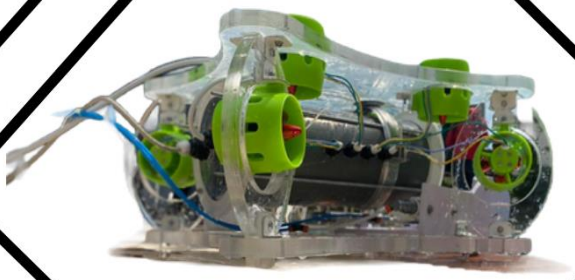
ELECTRO-GILLS

MEHREZ MYRIAM : CEO
BEN KHMIS RANIM : CFO
GAALOUL NABIH : MECHANIC TEAM HEAD
MSADDAK NESSIM : ELECTRIC TEAM HEAD
ESSID HOURIA : MARKETING DIRECTOR
ATTALLAH IMEN : PILOT
BEN AMOR RANIA : CO-PILOT
SAID JHENE : ELECTRIC TEAM MEMBER
GHALLEB YOUSSEF : ELECTRIC TEAM MEMBER
GHARBI HEDI : ELECTRIC TEAM MEMBER
CHEMKHI ROUA : ELECTRIC TEAM MEMBER
BEDRI AZIZ : MECHANIC TEAM MEMBER
BERRIMA WASSIM : MECHANIC TEAM MEMBER
MOKRASH YESSINE : MECHANIC TEAM MEMBER
CHELLY SARRA : MECHANIC TEAM MEMBER
ZELFANI AMIR : MECHANIC TEAM MEMBER
MENTOR : ZEINEB EMNA



Les écoles ideals high school
Nabeul _ Nabeul

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Abstract

Electronic Gills is a Tunisian company that was founded in 2018 by a mentor and a few high school students passionate about robotics currently there are 18 members raging from 9th to 11th grade students and a mentor. Our company focuses on meeting our client's demands so all of our team members must have the important qualification so we could make the best outcome possible

Going back to our history, Electronic Gills won the first place in the National ROV competition twice in 2018 and 2019. Furthermore, we won the second place in the Arab ROV competition in 2018 and the first place in 2019. In addition, we succeeded in attending the international ROV competition that was held in the USA.

Our ROV, made by a team of 18 passionate students, is characterized by its hydrodynamic shape that makes its movements fast, its light weight, its dome camera that can see deeper by night, and its two grippers can pick up high weighted things with other specific tools that make us attain the optimal result. Moreover, "Jellyfish" can also calculate fish pen's length and determine the position of the benthic marine species and transfer it or any other fish alive to another place without facing any danger.

Figure 1. Electro Gills members

Design Rationale:

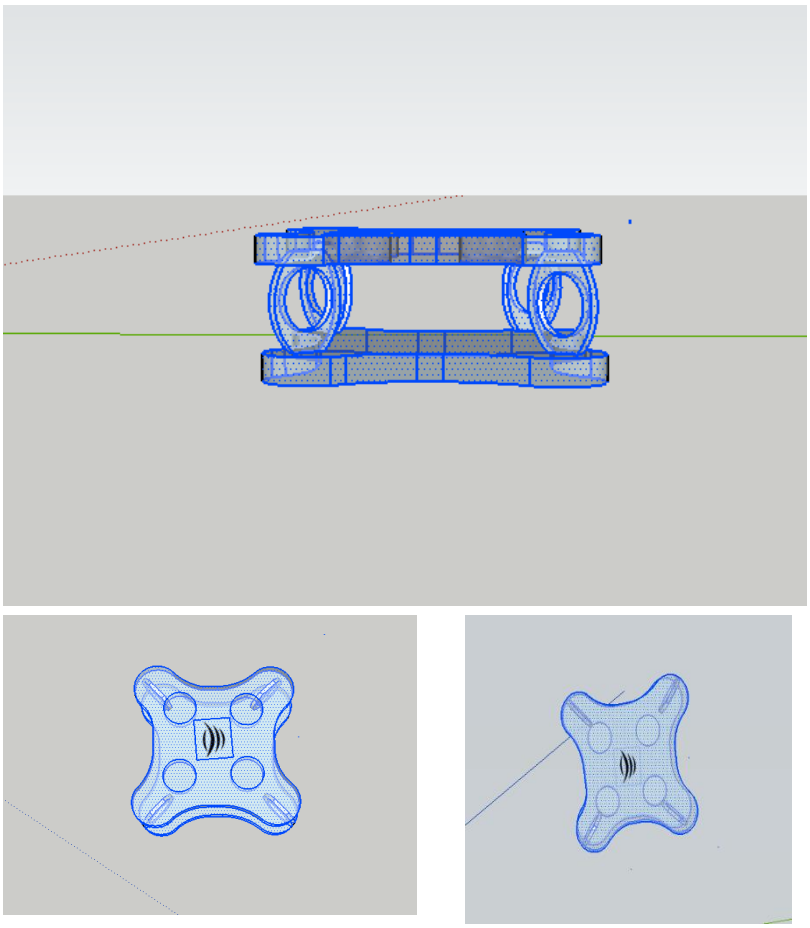

Figure2 : 3D design of the frame

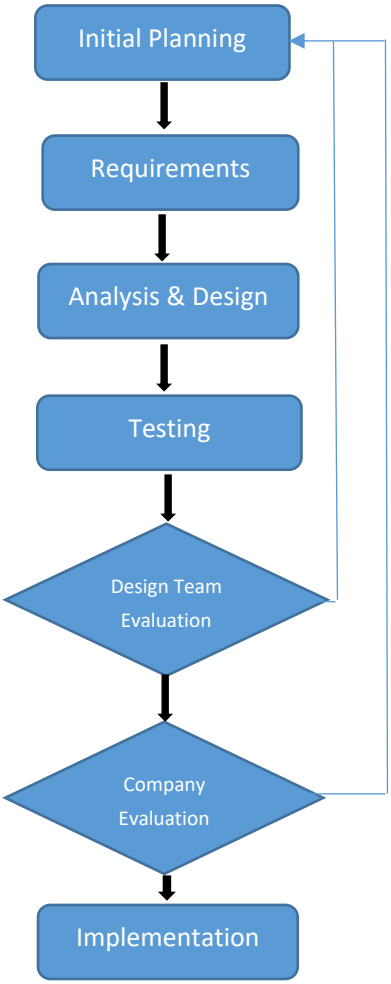

Figure3 the iterative design process

Electro Gills began with an initial planning phase in which we analyze the mission requirements and the specification sheets provided by MATE and also determine the corresponding feature concerning each objective and task. Then our company uses the iterative design process to design a ROV that is effective and reliable and respects the instructions and rules sat by MATE. Our company during this phase, also considered 2019's ROV and evaluated what did and what did not work to learn from the mistakes made and improve this year's ROV more. And then, the company brainstorm what was discussed throughout the planning phase considering size, weight, cost, complexity, safety etc

One this is all done, the company establishes a certain budget and a timeline which helps with everything concerning the costs of the research and development during the design phase. Then, each member of the design team takes a feature of the ROV and follow the iterative design process that ensures the constant evaluation of each feature. During this stage, each design team develops a prototype of their feature following what was discussed in the

iterative design process and what was evaluated. We, then, move to the testing phase where all the prototypes developed are tested with no exception and evaluated by the company and all the members, on their performance and fulfillment of the tasks needed and determine then if they are acceptable or not.

If the design passes the evaluation and testing stage, the prototype is then added to the ROV. If not, the design team passes again by the four steps of the iterative design process, re-analyses the feature and re-develops the prototype. Until the feature reaches a second evaluation and testing stage, leading to a final ROV that is effective and reliable.

Mechanical components:

Frame:

The frame of Jellyfish was first designed in 3D it was made to reach our costumer's demands so it had to be light and we had to avoid anything that could cause pression on the ROV as it has to go deep down in water so we were careful to leave open space and we have put in mind all the main components such as the brushless motors, the two manipulators, The pipe that has the cables and the electric system that has the cards and all the other program related components, which made our frame idea more specific and we finally came up the final decision .

We chose the material for the frame after a lot of thinking since we needed it to be light and easy to work with and hard at the same time and an additional fun idea came to mind it is only about the appearance we Decided that we wanted it to be transparent, furthermore "Plexiglas" since this material met all the requirements we settled with it We made the frame with 45cm (L)/ 40cm (l)/ 22cm (h)

Thru

Figure4: the team members examinating the ROV frame

When choosing the motors we still kept in mind the need of something light and that have really powerful pression so it could carry 11kg with no trouble and so we choose the brushless underwater thrusters.

12V-14V and 3A and it power ranges from 30W to 200W and they can go 2000m waterproof depth finally achieve enough power to move and be able to do the tasks properly. Also the chosen motors can change sense and that makes going to up, down, right, left and forward also we checked if it would be harmful for sea creatures of humans so we designed a case for them to cover the front face of the motors put it is still in the progress of production and it is going to be printed by a 3D printer after a week from now

Weight: 162g

Dimension: line length 250mm/ Diameter 74mm/ Total length 75mm/propeller diameter 60mm

Material: Motor 304 stainless steel bearing + aluminum alloy shell PLA PC propeller

Quantity: 8 thrusters

Figure 5 : Brushless waterproof thruster

Cables:

The ROV required two types of cables one to pass orders from the NVidia Jetson Nano card to the robot and it is the Rj45 carte /20m it weights 400g and there is the power cable 2x2,5 mm/ 20m and weights 1kg both of them were chosen after a lot of thinking and discussing among the members so we could have the best type that would suit our demands

Figure 6 : RJ45 cable

Figure7 : power cable

Speed variator:

Our ROV also required a speed variator along the thrusters. Using the speed variator we could control the motors speed easily furthermore it could be the most helpful to help us meet our clients requirements that is the competition Task. We used the same number of variators as the number as the motors so that makes it 8. We choose the Speed variators ESC that are 40 A because they are exactly what we need

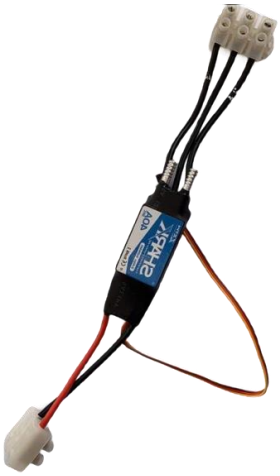

Figure8 : variator

Pipe:

To gather the Electric system in the ROV because we cannot have the cards touch the water since they are not waterproof The pipe is in PVC

Diameter: 14cm

Length: 28cm

Figure 9 : Pipe

Buoyancy:

We need to come closer to neutral buoyancy to obtain greater stability. And it's accomplished by employing commonplace plastic foam as the buoyant material. We used this calculation to precisely measure the correct amount of this afterwards. Figure 2, shown above, shows the Archimedes principle in action. In the event of a hardware breakdown, slightly positive buoyancy will cause it to ascend upwards. Following use, does not harm the environment by generating any dangerous chemical reaction. We also ignored the volume of the additional volume in our formula. To obtain this little positive buoyancy, add foam to the equation. In addition, the foam is placed at the top of the frame to which allows the center of mass of JELLYFISH to inline vertically with its center of buoyancy.

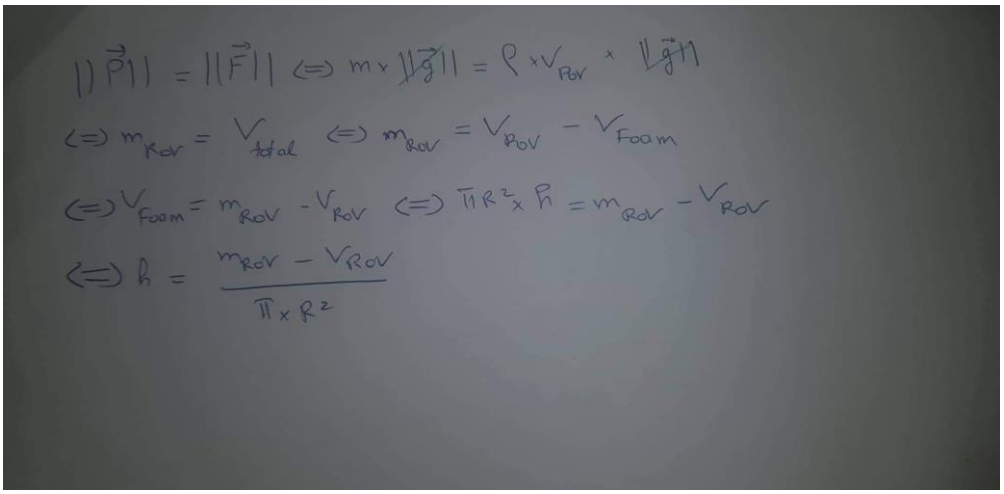

Figure10 : formulla buoyancy

Electrical Housing and system:

For this Year, we chose to focus on the electric system more than usual we used an NVidia Jetson Nano Card, Arduino Card, a Step down, Booster and fuses

NVidia Card:

NVidia card is a graphic device whose role is to produce the image from the camera to the computer wired in. we chose the NVIDIA card specifically because it doesn't need a lot of cabling. It has its own memory thus freeing up memory from the computer. Additionally, these memories are much faster than the system memory. It has its own CPE. The NVIDIA is going to control all the units and play the role of a servo motor.

Figure 11 : Nvidia Jetson Nano card

Arduino Card:

The Arduino Card controlled by the NVIDIA card is wired in with the 8 thrusters. The tether also consists of a USB cable that is connected to the Arduino Mega cable in which we learned two essential rules: the longer a wire is, the stronger is its resistance, the finer the wire is, the greater is its resistance.

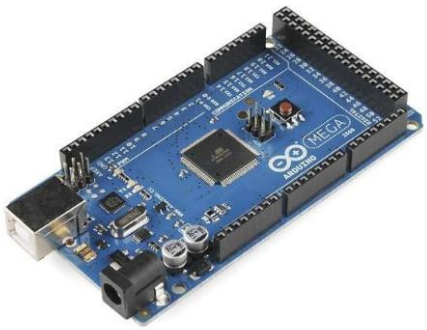

Figure12 :Arduino card

Step down:

It takes 12V from the energy source and then take it down to 5V to passe it the INVIDIA card

Figure 13 : step down

Booster:

It's a precaution to keep the electricity tension at 12V for the engines because of the lost energy in the wires

Figure14 : Booster

FUSE:

To meet safety requirements for the MATE competition, the company installed a 25 Amp fuse in the main power line. This safety device will stop the ROV if the electric current exceeds the required amount, preventing fires, electrical shock, and damage to the main control box. The fuse is located 20 cm from the main point of connection, meeting safety requirements put forward by MATE.

Figure 15 : Fuse

CONTROL PANEL:

The control panel for our JELLYFISH system includes a monitor that displays readings needed by the pilot while controlling the system. The display screen is divided into four sections meant for the cameras in both the main ROV. During the pilot testing phase, our pilot suggested that we use only one screen instead of two screens for convenience purposes. Our meticulous pilot wants an organized work space without loose components or unsecured wires. Therefore, our co-pilot takes special precautions before beginning the maneuvers of JELLYFISH. The second option is the joystick. It has both flexibility and stability, making it an interesting option. The pilots and co-pilots agreed that there is no chance of losing control while doing the tasks. Moreover, the joystick on our gaming controller has many other buttons.

The joystick as shown in figure 16 and it has a couple of interesting features: flexibility and stability at the same time. The pilot and co-pilot mutually agreed upon this quote: There is no chance to lose control while doing the tasks.

Moreover, our joystick contains a myriad of other buttons which can be a godsend,since we need to add more options to the ROV according to the tasks. Therefore, the Joystick was used to ensure the easiest and best control for the pilot as well as providing different vehicle speeds to achieve the mission in the least time possible.

Figure 16 : Joystick (remote)

SOFTWARE:

Communication with the camera could be done without screen usage by a communication protocol the SSH. In order to use this protocol, we type “ROV” which is a code word replacing “jet SSH jetson @ the cards IP address”. Intending to connect to said card using the software “Lunix” we require a passcode. ROS a software that stands for “Robot operated system”, is used to activate the camera and show the recording on the pc screen. Typing “USB card test. launch”, will give you access to launch the document named “USB card” that contains both of the cameras installed in our ROV.

SYSTEM DECISIONS:

This year, our strategy to build the ROV was design the components ourselves to fit our vision of the ROV and avoid using pre-built components.

The custom fabricated frame is made out of PVC with laser cutting. The company chose to custom the frame as light as possible so that we can fit the Arduino Mega board and the 8 thrusters within the PVC pipe, without sacrificing mounting space and to keep the ROV in the weight we agreed on and stick to the weight rule sat by MATE.

Although, not all the ROV's components are custom built or designed by the team members themselves, but we also relied on some reliable and tested products that we purchased from notorious and well-known companies. We decided to purchase components such as servos, regulated air cylinder, and the Brushless Motors and the Arduino Mega cards.

NEW VS REUSED

Budget constraints were a major factor in whether the company purchased or reused parts from previous years. The decision was made not to buy new parts if they were found to be cheaper to build or 3D print than the cost of replacing them. The Brushless Motors are purchased since these components are of good quality and cost-effective. The Brushless motors were chosen over the water pumps of the 2019 ROV because they are lightweight and more resistant. In Addition, Brushless Motors are electromagnetic so the speed can be controlled.

Mission specific Tools

MANIPULATOR

Due to the relatively high number of tasks that require fine maneuvering of subsea items, such as replacing the wires during the assigned missions, Electronic Gills opted to develop two manipulators that are both reliable and versatile. To develop reliable manipulators, the company designed two angular grippers which are used when limited space is available and their jaws are opened and closed around a central pivot point. It is fixed to the below platform of the ROV and it's adjustable. The rate of the closing and the opening of the grippers are operated by a nut on the regulated pneumatic cylender

Figure17 : gripper

Figure18 : regulated pneumatic cylender

2 CAMERAS (OF THE SAME KIND)

This camera is a driver-free camera with 640*480 resolution. The camera is well compatible with NVIDIA which is the card we're are using for our ROV. Its compact size of 30*25*21.4mm makes the module possible to be embedded in a variety of devices, which can be used for applications like image recognition. It has a USB 2.0 connector and an operating voltage 5V

Figure19 : camera

INFRARED CAPTOR

Electronic Gills also chose to use an infrared captor to identify which of the fish is dead and which of the fish is alive. So, the infrared captor we chose for this task has a temperature accuracy of plus-minus 2,5°C, a viewing angle of 60°, an optical axis gap of plus-minus 5,6°and a current consumption of 4,5mA

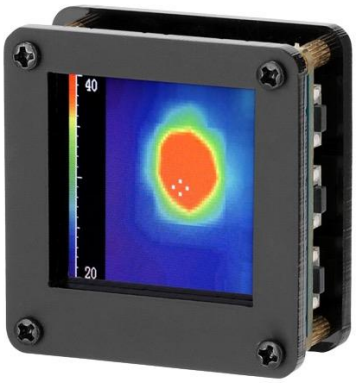

Figure20 : infrared captor

SHIP RUINS STITCHING

Electronic Gills also decided to create a program that will capture photographs as the ROV passes above the bottom of the pool in task n°3 like asked and patch them together automatically into a photomosaic which makes finding the ship ruins easier. Completing this duty saves time on missions automatically. And the coding language used for this program is Python

Safety:

All team members are taught that safety is a key part of our company's success. The team is always committed to following MATE published safety guidelines and upholding the highest safety standards. To create a safer work environment, all levels of our workforce need to be committed. The team stresses the importance of safe working practices among our employees by engaging them directly from the beginning. The company has created a safety committee to help protect employees from hazards and unsafe work practices, prevent accidents by removing any known obstacles, and evaluate the company's efforts to achieve an accident-free workplace.

Company safety:

Providing a safe and secure a working and living environment for our teammates is as important as developing a reliable ROV. In fact, following the guidelines is not a priority but a law, a commitment that we guarantee to all of our members.

Our organization followed this protocol for the protection of our employees. And to make sure we were all on the same page with the safety checklist provided by MATE competition and we asked our safety instructor to read the instructions in this checklist. In addition to that, we

asked our two mentors to monitor us while operating some potentially hazardous operations. In addition, during our school workshops we made sure to apply the three golden rules:

1) Always have the basic safety equipment on hand: safety googles, appropriate gloves, ear protection, safety shoes, and appropriate clothing are all required.

2) To avoid any mishaps, no member shall work alone.

3) Remove what you left behind because one could slip or trip on some debris left on the floor.

As mentioned in our safety philosophy, we want to ensure safety for the members while working but also on the ROV itself. We designed our ROV to do the demanded tasks perfectly but we also cared about the safety of the users or anyone surrounding the ROV. The safety features we had are various. First of all, our ROV is silicon free so that it doesn't damage any of the fauna nor the flora. For second, Jellyfish doesn't have any sharp edges so that it doesn't harm anyone near the ROV. For last, in case if the power cuts off, the ROV is designed to float without any exterior intervention.

Safety review

Figures21/22/23/24 : company memebers following safety mesures

LOGISTICS

COMPANY STRUCTURE AND TEAMWORK:

Throughout the building process and competition preparation, the Electronic Gills crew demonstrated remarkable teamwork. The company was divided into four segments at the start of the year (sponsoring, communication, electrical team, mechanical team, and designing team...) to work on key parts of the ROV and various aspects of the project. As a result, the organization was able to complete the assigned tasks with a significantly greater level of efficiency. Roles were assigned to company members based on their comprehension of the tasks, as well as their strengths, skill level, experience, and interests. These individuals were then divided into divisions, with one division commander in charge of each section. The division heads communicated with one another, expressed their worries, and informed the CEO.

We also tried to make time for every assignment that every team had to work on or for the ones that we had to work on together and that left us with

Preparation: 298 hours

Planification: 457 hours

Managing: 678 hours

Assessment and Report: 23 hours

Total Hours: 1456 hour

ACCOUNTING

The building process requires extensive budgeting and costing. We used the budget from the previous year's team costs and predicted additional expenses at the beginning of the year. Our Chief Financial Officer maintains a precise record of our spending on a shared spreadsheet throughout the season. From screws to research and development materials, it keeps track of everything. She then translates all of this information into a project costing summary, making it simple to understand how much money was spent during the year.

At each meeting, we go through the previous week's expenses and make a list of any items that are needed.

We think that excellent accounting is essential for a successful business, therefore we work hard to be as cost-effective and well-organized as possible. We always shop around to find the best combination of usable materials and reasonable rates, and we 3d print and reuse components wherever feasible to save money. We fundraise all year (even after submitting our technical documentation) to ensure that we can meet our costs by approaching local businesses. The whole design and building process is achievable thanks to our focus on cost and a well-organized accounting system.

BUDGET

Expenses:

CATEGORY	TYPE	EXAMPLES	PROJECT-ED COST	BUDGETED VALUE
Hardware	Purchased	Structure Boosters Brushless motor	$264.03 $11.55 $660.07	

		Waterproof tube Cable gland step-down Double-acting pneumatic cylinder	$297.03 $3.30 $3.30 $198.02	$1437.30
Electronics	Purchased reused	Control board, wires Monitor	$188.78 $66.01	$195.38
Senors	Purchased	Camera	$66.01	$66.01
General	Purchased	Competition entry fee	$100.00	$100.00
Travel	Purchased	Travel expenses	$5.000(per person)	$75.000

Table 1 : Regarding the expences

PROJECT COSTING

Expenses:

Expense	Type	Examples	Amount	Running balance
ROV Frame	Purchased	plexiglass	-$264.03	-$264.03
Propulsion	Purchased	Brushless motor	-$660.07	-$924.10
Control Box	Purchased	Screw shields board	-$1.45 -$2.53	-$928.08
Topside Electronics	Purchased	Arduino mega card NVIDIA card	-$27.39 -$161.39	-$1116.86
Onboard Electronics	Purchased	Camera	-$66.01	-$1182.87
General	Purchased	Registration Team shirts	-$100 -$391	-$1673.87
Travel	Purchased	Air fare Gas Airport parking Hotel rooms	-$844.88 -$53.00 -$1.32 -$650.00	-$3223.07
Misc	Purchased	Screw, Bolts, nuts PVC	-$2.64 -$1.16	-$3226.87

Income:

Table 2 : Project costing and sheet for ROV build

EXPENSE	TYPE	SOURCE	AMOUNT	RUNNING BALANCE

Funds	Donated	Société Tunisienne de Banque	$825.08	$825.08
Funds	Donated	Ennadhafa Judy	$660.07	$660.07

Table 3 : Income with sponsoring and donations

Total Reused and Donated parts	$4455.45
Total Raised	$1485.15
Total spent	-$3426.89
FINAL BALANCE	-$4683.745

Table4 : Total income including sponsoring and donations

Testing and Troubleshooting:

Testing and troubleshooting are an integral key step to the iterative design process outlined in the company's design rationale. Each feature of the ROV is constantly evaluated for both performance and reliability to ensure these traits are carried forward to our Jelly Fish. For instance, if the manipulator is designed to detach a cable from the rest (task 1.1) it will be evaluated on how well it can detach and grab the pipe . Any possible improvement is later analyzed and may result in another iteration of the design if performance or reliability can be improved. The testing process of Electro-Gills is deeply rooted within the iterative design process and is greatly effective for improving already working designs. However, features almost never work on the first design, and combining features on the main ROV often results in problems spanning multiple discipline areas. When troubleshooting, the first step taken is to gather everyone relevant to the issue at hand. If the problem is within a singular feature, the team will gather to resolve issues. If the problem is between multiple features of the ROV, the members will gather together to discuss the issue and suggest solutions. For example, if pressing the control joystick forward is expected to activate all motors, but the front right motor is not spinning, the exact motor will be isolated as not working. This allows us to check the area of code pertaining to that specific

motor and to check the wiring to the front right motor rather than all of the wiring. Usually, a simple check reveals the problem, and the issue is quickly resolved. Sometimes, multiple changes could also fix. When troubleshooting, the company is careful to change only one thing at a time. This helps identify and converge on exactly what change works and eliminates any confusion about what is contributing to the issue. This process of troubleshooting combined with the regular testing dictated by iterative design ensures that Electro-Gills can efficiently bring the best product possible to market while reacting quickly to any issues along the way.

CHALLENGE:

For the reactional challenge, we have to use 2 languages (English and French) and eventually a third one (Arabic) because some of the judges were foreigners. Thus, we presented the ROV in three languages in the event we hosted in LES ECOLES IDEALES, and in full English in the National Competition. Therefore, to overcome this issue, all team members spent a whole week preparing in those 3 languages to be more at ease during presentations and during the redaction of the different documents needed.

We faced some problems on how to manage our time and work simultaneously on the ROV and focus on our studies. Therefore, we learnt how to separate our time and focus on them both which was hard at first but by the time we got used to it.

We also learnt how to work together and in groups. How to give each one of us a task to focus on so that we can work faster. How to help each other. We also sat clear expectations for all group members, were honest of our abilities and respected each other

FUTURE ENHACEMENTS:

-Doing a platform web where customers can interact and give their opinions about our company so that we can take that into consideration and work to improve our company, increase our customer service & sell our product using this platform web.

-Involve with research laboratories to keep up with the latest developments

-Using this time, the design thinking as a tool to solve problems and missions' tasks not only for the MATE competition but now, for our other clients.

-Attending more difficult training courses for the mechanical & electrical team to Improve and make our product more efficient.

-Doing more events related with the ROV.

CORPORATE RESPONSIBILITY:

What do we do with JELLYFISH :

We did an information special event that was held In the Ideal High school the 18th of February 2022. We grouped a bunch of high school students in order to inform them about our team, the team's history, our objectives and goals, the competitions we are going to attend. Tell them more about the ROV and its features. We also talked about the specifications of this year's international competition and the technical and marketing presentations.

Figure 25 : company members group photo

Figure 26 : some of the company members speaking during the event

Lessons:

We have learned to work together as a team and work in harmony without wasting time by following these rules:

As an organization that shares responsibilities within a group, communication should be within the following basic rules:

When it comes to writing emails to all members, you need to write objects.

When you specify a meeting, you must specify the purpose, content, and duration. The best way to find a solution to the problem is to do some background research first, as we did in the conceptual design of frames and manipulators.

Appendix :

SID

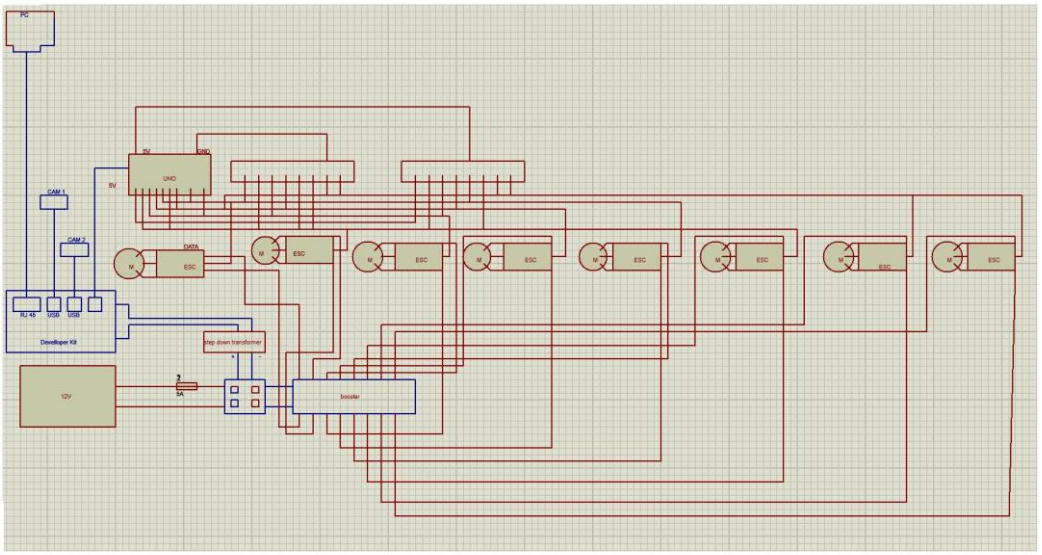

Figure 27 : SID

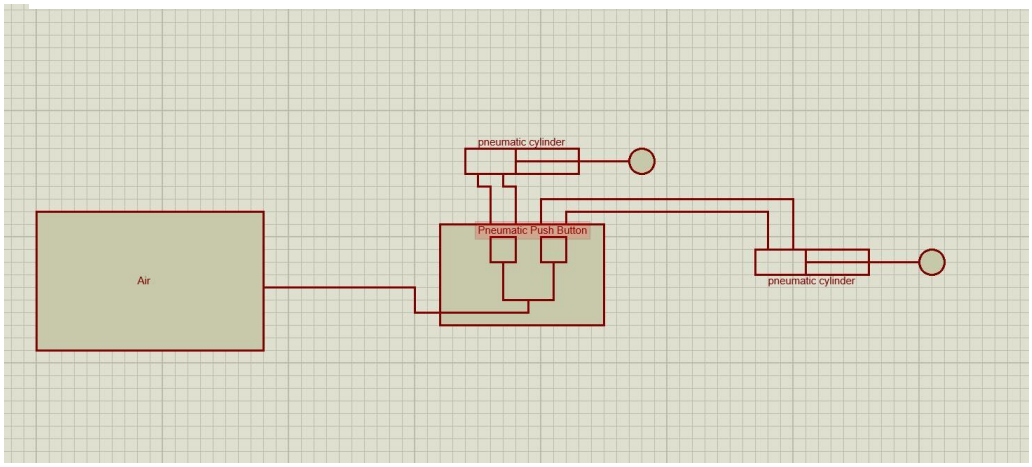

Figure 28 : Pneumatic part of the SID

REFLECTION:

Rania Ben Amor

“While I think I learnt a lot of things from this experience I still have the urge to expand my knowledge more and more. Through that process, no one could claim that he or she was the most hardworking person in the group because

truly we cannot achieve a dream work if we don’t have a strong teamwork. Teamwork is working together of people to achieve a certain goal. Teamwork is the basic need for an organization to function. Without teamwork nothing is possible.”

Roua Chemkhi:

“If we didn't put so much effort into it, we would not be successful. Our success was due to teamwork. Information retrieval, patience,

It was an amazing experience that opened my eyes to Technology's world and encouraged me to explore it further.

Myriam Mehrez:

“This was an unforgettable experience which has taught me how to work in a team, to be patient, to deal with stress and has improved my knowledge in terms of developing, designing and programming. This has also helped me decide what career I would like to pursue in the future.”

Acknowledgement:

The Gills would like to express their gratitude to whoever who contributed in making this dream a reality.

Electro Gills would like to recognize several sponsors and individuals for their continuous support and help.

-MATE ROV COMPETETION for organizing the 2022 International ROV Competition and creating the 2022 missions

-Les Ecoles Ideales for supporting us and giving us the opportunity to work in a healthy environment.

-STB (Société Tunisienne de Banque) for funding us.

-Clinique Violette for funding us

-JUDY for sponsoring us

-Huge shoutout to Hotel Amira for allowing us to use its pool for the testing of the ROV

However we are still in the process of finding new other sponsors to fund us and cover our backs.

Our ongoing support is extremely vital to our parents and guardians, and to our mentor Mrs Zeineb Rejab who have dedicated countless hours to making our experience a success.