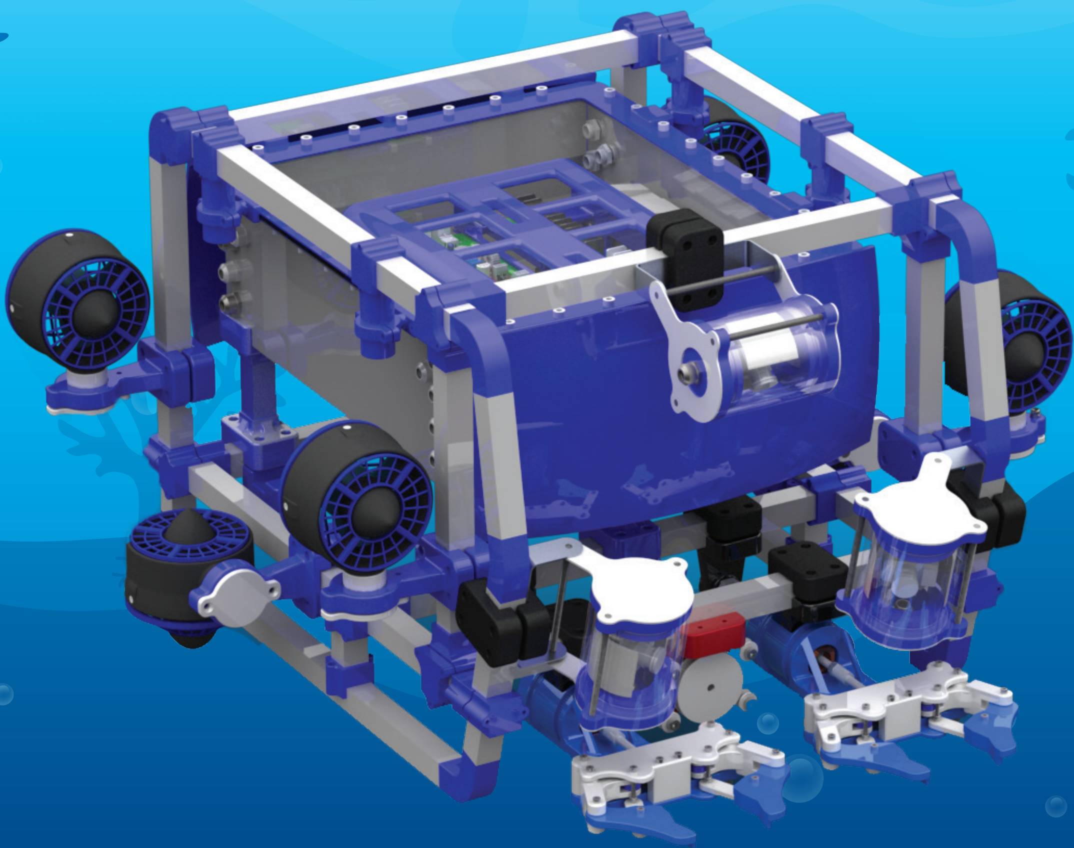
ERU HYDROTRON

EGYPTIAN RUSSIAN UNIVERSITY,
BADR CITY, CAIRO, EGYPT

MATE ROV COMPETITION Egypt

TECHNICAL DOCUMENTATION

" PREDATOR "



MATE ROV 2024

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1. ABSTRACT

Hydroton is an 27-person team of Mechatronics , Ai and bussines stdents From (ERU).

This report aims to document the design and simulation of an underwater Remotely Operated Vehicle (ROV) and then integrate it with The artificial intelligence world.

In response to the MATE Organization, The objective of this project focuses on creating a vehicle that's able to do basic and advanced underwater tasks based on the real world, From simulating missions to exploring the sea and determining the identification of unknown bodies underwter.

The main objective is to create a low-cost ROV Due to the extensive nature of the project, we collaborated to come up with satisfying results.

The development and implementation of a controlsystem interacting with the components was our primary focus to efficiently move the robot using its thrusters and gather data using sensors, video, and sampling.

"Predator" can be developed and used for multiple applications, such as inspecting the networks and pipelines of oil companies near important sites, fixing and replacing broken parts in cables that is connect in seas, and monitoring the life cycle of fish in aquaculture and fish farms by checking their vital signs, weight and size, and also can explore archaeological sites under the water.

"Predator" is made of high-quality components and manufactured using modern factoring techniques such as Laser cutting, Lathe machine, and 3D Printing.

This document describes how we created "Predator" from the initial plan to the final product. It also includes the challenges we faced, the lessons we learned, and the feedback we received from our seniors and mentors.

Figure (1)

2. DESIGN RATIONALE

A- DESIGN EVOLUTION

First, we started by searching about ROVs in general and specifically the ROVs which were part of the MATE competition; as it could be useful to build our ideas.

Then, we divided ourselves into sub-teams (mechanical, electrical, and software), each team started working on specific tasks according to the rules. The team started by doing a market survey to compare and select the available material and components which could be used, As Our main idea was to focus on the concept of adjustability.

After we finished our survey we had a clear image about which material would be the best choice for our ROV. The best feature of the Vodyanoy is the ability to change, add, or repair any part in no time thanks to the 3D-printing technology. on the other hand, The electrical team started to use its previous experiences trying to make the electrical system compact as possible using PCPs to distribute power and control the embedded system.

To meet this year's mission objectives, the software development team has implemented computer vision techniques, with software using OpenCV libraries to perform intensive computer vision and imageprocessing algorithms.

Real-time processing is crucial for this year's missions, and the software has been optimized using multithreading techniques to capture and process frames with high speed and low latency. Also, we created an interactive GUI (graphical user interface) for monitoring the tasks and the performance of "Predator".

B- MECHANICAL DESIGN

- Frame

The frame is one of the most unique and special components in our ROV As we focus on adjustability we put into our consideration the flexibility of the location of other components attached to it as cameras, grippers, thrusters, and enclosure.

So we decided to use a combination of aluminum tubes and 3D-printed joints (PLA). The aluminum tubes are fitted in the 3d joints which can be easily assembled and disassembled also making every link of the Frame independent. only the joint put them together without using any welding.

- We used Aluminum tubes as we have enough experience to deal with it and to be aware of it's manufacturing procedures. As they're a non corrosive material, easy to be machined, lightweight, low cost, and provide high level of adjustability.

- The joints are 3D printed parts which allow us to achieve our adjustability concept because these joints can easily link all tubes together. If there is any modification we need to add to the frame for example increase dimensions, easily we can add new joints without needing to make a big change in the design as we mentioned no welding.

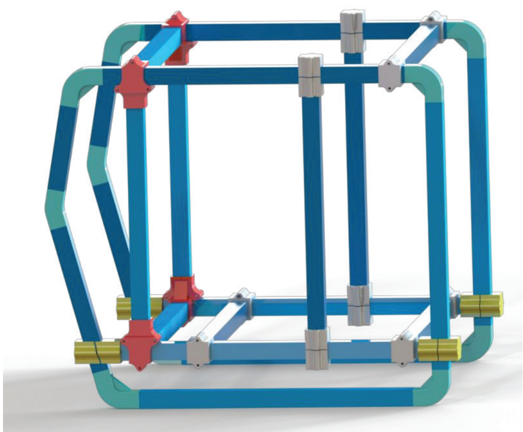


Figure (2)

The fixations: All fixations are 3D printed parts that are adjustable and movable and also could help to add more fixations to help the tasks.

- Six T200 thrusters are fixed along the frame with a changeable angle and location of each thruster according to the needed function. Two thrusters are fixed along the horizontal aluminum bar to move (predator) vertically and the remaining four are fixed on the four vertical bars
- Two grippers are attached to the frame with adjustable fixations moving along the frame.
- In cameras fixation, we control the position and orientation. After collecting the frame the mass is 2.850 kg

- Flow Simulation

CFD Computational Fluid Dynamics study has been applied to the ROV for visual examination of the flow field features along the domain enclosing the body of the ROV, test the endurance of the vehicle to the pressure forces acting on the body due to the sudden conversion of kinetic energy into pressure energy, and to estimate the drag and lift forces. The solution computed shows that the drag force is (25.5 Newtons) and the lift force is (-7 Newtons) which interprets the need of a flotation system to counter the negative force acting to sink the ROV.

The solution to this problem is illustrated at the buoyancy section. (The case is solved for the ROV moving with (0.6 m/sec)). Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA) simulation programs were used to conduct several case studies on our ROV for the purpose of:

1- Choosing the suitable material for the plates.

2- Testing the strength of the mechanical parts.

3- Measuring the coefficients of drag and lift force.

Study has been applied to the ROV for visual examination of the flow field features along the domain enclosing the body of the ROV, test the endurance of the vehicle to the pressure forces acting on the body due to the sudden conversion of kinetic energy into pressure energy, and to estimate the drag and lift forces.

Advantage of using a semi-sphere as the first part facing the flow, this leads to a significant decrease in drag as the streamlines flow smoothly alongside it.

- **Gripper**

The Predator arm is a parallel-jaw manipulator which is pneumatically powered. The end effectors are linked to pneumatic cylinder. Also, the end effectors are flattened to increase the contact area with objects gripped. The pneumatic manipulator is designed to move smoothly which is achieved by using two mechanical bearings to reduce friction. We used 2 gripper so that you can perform the tasks as quickly as possible, and as flexible as possible.

Arm Specifications:

Total Weight of two grippers = 1500 gram
wight of two pistons = 800 gram
Degrees of Freedom = 2

Fabrication:

* Cylinder Mechanism Connection	3D Printing
* bearing	Purchases
* Base	3D Printing
* Pneumatic Motor Casing	3D Printing
* Joints	3D Printing
* Pulleys	Purchases
* Pneumatic Motor	Purchases
* Pneumatic Cylinder	Purchases

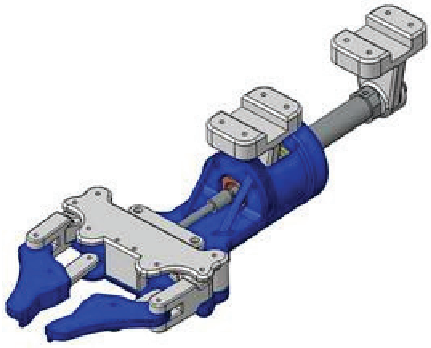


Figure (3)

Usage: Due to its rotational feature, high strength and multi-functional end effector shape, the pneumatic arm is used for:

* Install a floating solar panel array

* mooring cvonnector attached to an anchor point

* Remove encrusting marine growth attached to pvc pipe

* to push a button on docking station
* Hocking the tubes which is going to lift it to the water surface

System pneumatically actuated by a piston with a 5/2 solenoid valve. This provides the precision it needs as the piston rod takes even sliding steps to allow releasing. 5/2 solenoid valve positioned in Aluminium box, closed well by plastic cover. we have 2 Aluminium boxs, each component have 2 selonoid valves with quick links and glands. this boxes gives more adjustability and accuracy to Rov

Pnuematic SID :

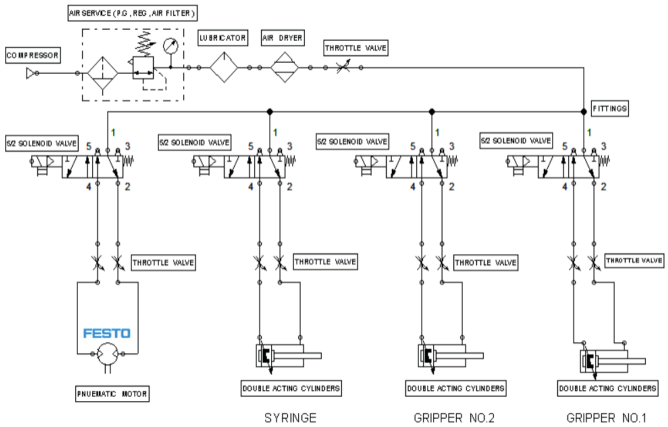


Figure (4)

- Pneumatic Motor

We used the pneumatic motor to control the rotation of the grippers vertically and horizontally. And we used pully and belt to control the rotation, and to connect between the two grippers and the pneumatic motor. Through the pully and belt we were able to achieve a principle adjustability .

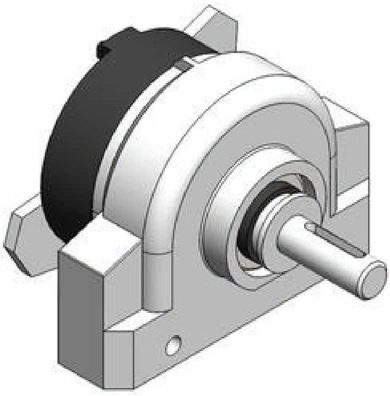


Figure (5)

- Enclosure

Powered by a shore-side power supply delivering a DC voltage of 48V/30A, This voltage is then fed to DC-to-DC Buck converters providing 12V and 5V. 3 PCB's are used (Power,Thrusters,Sensors)

for the encloser : We used almunium and polyethylene

Figure (6)

- Propulsion

Our group employs Blue Robotics T200 thrusters to control the movement of our vehicle. These thrusters are selected for their exceptional performance, including their high speed, efficiency, and thrust force within the range of 0.01kgf to 5.1kgf. Despite their many advantages, the T200 thrusters are susceptible to a particular drawback when considering the drag equation. $F_D = \frac{1}{2} \rho u^2 C_D A$

Where: FD: drag force (N), ρ: density of fluid(kg/m3),
u: speed of the ROV relative to the fluid (m/s2),
CD: drag coefficient, A: cross sectional area (m2).
This equation shows that drag force is directly
proportional to the square of the velocity according to that we in safe and haven't any resistance in front of predator for the maximum speed required. To achieve maximum thrust force in forward motion and yaw .

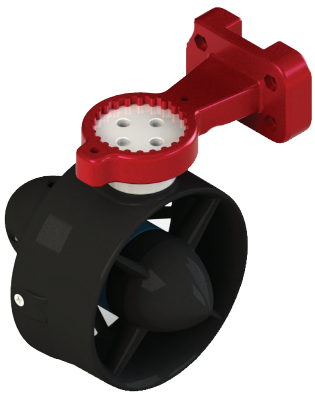


Figure (7)

- Buoyancy

Our main goal was to make the frame as hollowed as possible to increase the displaced volume to make natural buoyancy without using floats. This mission was achieved with the aluminum tubes that used in the most of predator frame as this tubes have squared tunnel shape; So this make the buoyancy force is slightly more than the weight force. The design of predator gives it the flexibility and adjustabilty to change the parts' place to avoid the errors between the location of center of gravity and center of buoyancy and to make sure that the buoyancy higher that the gravity

Quantity	Type	Displaced volume (cm^3)	Mass(gm)	Buoyant force
1	ROV frame	2920	2849	71
1	Electronic enclosure	13852	4678	9174
3	Camera case	595	1077	-482
2	Gripper	422	705	**-283**
1	Camera 360	621	756	-135
6	Thrusters	936	3600	-2664

Figure (8)

C- ELECTRICAL SYSTEMS

- Power

1.Teather

The tether contains the Cat6 Ethernet cables, two 12-American Wire Gauge (AWG12) DC power cables, and one 4mm pneumatic cable.

Cat6e cables are used to carry the video signals of the cameras to the TCU, and also responsible for transmitting the signals between the Top-Side Control Unit (TCU) and the control centre (Communication Board) to communicate with the systems of the ROV. Cat6e was chosen over alternatives such as coaxial, Cat5e, or Cat4 cables based on its lower crosstalk and higher signal-to-noise ratio (SNR), which altogether minimizes the distortion of the video signals during transmission over the 30m tether. AWG-12 is chosen for its low resistance/unit length, minimizing voltage drop over the tether's length, and carrying the ROV's current efficiently. The power cable is sized for the maximum current draw of over 32A and has a tested resistance of 0.208Ω. With the full load current drawn, the maximum voltage Drop on the power cables equals 6.25V, giving the ROV a minimum operating voltage of approximately 41.75V.

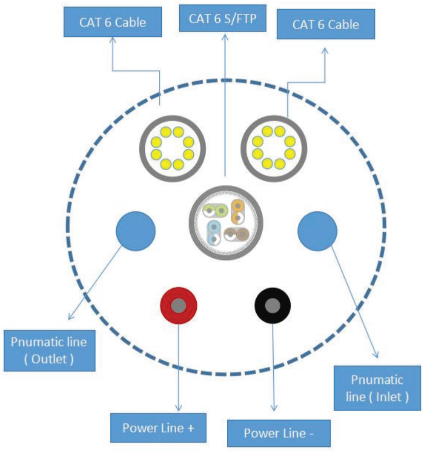


Figure (9)

The Tether includes:

- 2-wire (10 AWG) American Wire Gauge
- 6-motors cables.
- 4 Ethernet for cameras
- 1-tube for pneumatic tubes.

Tether Specifications:

- Length= 25 m
- Weight= 4.5Kg
- Diameter= 5cm

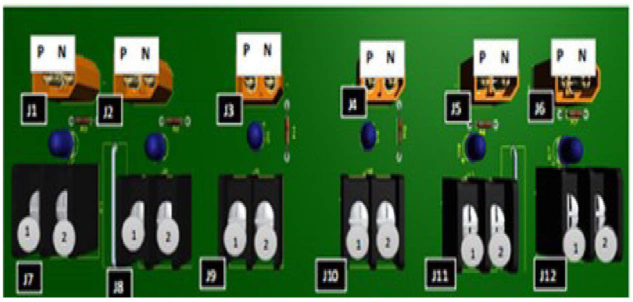


Figure (10) : Buck Out To Thruster

(J1,J3,J4,J5) 12V buck to Thruster	
1	+12V input
2	GND input

(J7,J8,J9,J10,J11,J12) Thrusters input	
1	+ve thruster input
2	-ve thruster input

Component	Input Voltage (V)	Maximum Current (A)	Quantity	Power (W)
Thrusters' ESCs	12	12.2	6	878.4
Analog Camera	12	0.6	3	21.6
360 imou-camera	12	0.3	1	3.6
Solenoid DCV	12	0.2	4	9.6
Temperture sensor	5	0.01	1	0.05
IMU sensor	5	0.01	1	0.05
Presure sensor	5	0.01	1	0.05
Microcontroller	5	0.2	2	2
Total Power (W)	-	-	-	915.35

Table(1): Max. Power Consumed

2. Power PCB's

Our predator is powered by a shore side power supply delivering a DC voltage of 48V/30A, This voltage is then fed to DC-to-DC Buck converters providing 12V and 5V. A dedicated converter supplies the sensitive vision system's components; therefore, decoupling them from electromagnetic interference (EMI) generated by inductive loads in the system (e.g., thrusters). The power distribution system has a separate PCB as shown in figure :

1- 48V/30A from the tether and split it into four rails to supply the four 48/12V Buck Converters to feed the six motors.

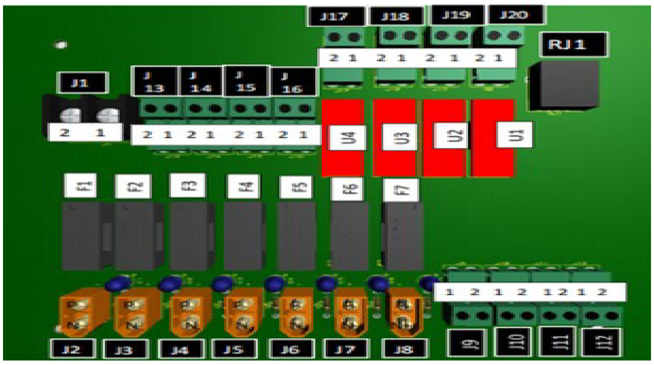
2- There is another 12V/20A buck converter to feed the cameras.

3- Also we take the output of the buck converter which is 12V and distribute it to the whole system also the two embedded PCBs is provided by 5v buck converter to feed the MCUs and sensors

The power board is responsible for distributing the power driven by the MATE power supply to the DC-DC buck converters, and from the converters to the whole system. Also the ESCs have a separate PCB that we connected the output of the bucks converter to the board as shown in Figure10

Decrease the volume of the enclosure and its weight. Enable us to use 4 bucks or 6 bucks and that will help the team in the future our team can improve the ROV and use 6 bucks for 6 motors. For that, the team came up with a simple PCB idea to:

Instead of using 6 bucks for every motor we used only 4 with interlocks to prevent us from running two motors at the same time.



J1 (48V Input)	
1	48V input
2	GND input
(J2,J3,J4,J5,J6,J7) BUCK 48V 30A input	
1	+ve buck input (p)
2	-ve buck input (N)
J8 (BUCK 48V 20A input)	
1	+ve buck input (p)
2	-ve buck input (N)
J9 (BUCK 12V 20A output)	
1	+ve buck output
2	-ve buck output
(J10,J11,J12) 12v System power	
1	+ve 12V
2	-ve 12V
(J13,J14,J15,J16) 12V Camera power	
1	+ve 12V
2	-ve 12V
(J17,J18,J19,J20) Video Baluns	
1	+ve balun signal
2	-ve balun signal

Notation

3. ESC And Thrusters

- Esc:

The thruster has a cable containing three wires. These three wires must be connected to the three motor wires on the electronic speed controller (ESC). The order does not matter, but if the motor direction is the reverse of what is desired, switch two of the wire.

The three wires in the cable (green, white, blue) are always connected to the same motor phases, so connecting the colors in a consistent fashion willresult in all motors rotating in the same direction.

- Thrusters:

Rather than designing and developing underwater thrusters, the team chose to use the Blue Robotics T200 thrusters as our primary thrust source. The T200 thrusters easily mount to the ROV frame, Six thrusters are used on the predator that are arranged in a vector steering configuration that allows the ROV to move forwards, backwards, vertically, and control the pitch, roll, and yaw of the vehicle.

Figure (11)

- Embedded Systems:

The main design goals for electrical system were modularity, easy maintinance, robustness, and compactness. That's why the team came to the conclusion that better space management is critical

Cylindrical-shaped enclosure design was proposed to circumvent the issue. So that the PCB arrangement was decided to be shelves which has enabled us to ensure that PREDATOR electronic components and connections have achieved optimal positioning which resulted in shorter and straightened wires to prevent muddles.

All boards have LEDs on them to indicate that the power is delivered to all electrical components of the ROV and to assist the hardware team during troubleshooting.

Thrusters Board:

This board has the MCU's PWM which is connected to the Electronic Speed Controllers (ESC) whic control and regulate the speed of the thrusters and transmit the signal from the Arduino . This board is connected with the Sensor board PCB through the laptop in the (TCU).

This PCB board, consists of:
Buck converter 12V/5V (U9) is responsible for delivering power to the board Nano MCU and six Basic ESCs PWM pins 5V usb output(U1) for feeding the 360 i m o u
camera Balun (U10) to extend the the serial communication up to 45 meters between the MCU and the station

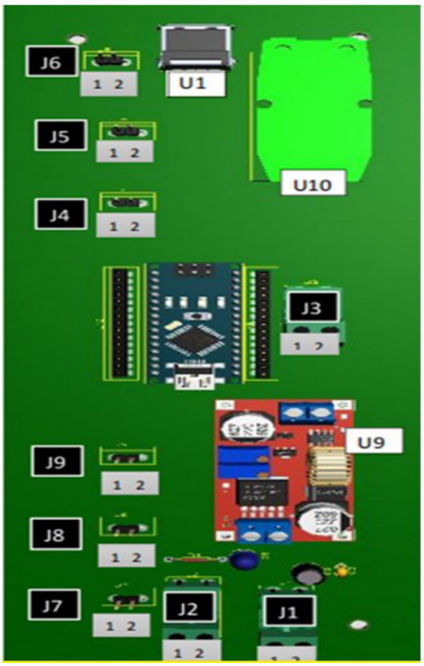


Figure (12)

(Sensors & actuators) PCB boards:
For the hardware adjustability and safety, a 3A fuse Is connected to the input of every solenoid valve to prevent damage to any component in case of an increased current draw.
The components of the board are designed in a manner that facilitate the replacement of the Arduino for firmware updates or any blown fuse. This PCB board, consists of:
An MCU responsible for sending sensors' readings to the topside GUI. The board also provides the signals of the ROV's Solenoid valves through relays that is connected to the MC digital outputs.
Pressure sensor and to indicate pressure inside the enclosure (J12).
IMU sensors to measure the balance, movement, and rotation of the ROV .
Temperature sensor to indicate the temperature inside the enclosure.
ULN2003 controls the solenoid Valves

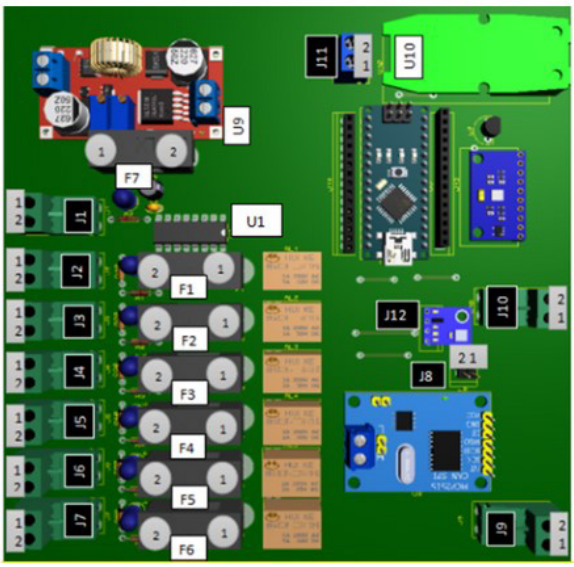


Figure (13)

Graphical User Interface: The PREDATOR Graphical User Interface (GUI) has been designed by our team of software engineers using the QT framework and coded entirely in the Python programming language. We started with the idea of designing the layouts of the user interface, and our primary objective was to create a custom user interface that provides the pilot and copilot with complete and intuitive control, as well as access to all relevant information about the PREDATOR's control unit.

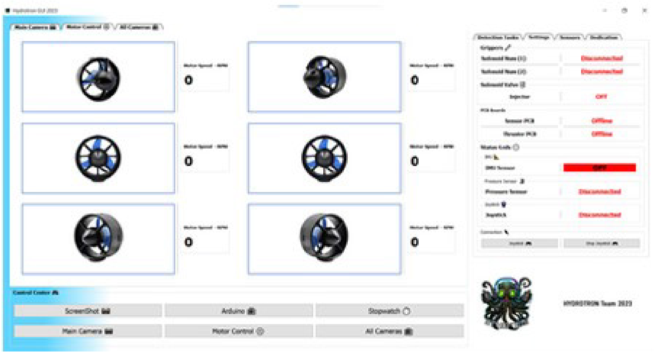


Figure (13)

The main section, located on the left-side screen, Consists of three tabs and six buttons, each with its own specific function. The main tab displays the main camera video feed, providing the pilot with a clear view of everything under the water. The motor control tab displays telemetry data about the motor speed, and the third tab displays the camera views, showing four camera feeds simultaneously as a DVR on a single screen. The second section, located on the right-side screen,

The second section, located on the right-side screen,consists of two parts, one for the team logo and the other containing four tabs. The first tab allows the copilot to perform vision tasks to assist the pilot while performing other tasks, saving time and increasing efficiency. The second and third tabs summarize real-time data from the boards, grippers, controllers, and sensors. The last tab is not related to the control system and is a memorial section dedicated to honoring the memories of the parents of team members who have passed away.

The center of the whole control system for giving movement and orders to ROV is the Xbox 360 Controller. It is responsible for sending input ommands for the movement of the Vodyanoy. The rotational and translational directions of thrusters can be adjusted by the controller to carry out different movements of the Vodyanoy, and it provides an interface to subsystems such as the gripper and injector. Overall, the Vodyanoy GUI provides an intuitive and user-friendly interface that enhances the control system's functionality and efficiency. Video System: As previously mentioned, clear and precise vision is an essential feature for any remotely operated vehicle. Vodyanoy Cameras seeks to maximize the pilot's field of view and situational awareness by incorporating four cameras into its design, but on request a fourth Stereo camera is available to be mounted onto the frame for mission specific tasks. These include one IP camera and three CCTV analog cameras, strategically positioned to optimize task efficiency Main Camera: IMOU Ranger 2 IP Camera was selected following extensive research and consultation with experts. Its features include a resolution of 2560 x 1440, providing high-quality and detailed footage, a 93° lens field of view, and a 3.6mm (about 0.14 in) focal length. These specifications facilitate easier piloting and improved performance of image processing applications. Sub-Cameras We chose three Dahua IR Bullet Cameras, each with 5MP resolution, capable of producing 2592x1944 resolution at 30 frames per second, and a 3.6mm (about 0.14 in) focal length. Their fixed lens, combined with an 85.4° (H) field of view, allows the pilot to monitor the environment and observe the gripper's actions during tasks. Our design includes a PCB board consisting of three channels and one Ethernet port, connected to a four channel digital video recorder that consolidates all the cameras into one layer with four labels, supporting a resolution of up to 1920/1080 pixels.

The camera signals are transmitted to the board via a UTP101USB USB Video Balun mounted on the camera board and connected to the DVR to eliminate noise and improve signal clarity

3- Testing And Troubleshooting

* PNEUMATIC SYSTEM TEST

The purpose of this test is to check if it is suitable enough to do the required missions with the minimum power losses due to friction or any other forms of power loss. So, our company prototyped the gripper to predict any malfunctions that may occur and devise solutions beforehand. As a result, the piston stroke was found to be not suitable enough to hold objects tightly and fit our power specifications.

* ELECTRONICS ENCLOSUR SEALING TEST

This test aims to ensure that the electronic enclosure is completely sealed to achieve the electWonic components safety. The test went through two phase. First phase: the cab assembled to the enclosure and wires had been put in the glands but without electronic components and tested separat in the pool and left for hours in specific depth in the pool.

Second phase: all the electronic components had been put in the enclosure and repeated the same in phase one Frame TEST The initial step in creating predator mechanical system involved designing all of its compnents on Solidworks to confirm the viability of the design concepts. Afterward, an improved and more refined version of the prototype was produced using Aluminum tubing and 3D printed joints for the final design. Before assembly, individual tests were conducted on each component to avoid the accumulation of issues that may be challenging to diagnose once the ROV is fully constructed. The sealing of the frame was verified by measure its weight before put it in the pool then immersing it to pool bottom for hours then we measure its weight again and it gives the same measure. Also stress test was made we put a weight load about 120 kg on the top frame to ensure the integrity of all 3d joints fasteings

4- Challenges

a- Non Technical

Developing an ROV can be challenging, especially for a team that is new to the process. To address this challenge, the team should conduct thorough research and seek advice and guidance from experts or experienced individuals in the field. Limited pools and lack of testing areas also proved to be a challenge. After contacting sporting clubs and facilities we managed to find facilities that allowed testing the ROV at their pools.

b- Technical

- 3D Printed parts failure during testing

After designing our 3D printed parts and joints we tested them and suddenly it failed. After research and taking notes we noticed that the failure was due to insufficient distribution of stresses over the parts, Specially the joints. Therefore, in order to solve this problem we had to redesign the joints with a new stress distribution study that lead to a near perfect joints

- Ethernet cable weight

We have 3 cameras that have to be connected to the PCB, each with a separated Ethernet cable that weighs 800g. And that caused a probelm of having an over weigh of almost 2200g, that will load on the PCB and the overall weigh of the ROV. To solve this problem we used "Ethernet Balun" to connect all 3 cameras with a single Ethernet cable.

Figure (16)

Serial Communication Delay

Our embedded system represented in "Thruster PCB, Sensors & actuators PCB" communicated with each other with a "I2C Communication protocol". The communication signal that came from the two PCB's were combined to be dealt with by the software using a "Serial Communication", and that caused a problem of delay response to the actuator as the software can only deal with a single "Serial Signal". To solve this we used two "Serial Communication Protocols" separately from each board to use real time response for any motors.

5- Lessons Learned

The team took advantage of its time to advance its knowledge. Many global platforms have offered online courses for free (e.g., Udacity, Udemy, Coursera, Etc.) and offline courses. This opportunity pushed the members to learn new technical skills, gain more experience, and develop their mindsets. Recorded playlists discussing different topics such as programing in C++, and Python, hardware basics, AutoCAD and SolidWorks, Design Modeler, and Ansys.

6- Safety

a- Company Safety Philosophy

In Hydrotron, we prioritize a safe workspace as essential for creating an environment conducive to designing, manufacturing, and testing. We are committed to meeting the safety requirements set forth by MATE by ensuring all personnel strictly adhere to safety protocols and warning labels. Our safety philosophy revolves around the well-being of our employees, and we always prioritize their safety over that of the machines. To comply with MATE's safety regulations, we implement a comprehensive set of workplace guidelines and protocols during the manufacturing and pre-launch phases. predator ROV is designed and built with safety in mind. It has a number of features that help to minimize potential hazards associated with underwater operations.

b- Safety Protocol Standards

Using proper technique when using any sharp tools ·Electrical safety is a primary concern when manufacturing and testing ROVs. All electrical connections are properly insulated and grounded, and all electrical equipment is certified for use in a marine environment.

·All hazardous materials are clearly labeled with sticker and stored in appropriate containers

·All equipment used in the manufacturing and testing areas is regularly inspected and maintained to ensure that it is in good working order and free from defects or damage

·safety checks are performed before every test

c-Testing Safety

Before each use, thoroughly inspect the ROV and test all safety features to ensure they are functioning properly Perform regular maintenance and testing to ensure the ROV is in good working condition

d-Safety Features

We are using, a suitable-sized fuse which is connected 30 cm from the Anderson Power-pole connectors. 3D printed shrouds cover the thrusters' intake and exhaust without disrupting the flow. CIRCUIT-BRAKER are present on the main power supply unit on the TCU. Power terminals are fused to provide over-current protection. The fuses are strategically placed on the power PCB

equipment is certified for use in a marine environment.

·All hazardous materials are clearly labeled with sticker and stored in appropriate containers

·All equipment used in the manufacturing and testing areas is regularly inspected and maintained to ensure that it is in good working order and free from defects or damage

·safety checks are performed before every test

c-Testing Safety

Before each use, thoroughly inspect the ROV and test all safety features to ensure they are functioning properly Perform regular maintenance and testing to ensure the ROV is in good working condition

d-Safety Features

We are using, a suitable-sized fuse which is connected 30 cm from the Anderson Power-pole connectors. 3D printed shrouds cover the thrusters' intake and exhaust without disrupting the flow. CIRCUIT-BRAKER are present on the main power supply unit on the TCU. Power terminals are fused to provide over-current protection. The fuses are strategically placed on the power PCB

boards for quick replacement. To prevent any personal damage we used a waterproof electronics housing, thrusters, and cameras. The circuit breaker: shuts down the ROV automatically if the current draw exceeds the 32 A . Automatic pull up Scenario: in case of the controller disconnected or the communication with the thruster PCB. our pull itself to the surface automatically. Maximum depth limit: Set a maximum depth limit for the ROV to prevent damage or malfunction due excessive pressure.

e-PCB Safety

PCB board specially made by the team for power distribution. Over-current protection devices such as fuses to prevent damage to the PCB. We put power LED as an indication for fault power or fuse damage so we can know which part is fault without opening the enclosure as the enclosure is transparent

6- Project Management

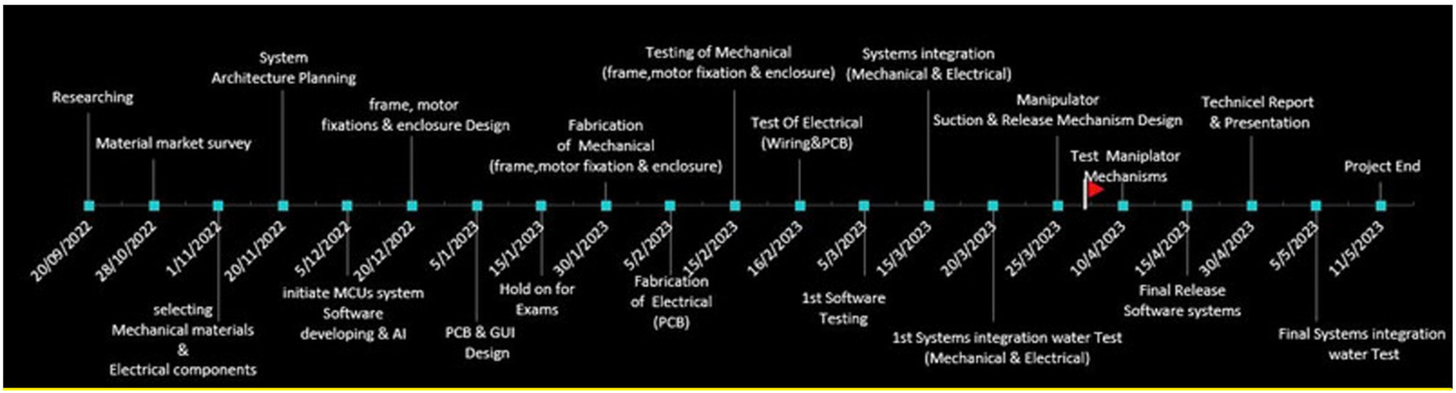
We started the new year with a goal of participation in MATE ROV competition, so we took every step we could towards this goal. We started by combining manpower that was able to give the project all they could, and most importantly have the mindset of hard-work and ethical mentality. Then we divided our team into sub-teams (Mechanical, Electrical), but at the same time everyone knew what's happening and had the full information and knowledge of every part of the ROV.

a- Scheduled Process

Developing a plan with minor goals was our first to do. The company then implemented the schedule, beginning with a focus on Research and Development while asking individuals with expertise for advises. Knowing that delays could negatively affect other departments, the company adopted a time management philosophy that made sure we met every single deadline.

b- Resources Management

To efficiently manage data, we relied heavily on Google Drive and Canva. Google Drive provided a reliable platform for storing various file types, including documents and spreadsheets. Additionally, its real-time collaboration feature proved beneficial for team projects. Canva, on the other hand, allowe us to create a range of visually appealing content, such as social media graphics, presentations, and infographics. Its user-friendly interface made it easy to use and customize designs to fit our needs. Together, these tools played a vital role in helping us manage and create resources efficiently



TIMELINE

7- Acknowledgments

* We would like to express our sincere gratitude to Dr. Magdy Roman for his help and support throughout all.

* We would like to express our appreciation for the financial support provided by our university.

* Our sincere thanks goes to Eng. Assem Reda for his mentorship

* This event would not have been possible without the tireless efforts of Delta Square and AAST.

* We would like to thank MATE Center for their hard work and dedication in making this event a success.

8- References

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* "ESC Of T200 Thruster Documentation," BlueRobotics

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9- Appendices

a- Safety Checklist

* Pre Test

- Ensure that the area is clear and safe

- Verify that power switches and circuit breakers on the TCU are turned on.

- The tether is fully extended and laid out on deck.

- Connect the tether and securely fasten it.

- Connect and secure the tether to the ROV.

-Connect the tether strain relief to the ROV.

-Check that the electronics housing is sealed and Perform a visual inspection of the wires to ensure there is no damage or loose connections.

-Nuts on the electronics housing are tightened.

- Thrusters are free from any obstructions.

-Connect the power source to the TCU.

-Verify that the TCU is receiving 48 volts nominal.
- Power on the TCU. Perform a thruster test. Check the video feeds

* Under Water Test

- Check for any bubbles.
- Perform a visual inspection to ensure that there are no water leaks.
- If there are any large bubbles, pull the ROV to the surface immediately.
-Run thrusters and begin sailing.

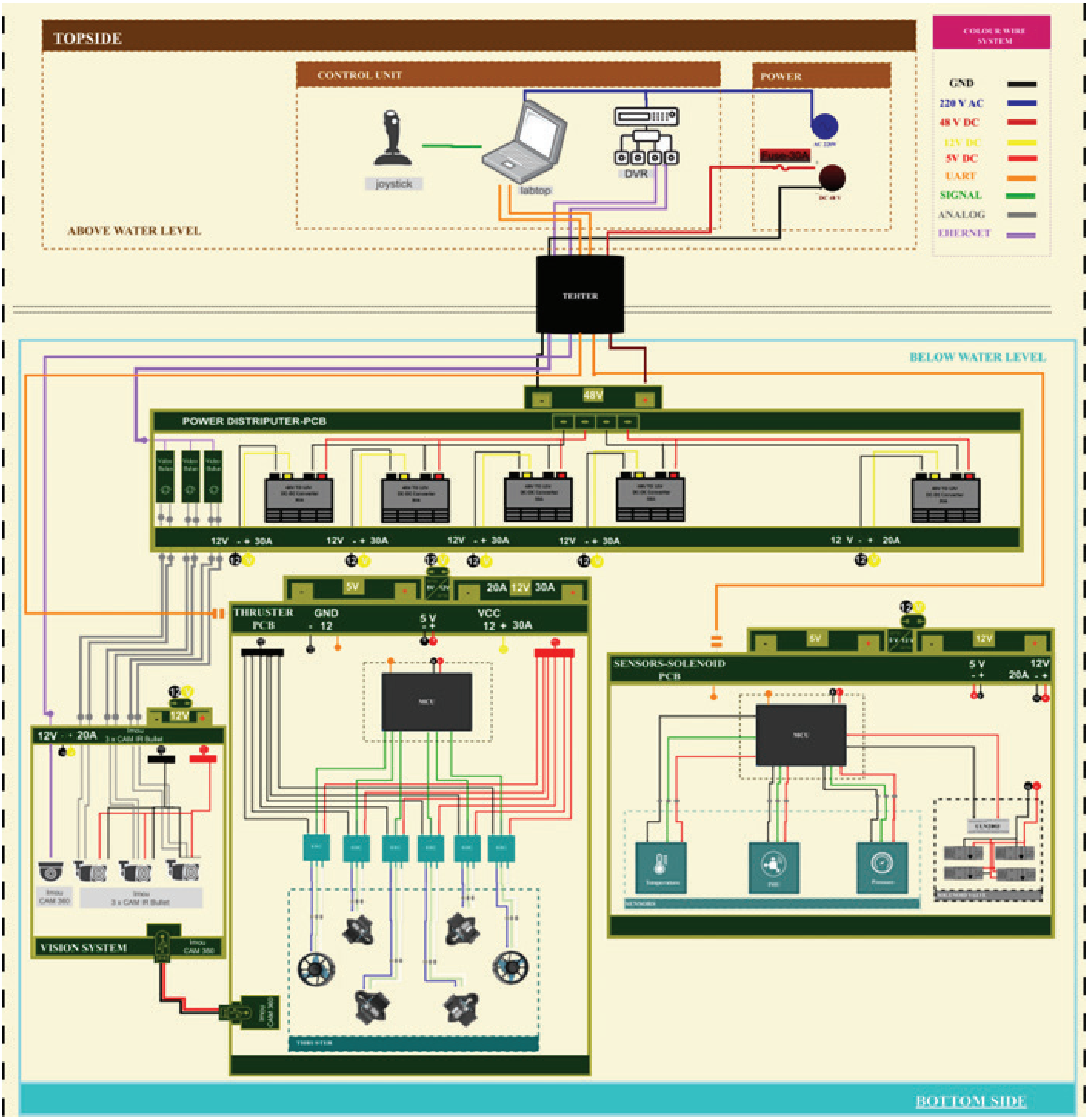
* Communication Loss

-Retrieve it via the tether.
-Reboot the ROV and try solving the problem.
c-onfirm that there are no leaks and resume operations

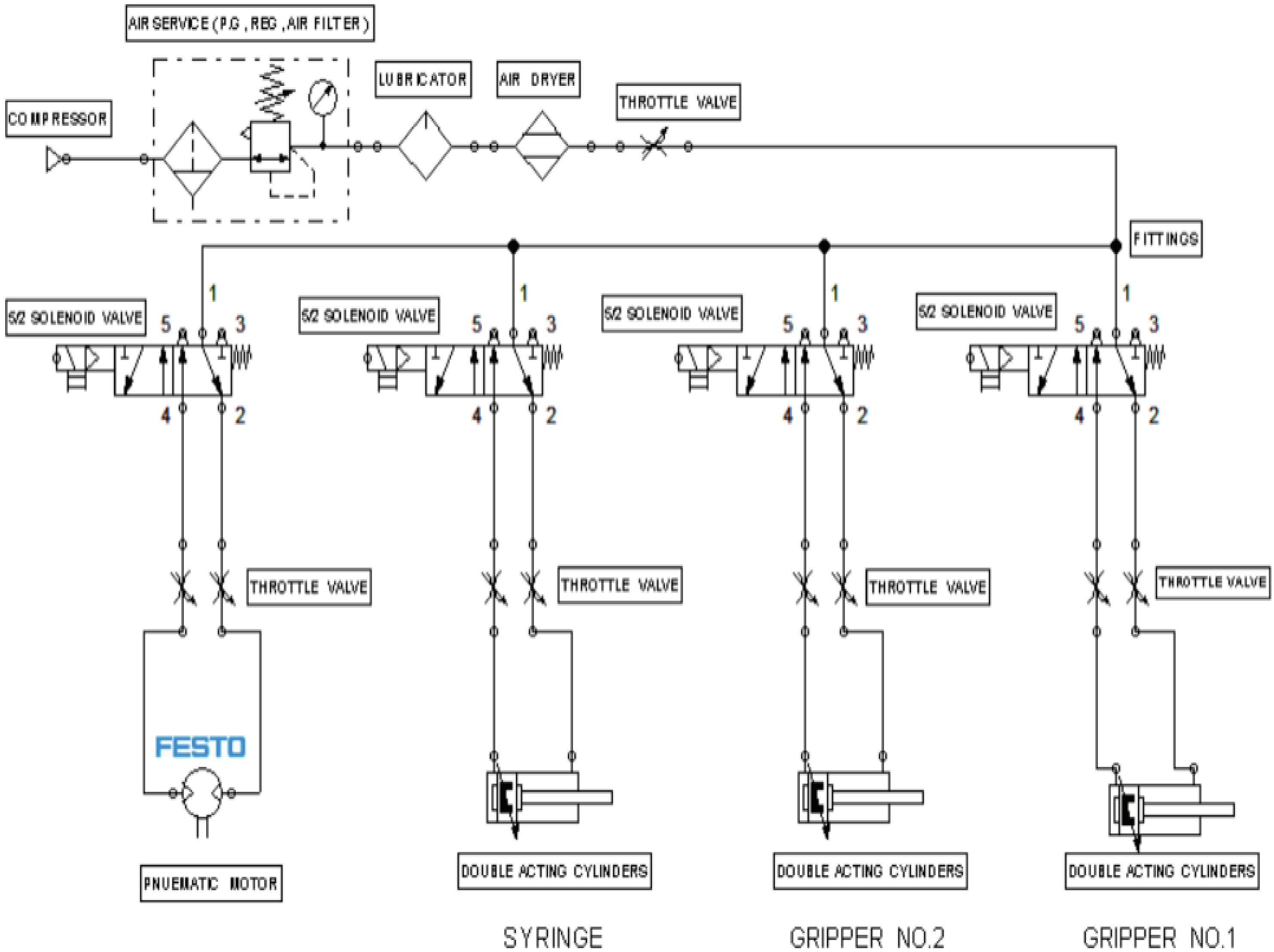
* Overall Check

-Verify that the thrusters are free of foreign
-objects and can spin freely.
-Perform a visual inspection for any damage.
-Ensure that all cables are neatly secured.
-Verify that the tether is free of any kinks.
-Conduct a visual inspection for any leaks.
-Test all onboard tools to ensure that they are functioning properly.
-Verify that the camera positions are correct.
- Wash down the thrusters with deionized water.

B- OVERALL SID



C- PNEUMATIC SID



D- BUDGET

SOURCE	INCOME	TYPE
Team members' fund	$3,490.00	income
Egyptian Russian University funding	$2,262.00	income
Total income	$5,752.00	-

PRODUCTION EXPENSES	BUDGET	TYPE	DESCRIPTION	COST
Thrusters	$1,700.0	Purchased	6 T200 thrusters including basic ESCs	$1,667.0
Frame	$90.0	Purchased	Aluminiunm Tubes, Nuts and Bolts	$93.0
3D Printing	$1,000.0	Purchased	Frame joints', motor fixation, cameras' Boxes, PCB fixations, Buck converter fixations, enclosure fixations, injector fixation and valves' fixations	$984.0
Buck converter 48V 30A waterproof	$900.0	Purchased	6 Buck converter	$819.0
Electronic components	$250.0	Production	MCUs, sensors	$230.0
Electrical components	$290.0	Production	main power cables, Buck converters, anderson plug, Fuses	$405.0
vision system	$203.0	Purchased	cameras, Baluns, DVR	$200.0
Tether	$94.0	Production	cat6 cable, AWG-16, sheathing	$92.0
Pneumatic system	$75.0	Production	Solenoids, tubing, fittings	$75.0
TCU	$190.0	Production	joystick, LCD, valves, fitting	$180.0
Miscellaneous costs	$80.0	Production	heatshrink, zip-ties,strain-relief	$70.0
Total	$4,872.00			
RESEARCH & DEVELOPMENT	**BUDGET**			
Electronics	$25.0	Purchased	PCB fabrication	$50.0
GO-BGC	$80.0	Purchased	PVC tube, stepper motor, power screw, wood fixations	$120.0
Total	$105.00			
OPERATION EXPENSES	**BUDGET**			
MATE Registeration Fee	$475.0		Regional & International registration	$475.0
Fluid Quiz Fee	$30.0			$30.0
Printings	$20.0	Media Production	Banner, Poster, Flyers	$30.0
Mission props	$70.0	Production	MATE mission props	$90.0
Total	$595.00			
CAPITAL EXPENSES	**BUDGET**			
TOOLS	$60.0	New	Wrenches, Screwdrivers,	$60.0
Elctrical tools	$50.0	New	Soldering Station, Hot-air gun	$55.0
Compressor	$70.0	Upgrade	25-Liter compressor Unit	$90.0
Total	$180.00			