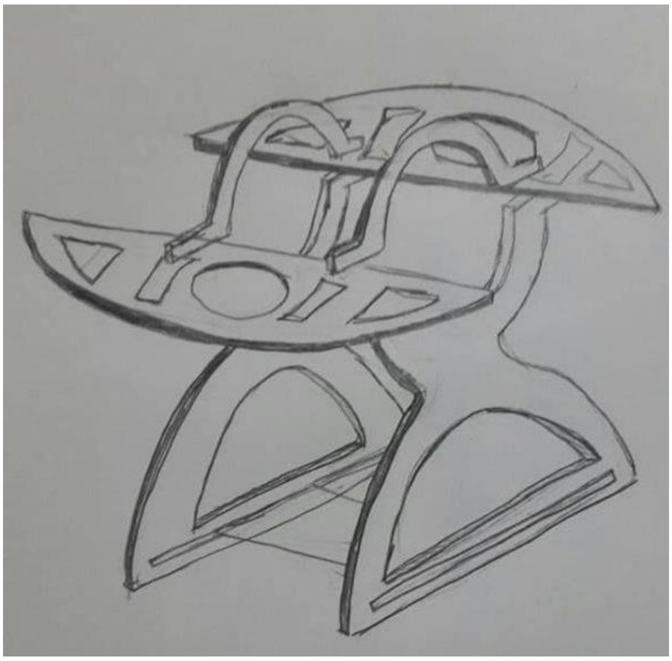
We had an acrylic tube its length was 25cm which made it take a big space as well as end cap weight was too much. We had two plates beside each other which was so bad because our limited space, and that made us in need to install forward and backward motors in another part.

This year ROV:

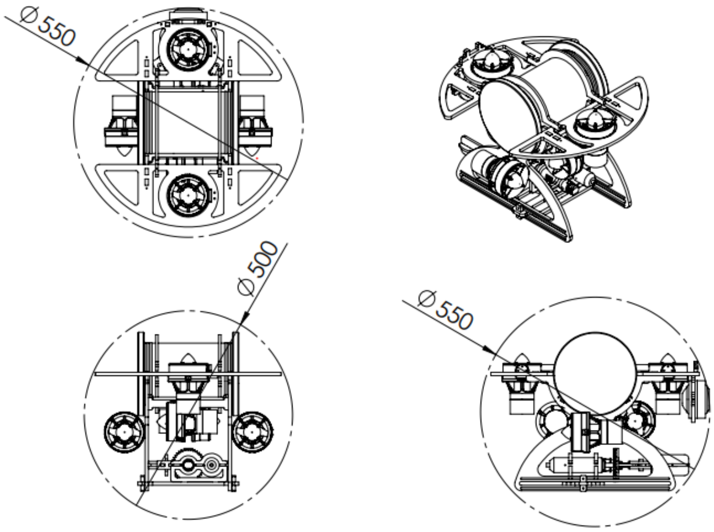
We focused in solving the problems that we had in the previous year. We did this year lots of modifications to fix the problems encountered us in our 1st ROV.

We changed our design system to be one plate horizontally and two plates vertically which helped us to benefit from the area as much as possible, so that we do not need the other part to install forward and backward motors and that helped us in decreasing the weight.

We used this year modified bilge pump to have a much more force which will help us to finish the missions faster. we have also changed the motors angle to make use of the greater force component in the forward/reverse direction. The acrylic tube was shortened, the motors guards were added to increase thrusting and for safety, we put the motors in front and back to be able to maneuver and pitch.



(Fig. 4: Free-hand sketch of our ROV during brainstorming)



(Fig. 5: 2D sketch of our ROV)

B. Frame

1. Design

We used Solidworks CAD to design our ROV, the Design was purposed to let the motors work with the best efficiency, provide the pilot with full display, use the least parts and have ample space for tools, in order to achieve that we designed a frame which is mainly composed of three plates, the upper plate is put horizontally the up and down motors are attached to it and the control box mounted in the middle to maintain the slightly positive buoyancy as it is our main source of flotation and it was fixed by crescent holders so we are able to change and control electronics easily. The lower two plates are fixed vertically by close fitting to the upper plates. The forward/backward motors are placed externally and the left, right motors are placed internally in the lower two plates and the arm is constrained in a slider. A moveable camera was constrained in the top to monitor the arm's movement while working on missions, up and down motors were put vertically. Our ROV is 30 cm height, 50 cm in width, 50 cm in length and its weight in air is 12 Kg.

(Fig. 6: The Kraken Frame)

2. Material Selection & Fabrication

We have chosen Artilon (Poly Ethylene) in the frame due to its superior mechanical and physical properties. It is lightweight, durable, and easily fabricated. Selecting Acrylic for the arm was because it is Easily Fabricated and Shaped, Highly Transparent, Lightweight and its Strength so it can be loaded with the missions' carried weight. We modeled them using CNC router, laser cutter and 3D printing.

3. Drag

Drag is a force acting opposite to the relative motion of any object moving with respect to a surrounding fluid. While designing our ROV we have tried our best to minimize the drag force to increase the velocity so according to skin friction drag We have selected the Polyethylene material for smoother surface and to diminish friction and to minify the exposed surface to the fluid "water" according to the foam drag following the equation **Fd = ½ P v^2 Cd A** We have several choices for reducing the drag force first by selecting the round shape for our ROV to reduce the drag coefficient so that the drag coefficient is 0,45 and as We have mentioned by minifying the surface area.

4. Buoyancy

Buoyancy force is the upward force exerted by the fluid on the body that immersed in order to compensate for the weight of frame, electronic components and the other components a buoyancy foam seen in (Fig. 7) was fabricated and mounted on the top, the acrylic tube provided us with high Buoyancy force as well. These things obtain the slightly positive buoyancy (Calculated and based on **"Archimedes' Principle"**). Our ROV is 5% slightly positive.

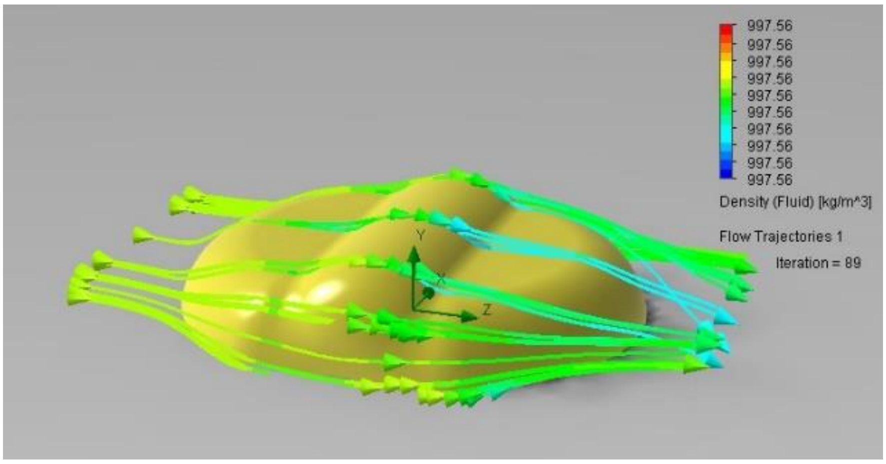
(Fig. 7: Buoyancy Foam)

5. Fiberglass

The main reasons why we made fiberglass:

1- To reduce skin friction drag and from drag by customize the fiber to be very smooth and make the shape of the fiber aerodynamic to the extent possible.

2- To make the shape of the kraken look more better by covering the wires, electronics and to protect control tube. We also painted the fiberglass in yellow because it travels 100 FT underwater and this will provide a clear vision of The Kraken



(Fig. 8: Flow simulation of the kraken's fiberglass)

C. Propulsion System

In our journey this year to build a cheaper and best ROV, after many discussions within the company we saw that the Blue robotics T100 brushless motor thrusters seemed to be very expensive for us. So, we decided to use a bilge pump with 3D-printed base and pillars were designed and fabricated by company members and were used to hold and support the kort nozzle, these pillars are designed to make the flow smoother and streamlined through the kort nozzle. We used the modified bilge pumps from last year. The motors are constrained in a way to achieve all the possible motions and to preserve all the thrust and power by putting them parallel to each other and controlling every motion using only two motors instead of putting them with a certain angle and controlling every motion by four motors which wastes portion of the thrust and power. In order to achieve that the forward and backward thrusters are put with an angle 90° in the corners and the other two motors are put internally with an angle 180° for rotating.

(Fig. 9: The modified bilge pump)

D. Grippers/Manipulators

Our manipulator is made up of a pneumatic cylinder responsible for opening and closing with a DC motor responsible for its rotation.

1) Materials

-We used **Polyethylene** for base, fork in the gripper, tube and end cap in rotating part because Polyethylene is strong, water resistant and it can be easily machined.

-We used Acrylic for end effectors and gears because it is water resistant, achieves clear vision for the pilot and smoothly machined to ensure the accuracy of the gears.

-We used **Copper** for the coupler and extension part (Fig. 12) because it is strong and light in weight.

2) Fabrication

-CNC: In polyethylene and acrylic parts.

-Center Lathe: For extension parts.

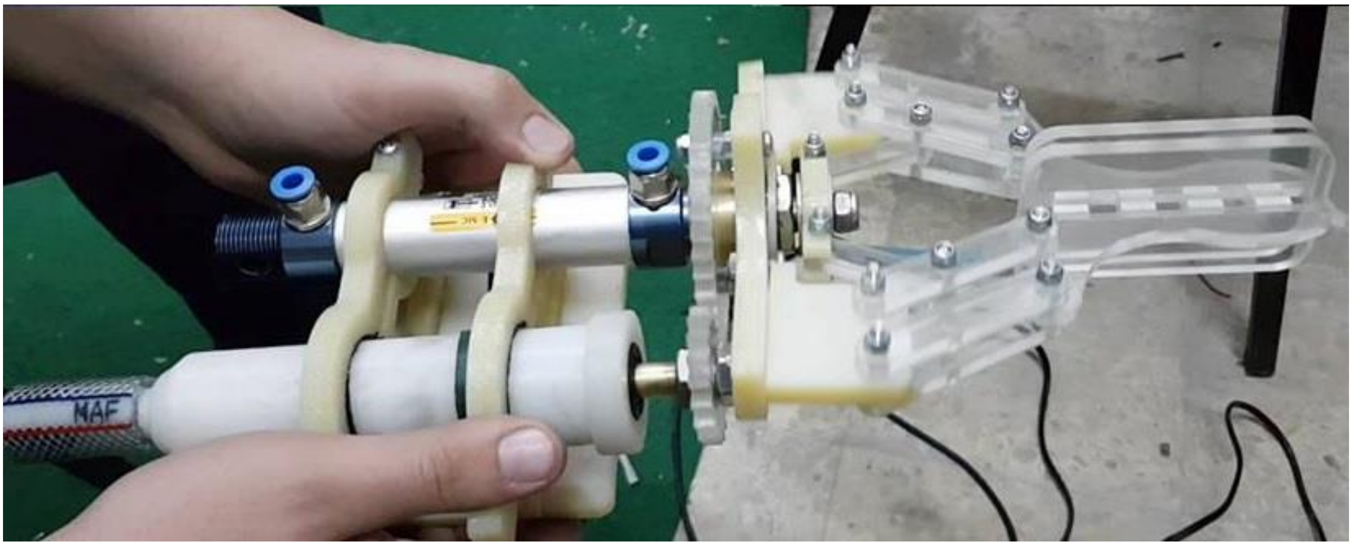
3) The Gripping Mechanism

Our company designed the gripper to hold bodies firmly under water. This mechanism utilizes the 50 mm piston to close and open two end effectors parallel to each other keeping the force perpendicular to the held object. It can hold objects with diameter size up to 9.8 cm. The end effectors are straight and elongated in shape ensuring a large contact area with the held object as long as it is not spherical in shape.

The pneumatic manipulator rotation is supported by 2 ball bearings to facilitate its rotation by minimizing the friction force. The arm can rotate 360̊ on both directions.

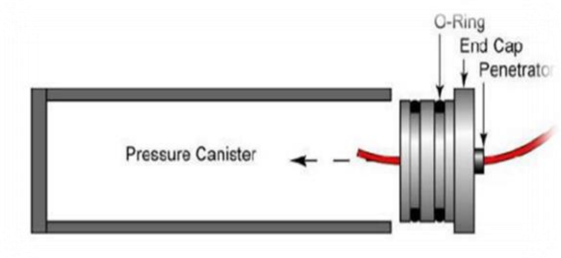
4) The Rotating Mechanism

The rotating mechanism is a very important part to give the gripper the ability to interact with object on both the horizontal and vertical plain. The gear box was implemented to reduce the motor's speed.



(Fig. 10: Real view of our manipulator)

E. Sealing



(Fig. 11: Control box sealing)

1. Acrylic Tube (Control Box Sealing)

We use in the control box sealing 2 end caps each one of them has 2 O-rings, 1 of them is basic and the other is for safety. One of them have only one hole to get out all wires out of it and the other is completely closed. We use polyethylene in the manufacturing of the caps for its cheap price and its light weight and easy cutting.

- Acrylic tube
- rubber O-rings
- Polyethylene for end caps

(Fig. 12: Wires sealing)

2. Arm sealing

We seal the wire hole with end cap. It is like hose and inside it a perforated rubber, the wires get out from the holes in the rubber and it bind them with zip tie and behind the motor's shaft we use oil sealing to prevents water from entering.

3. Cameras sealing

We bought the isolated cameras seen in (Fig. 13) because of its excellent quality and its cheap price, also we for saved time and efforts.

(Fig. 13: Insolated Camera)

F. Vision System

In order to give our pilot, the best viewing angles for manipulators and surroundings, we use two cameras, first is directed forward which helps the pilot in navigation. The other one is directed to see the manipulators. These two cameras are related to amplifier seen in (Fig. 14) then to DVR to be monitored on the pilot's screen. We use DVR Dahua (Fig. 15) with the following specifications to get the output of camera and show it on the screen and laptop.

- Type: HDCVR.
- Resolution: 720p.
- Video input: 4 channels.
- USB port: 2 ports.
- Power supply: 12v/1.5A.
- 1 HDMI.

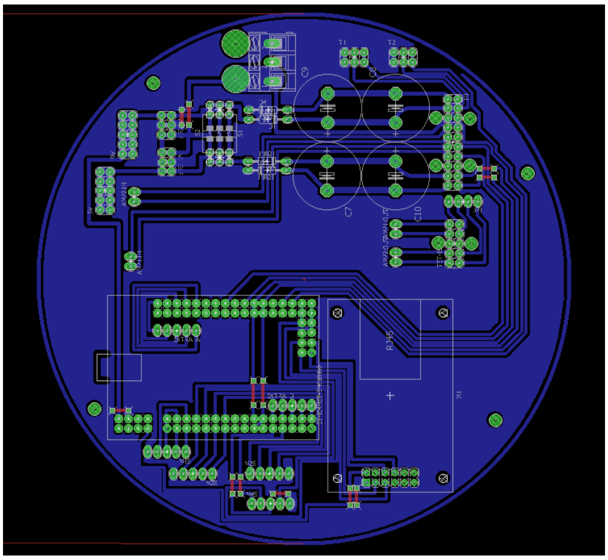
(Fig. 14: Amplifier)

(Fig. 15: DVR)

G. Electronics and Control

1. Mother Board (Onboard Circuit)

1) Circuit Layout



(Fig. 16: The motherboard circuit via Eagle)

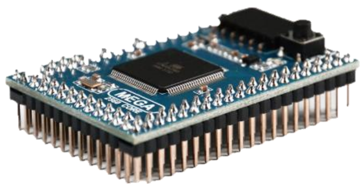
As we broaden our aim every year the amounts of tasks depending on the electrical power increases in return. This year our electrical department sustained two major problems one of them was the insufficient space that have forced them to create and design an immaculate electric circuit which provides full control over the ROV's power distribution and communication systems. Containing the following items as the main components:

- An Arduino mega-mini development board
- 4 Cytron 10Amp DC Motor Drivers
- Power regulation system providing 3.3, 5 and 9 volts
- Two Mosfet transistors
- SPI module for communication

All located on a circular board with the diameter of 14 cm. We used an Arduino mega-mini development board for not only its small size but also for it capabilities providing more digital and analogue pins. The connectors are suited in one direction and fetched in parallel to simplify the overall flow of current. Extra analogue and digital pins are supplied from the Arduino board to try and test new ideas and concepts. The tracks are adjusted to a specific width according to the rate of current flowing. Extra ground pin headers are used in urgent supply cases and Extra 5V and 9V pin headers are outputted from the two regulators as well. We used Eagle CAD in order to design our PCB.

2) Board Components

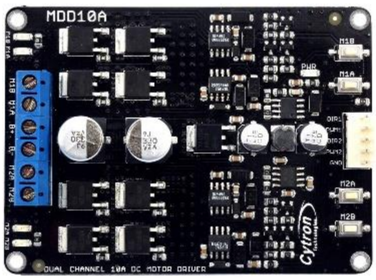
- Arduino board



(Fig. 17: Arduino Mega-Mini)

Our Mega-Mini board seen in (Fig. 17) is the Control Unit of the circuit as it overtakes several tasks. It is supplied by a 9 Voltage supply from the 9V regulator. It receives the pilot's signal as a concatenated string of data from the GUI software using the SPI protocol. It gathers the overall data and resend it back to the GUI software as a concatenated string of data with all the sensor readings and overall changes in the system.

- DC Motor Drivers



(Fig. 18: The Cytron motor driver)

The Cytron 10 Amps motor drivers control the motor's direction according to the received signals and controls the motors' speed according to the received PWM signal from the Arduino board seen in (Fig. 18). There are 4 motor drivers in total in the ROV controlling 6 Bilge pump motors and one dc motor.

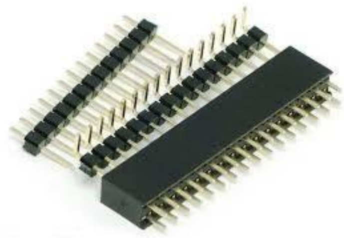
- ENC28j60 SPI Module

The ENC28j60 Ethernet Module seen in (Fig. 19) is a board which contains an Ethernet port and converts Ethernet input into SPI or (Serial Peripheral Interface). The board is based in on microchip's ENC28j60 integrated circuit and it can be used to provide internet connectivity to microcontroller systems like Arduino boards over Ethernet. Since the board is small in size and it supports SPI interfacing protocol with very fast response to commands sent to the ROV and data received from the sensors.

(Fig. 19: SPI Module)

- Pin headers & connectors

We used pin header for all the external connections to the circuit due to their cheap price, abundance, efficiency and durability. We came up with a way to hold in place using cable ties. We use a variety of pin headers including double row pin header male and female seen in (Fig. 20). We also use XT60 connectors for delivering power to the circuit seen in (Fig. 21)**.**



(Fig. 20: Pin headers)

(Fig. 21: XT-60 Connector)

2. Tether

The tether consists of three main sections:

1) Pneumatic House

The pneumatic House connects the compressor to the solenoid for transporting the pressured air to the pneumatic arm.

2) Ethernet cable

It was chosen to contain the cameras signal, and the wires that transport signals between the on-board microcontroller and the main laptop on the station.

3) Power cable (2 wires)

we enclosed the tether by shrink and nylon sheath seen in (Fig. 22) to keep it contained and remain light weight. The tether buoyancy was tested and it was found that it does not affect our ROV.

(Fig. 22: The Tether)

3. Station

We used the same body of control box of the last year because it had all we needed (Easy transparent and strong body) it perfectly fit the specific components the box is fully made of wood and we divided the control box into 3 major zones. It receives signals to and from ROV by the Vega port. Instead of wiring all the power we put 1 AC plug connector and plugged all of the components (DVR, Screen and Power supply) to reduce the errors and increase the safety. After receiving camera signal from the Vega port, it passes through the DVR to display the cameras vision. We also put a plastic layer to cover all components with a lightning power switch.

4. Power distribution

Our vehicle is powered by an external 12VDC power supply. The 12V output of the power supply is connected to the cameras, solenoids and power pins of the motor drivers. As for the rest of our circuit, we used two linear voltage regulators. A 9V regulator was used to power the Arduino and a 5V one was used to power the Bluetooth module. The presence of those regulators insures that the regulator on the Arduino board does not heat up significantly.

(Fig. 23: Voltage Regulator)

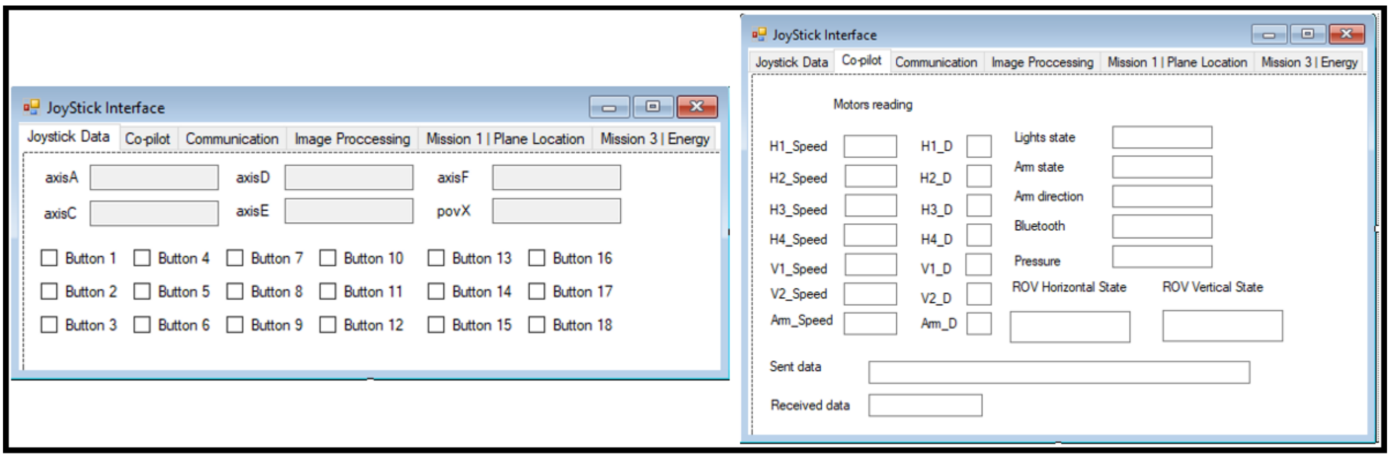
5. Control and Communication

Our ROV is controlled by The Extreme 3D Pro Joystick seen in (Fig. 24) which communicates to C# application. The C# application maps the pilot movement of the joystick to numbers represent directions, speeds of motors and other orders, then the C# program concatenates all data in a String and sends it to the mother board controller (Arduino Mini Mega) using User Datagram Protocol (UDP) via Ethernet cable. UDP is then translated to SPI using SPI module. The SPI module translates the UDP to SPI that Arduino can understand. After microcontroller receives data it starts to parsing this data into values and write them on the motor drivers, lights and pneumatic arm. We made the ROV controlling as simple and as straightforward as possible to make it easy to receive or send data and to ensure that the pilot would be able to drive efficiently.

(Fig. 24: Joystick)

6. Graphical User Interface

We have designed a user-friendly GUI written in C#, it provides full control and monitoring of our vehicle it has six tabs; each has a purpose. The GUI is one of the ways of viewing a feedback from the RO, it provides the stick position, the slider position, buttons conditions (Clicked or not), live monitoring of motors, communication success which is essential for the Co-pilot to help the pilot have a good insight.



(Fig. 25: The kraken's GUI)

H. Missions Tools

1. Multi-Tasking Manipulator

As previously mentioned the company mechanical department team has improved one manipulator with two degrees of freedom, the purpose behind making it was to ease **"Energy Mission"** for the pilot because controlling one manipulator is much easier than controlling two hence the pilot will be able to move and assemble objects fast and efficiently.

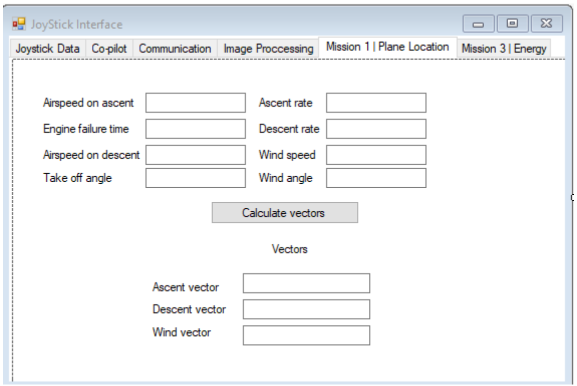
(Fig. 26: The kraken's manipulator)

2. OBS' Release Mechanism

Our company used a releasing mechanism based on sending Bluetooth signal from Our ROV to the release mechanism micro-controller it turns the DC motor on by an indication of the transistor.

3. Computer Application

The company software department developed a computer application using C# programming language, they created 2 tabs. One to localize the plane location and calculate the total power of turbines and the other one is for measuring the distances under water, we accomplish this by taking an image by ROV's camera and including an object that we know its length in the picture then compare it with the bits in the image. These tabs have been designed based on the requirements of the **"Aircraft and energy missions".**



(Fig. 27: Computer application tab)

4. Lift bag's Release Mechanism

The mechanical department designed a part which looks like a hook seen in (Fig. 28), the hook was linked to the lift bag using rope so that the pilot will easily attach/detach the lift bag mechanism to/from the debris. We also use pneumatic system for pumping the lift bag.

(Fig. 28: The designed part)

(Fig. 29: Real view of the lift bag)

IV. Safety

From day one and the rule **"Safety First"** is held in our minds, we have been thinking day after the other in our company how to make our work environment safe and make sure that no accident whatever may happen of course that seems to be un-imaginable but when you develop your safety protocols it may occurs one day.

As we believe that safety starts from yourself we started our training for the new members by putting some safety values that must be put in consideration during our project or else firm decisions are taken against those who break down any of these rules.

A. Safety Features

1. Self-Safety features

As mentioned before, each member has to start by himself to make sure that there will exist no accidents or even any errors which is in the track of trying to make a fully safe environment of work.

Safety protocols is the main value in our work so during work which are:

- During welding or using drillers you must wear glasses
- Using dry hands and tool and stand on a dry surface while using electrical equipment.
- No one works alone to avoid any accidents.
- Company members must wear non-electrical conducting gloves, toed shoes and safety glasses.
- Wearing special masks and gloves during dealing with chemical substances.
- First aid kit presents always.

(Fig. 30: Marwan Fouda during using gloves and glasses)

2. Vehicle's safety features

After months of working on our project we cannot let our achievement pass with any issue so our mechanical engineering team and the electrical one made sure that the safety conditions are applied on our project.

The mechanical team made sure that nothing that may cause harms exist on our ROV so they smoothed the sharp edges, covered the propellers with Kort Nozzles, safety signs covers all the ROV, pressure release valve and regulators exist in the pneumatic system and finally caped nuts exist at any end on any bolt.

Also, the electrical team did his role, fuses are used all over the ROV and the tether to protect it from overcurrent also heat shrinks are used on welded wire

B. Testing protocol

Our company has safety check list to ensure that everything is done correctly before testing the ROV and we start with a dry test for the thrusters and all the ROV electrical and mechanical process to be sure that everything is working correctly before trying it underwater we have priority of checking we start with the power supply then the pressure of the compressor to be sure that all the members of the crew are safe.

C. Safety Check List

Tether connected to the ROV	√
Check if the cables are securely fastened to the frame.	√
All electrical components are properly sealed.	√
Check the 12v from power supply by Avometer.	√
Check fuse.	√
Ensure the pressure release valve is closed tightly and with mounted Protection cap.	√
Check cameras.	√
Check current.	√
Thrusters and propellers are properly attached.	√
Service, transport or handling of ROV must be performed by at least 2 company members.	√
No exposed wires.	√
THRUSTER RESPOND TO CONTROLS.	√
Check the buoyancy.	√
Before service of the ROV, gently touch the heat sink, with hands and Evaluate if it is cool enough to touch comfortably.	√
Check the bubbles.	√

D. Operational Checklist

BEFORE MISSION RUN

- ☐ Set station box and run ROV system.
- ☐ Drag the arm slider and Fix it.
- ☐ Check no wiring or physical damage.
- ☐ Check wiring sealing.
- ☐ Set compressor output 275kPa.
- ☐ Check power supply output 12v.
- ☐ Check fuse.
- ☐ Test thrusters and cameras.
- ☐ Check pneumatic air lien.
- ☐ THE KRAKEN READY FOR LAUNCH.

LAUNCHING

- ☐ Adjust the position of the Gripper camera.
- ☐ Fix the Camera.
- ☐ Handle ROV into Water.

END OF MISSION

- ☐ Bring up ROV.
- ☐ Power down ROV, Control box and compressor.
- ☐ Stow tether securely.

V. Conclusion

A. Build Vs. Buy

Our company is made out of steel and is composed of critical thinkers that could make a solution literally pop out of the sky. For example, a T-100 thruster costs $120, which approximately is 2,124 L.E. As a result, we purchased the T-100's propeller and kort nozzle separately and installed on a bilge pump motor using a 3d-printed extension designed by our mechanical team. Moreover, we manufactured our own PCB as purchasing a ready-made version would be a waste of money. Not only this but also, several components were still in perfect condition such as: tether, motors and motor driver. Further, certain components needed to be purchased ready-made as the hand-made version will not be efficient.

B. New Vs. Reused

We are working hard every year to save money by using parts from our last ROV, and that does not mean that we are not eager to innovate and develop more effective and efficient systems for both the mechanical and electrical parts of our ROV, we did not disassemble our last ROV because we are using it as a teaching tool for others. The parts we used from our last ROVs are our Bilge pumps, T100 Nozzles, Propellers, station box, DVR, cat6 cable, Motor drivers, Cameras, as they are lightly used and still maintain the same quality.

C. Budget

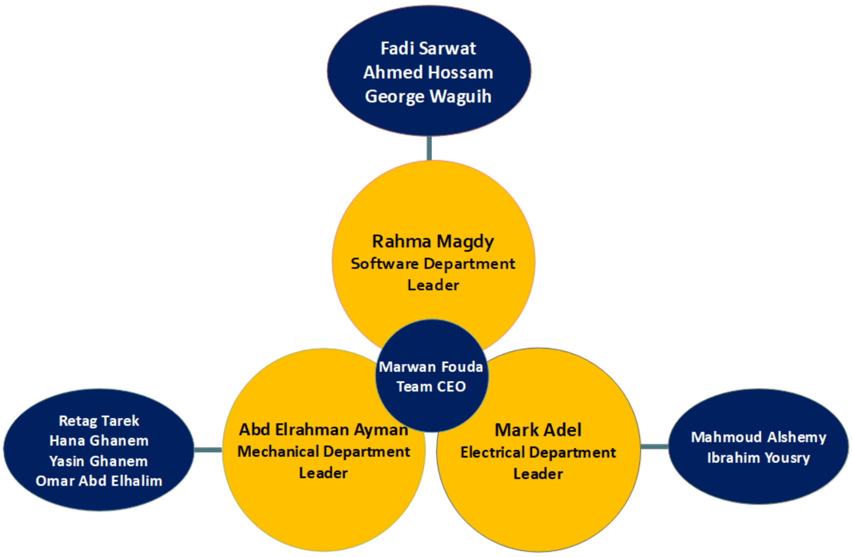
	Source	Note	Total
Income	Member dues for building the ROV	105$ each one	**1,365$**
	Member dues for traveling expenses	5 Students and 3 mentors, 1000$ for each one.	**8,000$**
	Sponsorship	We got funding by 5 flight tickets and the accommodation	**9,000$**
Total budget			**18,365$**

Category	Expense	New\re-use	Source/Note	Unit price	Quantity	Total
Mechanics	Acrylic tube	New	Putting every electric component Inside it	22$	1	22$
	Sheet Polyethylene	New	Used for making the vehicle frame	53$	---	53$
	Frame cutting	-------	(CNC) laser cutter	32$	---	32$
	T100 nozzle	Re-use	Used as a guard for safety precautions	5$	6	30$
	propellers	Re-use	Used for vehicle movement	4$	6	24$
	O-Ring	New	Used for sealing	0.5$	10	5$
	Acrylic tube sealing	New	Sealing electric components by two caps	26$	2	52$
	Balance system	New	Used: foam and weights	3$	2	6$
	Bolts and nuts	New	Used for holding the arm and frame	0.5$	40	20$
	Station box	Re-use	Used to control the ROV	11$	1	11$
	5/2 solenoid valve	New	Used for control the pneumatic gripper	8$	1	8$
	2/2 solenoid valve	New	Used for control the lift bag air	8$	1	8$
	double acting cylinder	New	Used for the pneumatic arm	13$	1	13$
	Fiberglass	New	USD for reduce drag	32$	1	32$
	Mechanics total			**316$**		
Electric	Motherboard	New	Used for handling the ROV's system	8$	1	8$
	6mm Power cable	New	Used for tether cable	0.5$	30m	15$
	CAT6 Cable	Re-use	Used for tether cable	0.5$	14m	7$
	Anderson Plugs	New		5$	1	5$
	Motor drivers	Re-use	Used for controlling motors	24$	4	96$
	Arduino Mega Mini	New	Used to control the electrical system	15$	1	15$
	Bilge pump	Re-use	Responsible for the thrusters Energy	24$	6	144$
	Dc motor	New	Responsible for the Gripper movement	13$	1	13$
	Joy stick	New	Responsible for the ROV movement	45$	1	45$
	DVR	Re-use	Used to display cameras vision	15$	1	15$
	Dehua camera	Re-use	Responsible for the Visual view	10$	2	20$
	Electric total			**383$**		
ROV total cost				**699$**		

Category	Expense	Source/Note	Unit price	Total
General	Competition fees	the entry fees for the competition and the local competition.	**350$**	
	The ROV total cost	The cost of the all components inside the ROV	**699$**	
	Travel and accommodation	Flight tickets and accommodation for 10 students and 3 mentors	**17,000$**	
Total budget			**18,049$**	

D. Project Management

Since the first day, the company rules were applied, the team CEO divided us into groups and each group has a leader as seen in (Fig. 3), the CEO give the orders and tasks to groups leaders and they distributed the tasks among members in a way which enhance members abilities to accomplish all requirements and deliverables on time to finish tasks faster and in effective way. We have followed a **"Team Scoring Rules"** to evaluate each member's work applying monthly reward/punishment rules.

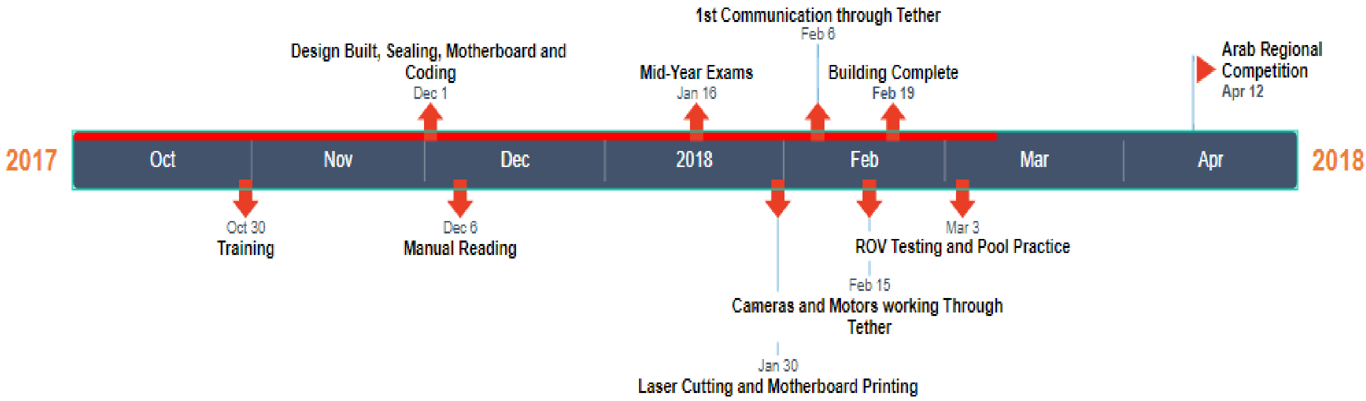


(**Fig. 31: Job Assignments**)

We had our first meeting on August 21st,2017. To strengthen our knowledge and improve our skills we began to meet twice a week after school for our training camp until October30th,2017.

On November 11th,2017 we had our 2nd meeting to put the baseline of things needed to make/design (e.g. Control box, Frame, etc...). Our to-do list was shared with everyone to ensure that everyone would be productive and no tasks would be repeated, we put Tuesday and Thursday as fixed meetings in order to evaluate our progress and discuss what we had reached.

As we approached the competition and our work increases everyone become involved with more aspects, since that our goal was to get our bot ready for the pool before the beginning of April, so that we leased a pool for two weeks to make sure that we would have an ample amount of practice before the regional competition.



(Fig. 32: Timeline)

E. Troubleshooting Techniques

During working on The Kraken some issues happen in mechanical, electrical and software departments resulting from human errors or random errors so that we decided to put a troubleshooting strategy to trace and take action on these errors.

There are several techniques that our company use in troubleshooting problems. When a problem appears, we begin to identify the problem by testing step by step and determine the affected or malfunctioned components of the ROV so we be able to reach the exact cause of the error.

- We follow the following tips in solving problems:
  - Write down the steps: Once we start troubleshooting, we take notes about error and write down each step we take. This way, we will be able to remember exactly what we have done and can avoid repeating the same mistakes.
  - Always check the cables: If we are having trouble with a specific piece of ROV hardware, such as motor doesn't work or any other component, an easy first step is to check all related cables to make sure they're properly connected.
  - Follow the system checklist: in order to make sure that there is nothing missed.
  - Define an action plan.
  - Reboot and check if everything is working fine.

F. Challenges

1. Technical Challenges

This year we encountered and overcame multiple technical challenges, which improved our skills and experiences. The first challenge was in the motherboard because it is our first time to make a PCB with a lot of components we failed 6 times which came from different mistakes (Eagle design, Ironing the circuit, Drilling, Soldering). The second challenge was in code this year we used a new way of communication between the station and ROV (we used laptop to send joystick signals instead of Arduino and USB module) so we faced different issues in the code and in transportation of signals such after we had checked that C# program is fully working, it failed to send data to Arduino so we tried to change the module that send TX and RX until it was fixed. The third challenge was in sealing this year we also tried using a different method to seal our acrylic tube that we put a new type of connectors, but the sealing had broken two times so we used the last year sealing strategy. The fourth challenge was in the arm as we used pneumatic arm for the first time so we had a lot of problems (Solenoid sealing, Wires connection, Pneumatic arm fitting with the DC arm to have two degrees of freedom).

2. Non-technical Challenges

One of the challenges that proved working in Egypt is difficult was that the exchange rate from dollar to Egyptian pounds is extremely high and since we did not find a financial sponsor we used a lot of components from the previous years and a lot of components we made ourselves to reduce the cost. As we are 13 school students it was hard for us to find fixed days to work across the week as everyone had his own duties and this affected negatively our company, we started meeting according to the departments: electrical and mechanical, we fixed Thursdays for meetings, in the last days, we had to meet every day during our mid-year holiday to finish our work and sometimes we had to work from dusk till dawn.

G. Lessons Learned

This year, our company has used advanced controlling system and pneumatic system for the arm which made us gain extra knowledge and we welcomed new members to spread this knowledge. Since the first day we started our project and worked hard to get the best out of us by doing technical researches, applying laws of physics, developing our soft skills and overcoming challenges.

1. Technical Skills

Electrical Engineering; Arduino Programming, C# GUI Programming and Circuits PCB Design.

Mechanical Engineering; Solidworks, Manipulators Mechanics and Pneumatic System.

2. Non-Technical Skills

Project Management Skills, Communication Skills (Presentation and Writing Skills), Team Working, Critical Thinking, Crisis Management, Time Management and Self-Learning.

H. Future Improvements

For the future, Our Company plans to make the ROV smaller and lighter for more stability, higher speeds. Material selection and working with those materials which is in the meantime very hard here in Egypt for financial reasons. Using the T200 motors for thrust to add more speed and less weigh. Changing the sealing into connectors instead of the current sealing system to add flexibility in repairing if damaged and also giving us the ability to swap anything if we need in a matter of just seconds ex: adding length to the tether or maybe even swapping the whole thing changing the motors or even the whole design. We made a prototype and still working on perfecting the way we make that connector. We are also planning to add more features like introducing a flexible manipulator to give the ROV the ability to adapt and work in all environments in the meantime we are trying out different concepts for this arm. Also, our company planning to add a separate system for calibration and stability and a mapping system to speed up the time taken in the missions to get to a certain position.

I. Reflections

"Participating in MATE competition for the second consecutive year has enabled me to grow significantly because of the countless challenges and obstacles that arose. However, I was able to gain an ample of technical skills, such as troubleshooting. As a result, my non-technical accomplishments that I gained this year were the most valuable thing I learned." **-Marwan Fouda, CEO.**

"My participation in Robo-Tech Company has provided lessons of leadership and cooperation, as well as knowledge that will be of great benefit to my career. I have gained technical skills and experience in mechanical design, CAD software and manufacturing, as well as non-technical skills including team working and presentation skills. Working experimentally, testing material and choosing which to use based on the mission requirements have been very fruitful and exciting." **-Abdelrahman Ayman, Mechanical Department Leader.**

"At the beginning, some of us struggled with working together, communicating effectively and understanding the content of the training, because every one of us has his own ideas and personality. For example, a few members had some negative experiences working together on projects in the past, I was one of them, but as soon as the competition was published, this issue began to die out because everyone of us focused on achieving our company goal." **-Hana Ghanem, Design Engineer.**

J. Acknowledgment

We would like to express our very great appreciation to the following benefactors:

Eng. Omar Mahmoud, for his assistance and supporting us with technical/non-technical knowledge

(MATE) Center, for providing us with this golden opportunity which allowed us to expand our knowledge and apply it.

WE Telecom Egypt, for funding us with 5 flights tickets and the accommodation.

AAST, for allowing using the academy pool.

We are all grateful for **our parents**, without the inspiration and support they gave to us we wouldn't be what we are today.

Mazar Co-Working Space, for providing us with the suitable atmosphere to work in.

(Fig. 33: Benefactors logos)

K. References

- Books:

-Arduino Cookbook by Michael Margolis. / Head First C# by Andrew Stellman. / Modelling and control of Robot Manipulators by Lorenzo Sciavicco, Bruno Siciliano.

- Online Courses

Youtube | Solidworks Complete Learning Tutorials

Youtube | Arduino Lessons

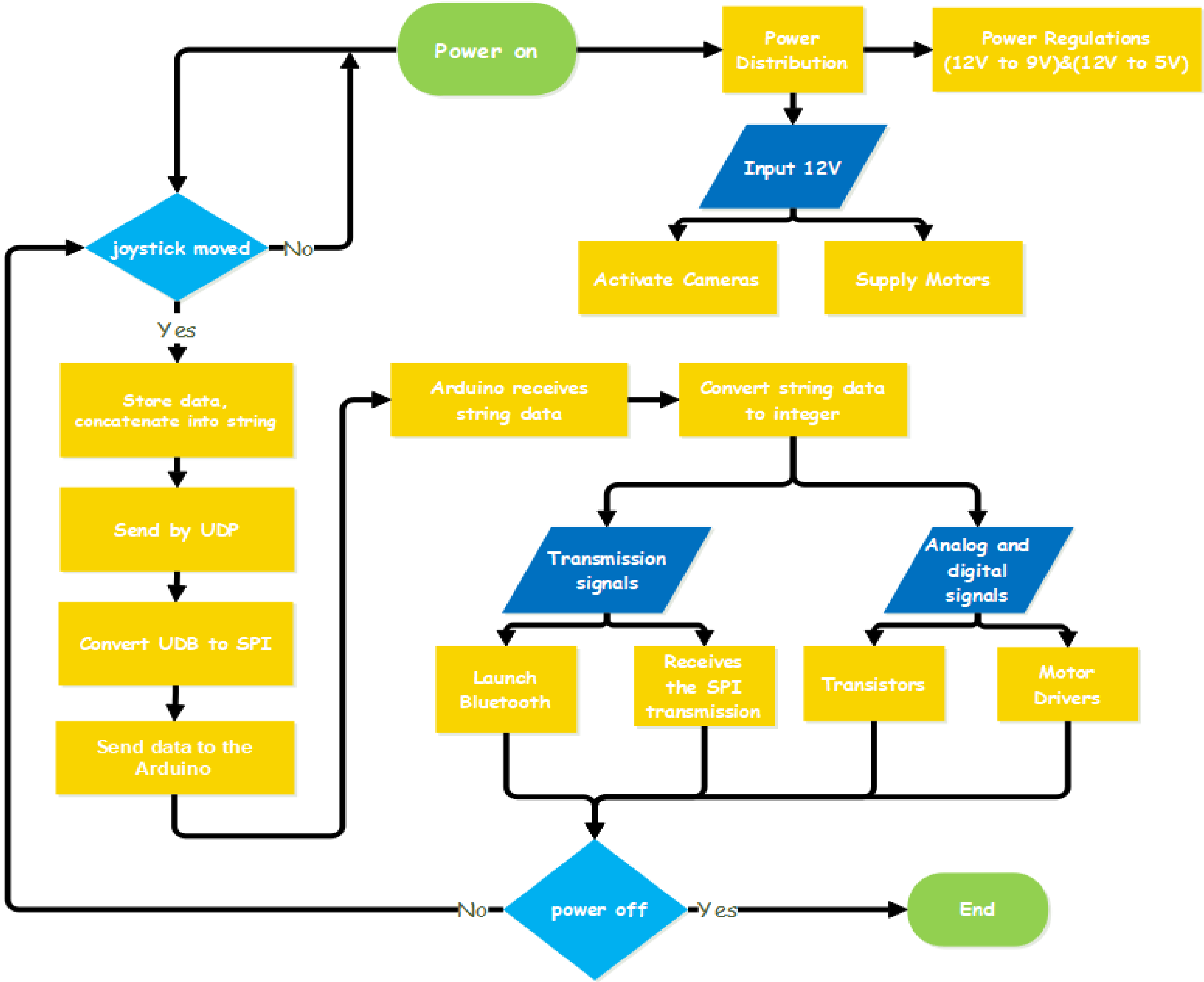
Youtube | Tutorial Series for CadSoft Eagle

Youtube | C# Visual Studio Tutorials

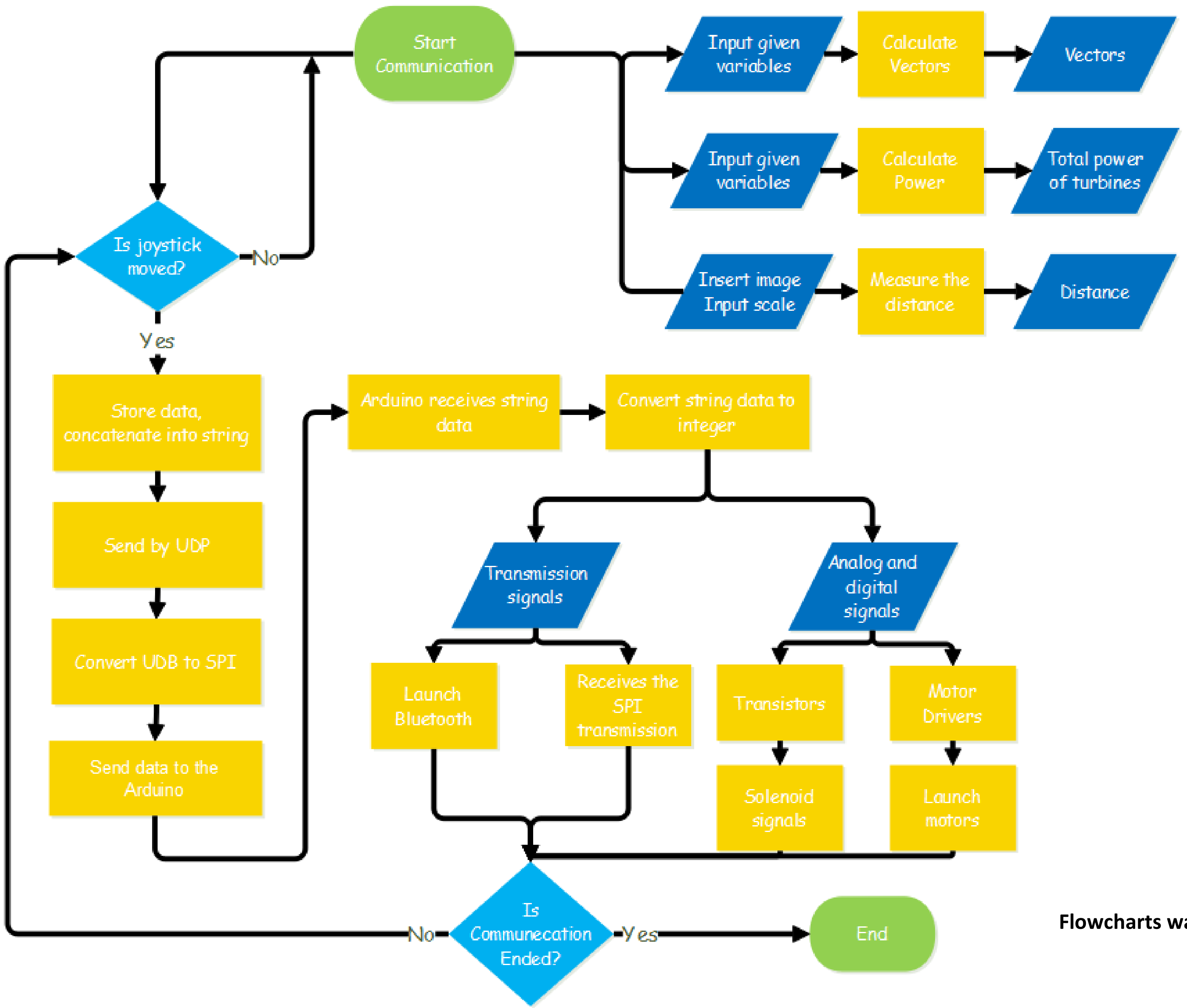
VI. Appendices

A. Flowcharts

1. System Flowchart



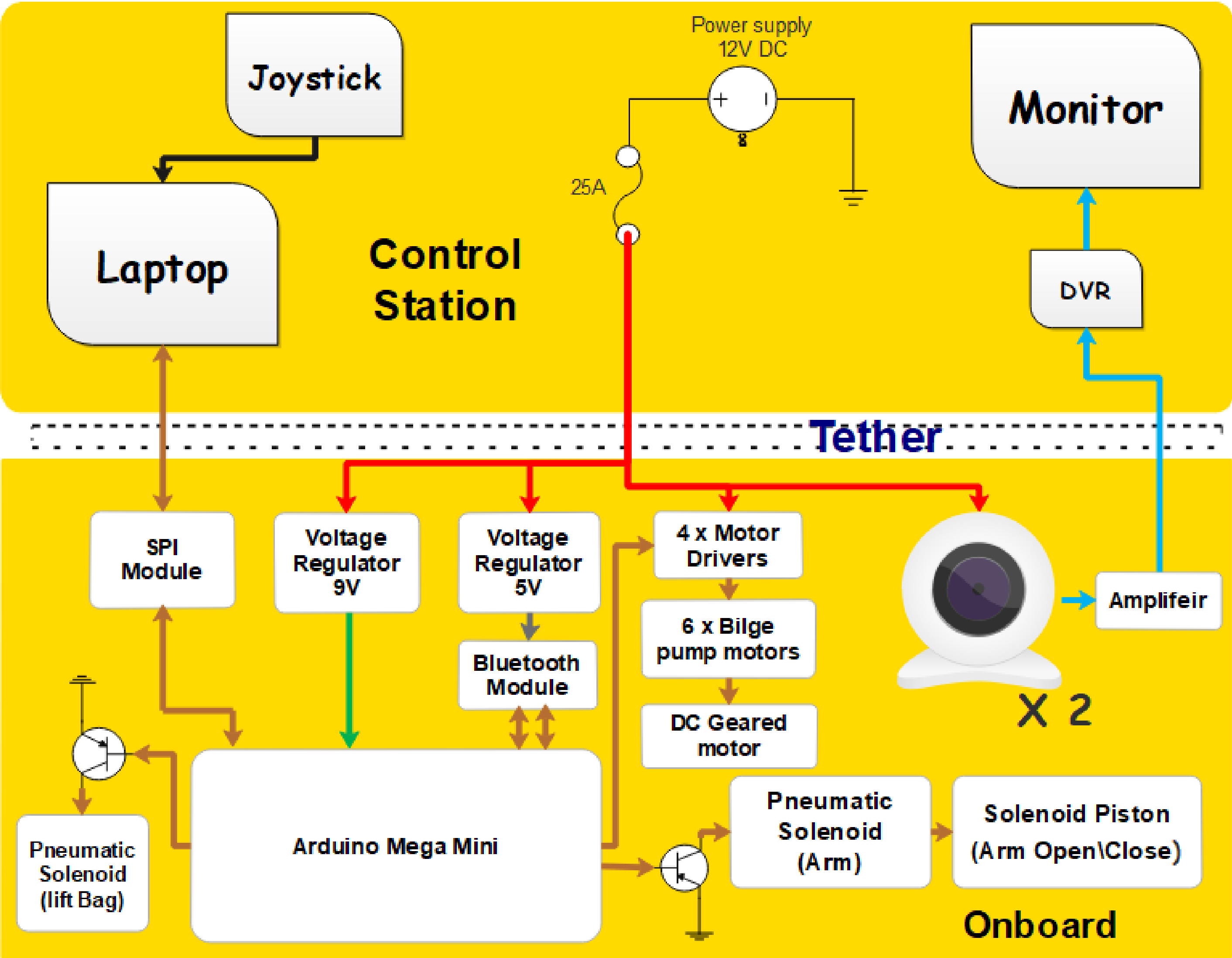
2. Software Flowchart



Flowcharts was made using Edraw Max CAD

B. System Interconnection Diagram

1. Electrical System SID



ROV Overcurrent Protection :
Four motors, 3 amps each = 12 amps.
DC geared motor = 1.5 amps.
Module and sensor =0.20amps
Two cameras = 0.500 amps.
Arduino = 0.100amps.
Lights = 0.350 amps.
Total Amps: 14.65 amps X 150% = 21.975 Amps.

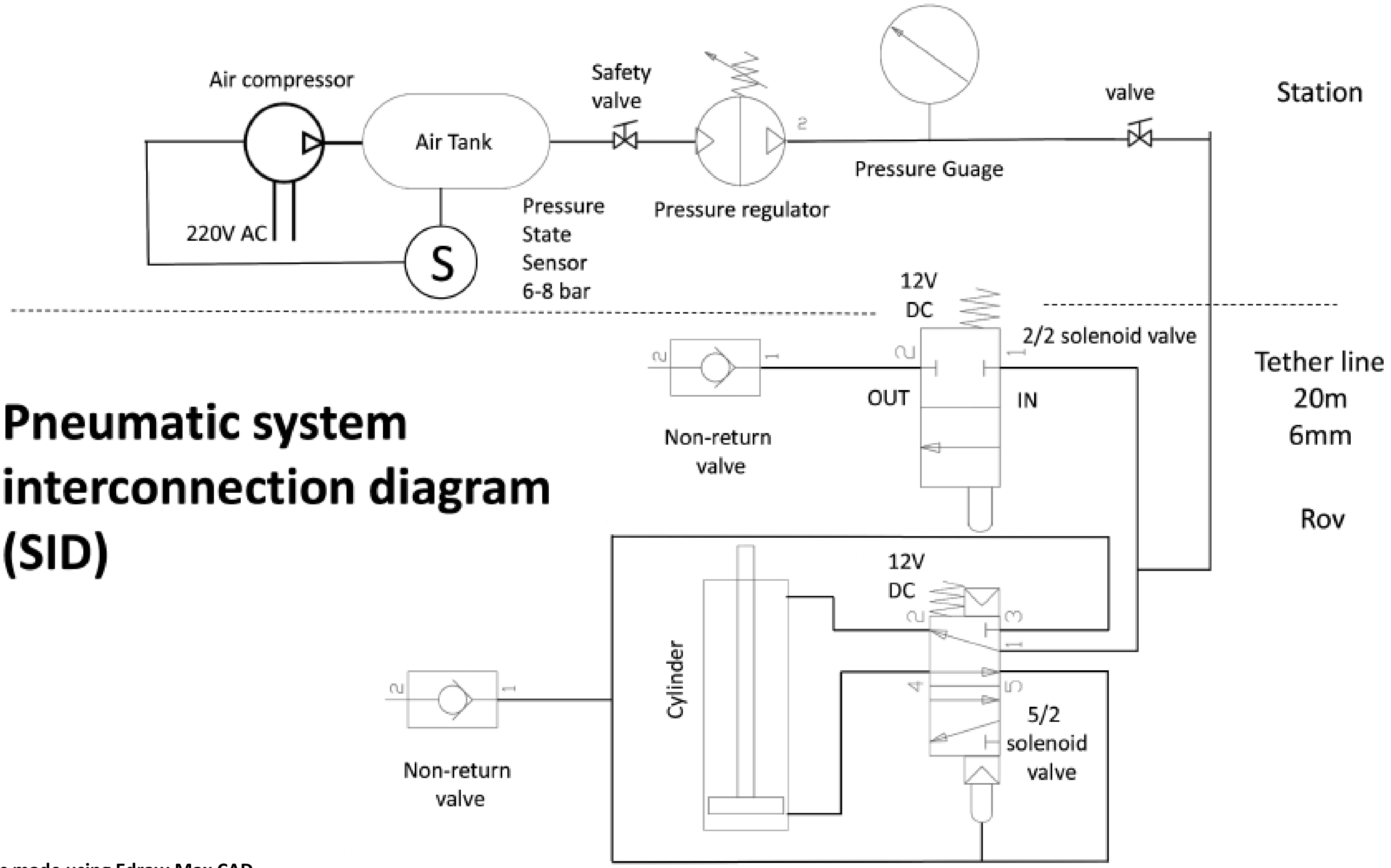
ROV uses a 25 amp fuse

Legend

- 12V DC
- 9V DC
- 5V DC
- Cameras signal
- Arduino signal

2. Pneumatic System SID

Pneumatic system interconnection diagram (SID)



SIDs was made using Edraw Max CAD