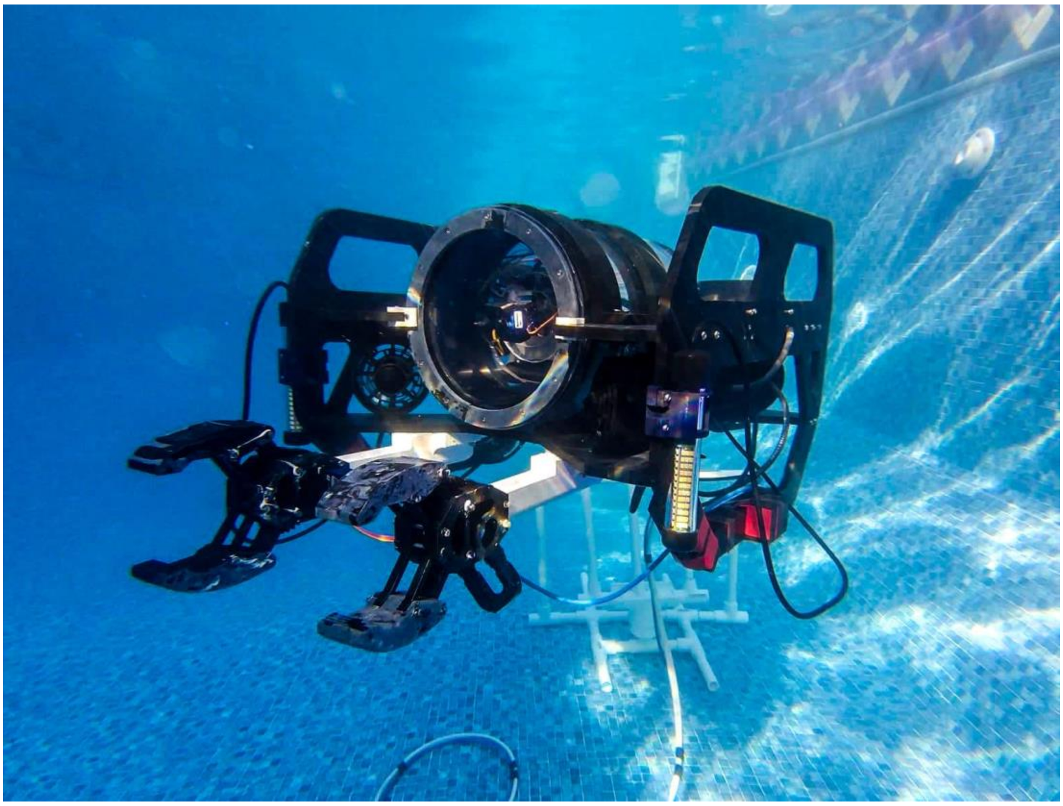

SeaFox-3

Technical Documentation

'20 - Julio Hurtado
'23 - Miguel Bravo
'21 - Alexandra Siono
'19 - Luis Manuel Torres
'18 - Miguel García
'18 - Marian Meza
'23 - Rubén Alan Haros
'19 - Marco Leal
'19 - Juan Pablo Romero
'19 - Mariana Figueroa
'21 - Carlos Figueroa
Luis Carlos Básaca – Team Mentor

Introduction

Abstract

This document is an overview of the design and manufacturing of the ROV prototype that Sea Fox inventive is presenting on the MATE 2019 competition. This ROV is designed to carry out missions in environments such as rivers, lakes or dams. This will be the 3rd generation in CETYS University in which a team of students meets to design and build an ROV, in past competitions they were not able to meet the objectives and standards for which it was not possible for the team to compete. Now, the mistakes learned in the past years and the effort and good organization have made it possible for SeaFox Inventive to proudly announce its new ROV: 'SeaFox-3'. (The name is a tribute to the two previous generations of which we learned a lot).

Fig. 1. SeaFox team members

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Design Rationale

Design process

SeaFox-3 is the result of the learning obtained in past years, two prototypes that could not reach their objectives, gave this generation valuable knowledge to carry out a functional, practical and innovative prototype. The focus in this generation is to concentrate on the priorities, although this year there are very exciting challenges, the main mission of the team was to be able to finish the school year with a fully functional ROV. For that, a classification was made of the components of SeaFox-3, this was done by means of the function that they had, or the activity in which they were occupied and in this way, the components with greater relevance were prioritized.

Fig. 2. Planning team meeting

Obviously the components that had the highest priority on our list were those that were responsible for the sealing of our electrical package and navigation. To save future problems it was decided that it was best to resort to components that were safe and reliable.

Once the construction of the ROV was completed with its most basic navigation and vision functions, it was continued to complete each of its extra functions as if they were modules that can be installed and uninstalled with ease. SeaFox-3 has a robust design and a lot of space to be used. We believe that is one of our main advantages.

Fig. 3. Team with frame parts

Mechanical Design

It was decided that this year's design needed to be focused on versatility, simplicity, and ease of manufacturing. Therefore, it would be simple to modify the design if needed. This year's design was drastically different from past years, as it was decided to strive for a sleeker frame, and a smaller overall weight of the mechanical components of the ROV.

The initial design was made taking weight distribution into consideration, carefully arranging the different subsystems and actuators in a way that the center of mass remained centered and balanced, and that minimum ballast would be required, only to achieve neutral buoyancy.

Once an initial design was chosen, flow simulations were ran, and design modifications were made, prioritizing ease and cost of manufacture, while also optimizing the fluid mechanics performance of the ROV. When the final mechanical design revision was ready, blueprints were made, and a manufacture plan was put into action, starting with the generation of G-code for CNC manufacturing of the HDPE plates, leaving as little manual manufacturing as possible. Finally, the individual components of the frame were assembled, and the electronics capsule was installed and secured in place.

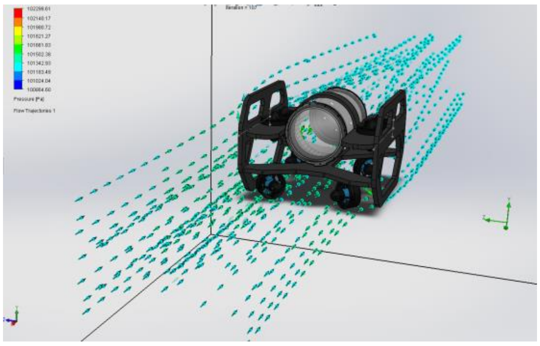

Fig. 4. Frame design flow simulation

Frame

Logically, among the components with a higher priority there was the matter of the physical structure. In past years, the material used for the structures of the ROV consisted on on metallic parts, usually aluminium for being a lighter material. However, after studying the composition of the structure of commercial ROVs and other equipment in past MATE competitions, it was concluded that high-density polyethylene (HDPE) is a good frame material, due to the balance in lightness and the strength that it would provide to the structure; additionally, due to the mass properties of the material, which has positive buoyancy, it helped with achieving neutral buoyancy without having to add many floaters, which was an issue in past designs. Also, because how easy it would be to machine this material. It was finally decided to use 1 cm wide plates.

Fig. 5. SeaFox-3 design development

Buoyancy and stability

Our ROV does not require additional floating elements thanks to the capsule, the 3D prints, the encapsulation of the lights and the material of which the frame is composed. All of this components add a lot of positive buoyancy. The highest concentration of air volume is in the capsule, this is an advantage because the capsule is in a slightly higher position in the vehicle, therefore it helps to stabilize it.

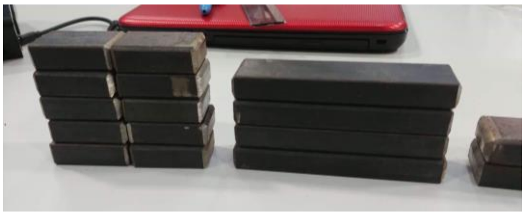

Fig. 6. Weights made out of iron

In order to neutralize the huge amount of positive buoyancy SeaFox-3 uses a static ballast system which consist only in weights made out of iron bars attached to the bottom of the vehicle.

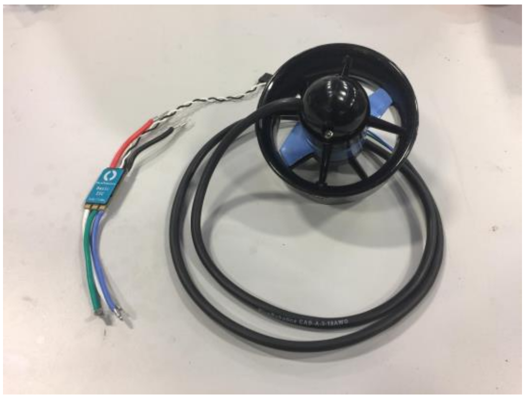

Fig. 7. T100 thruster with Basic ESC

Propulsion

SeaFox-3 is able to move thanks to the BlueRobotics T100 thrusters. These are very popular in commercial ROVs, because they are easy to install and do not need a meticulous maintenance unlike the brushless motors adapted to be used underwater. These are certainly expensive but thanks to the fact that the past generations of ROV teams in CETYS University left a large stock, it was decided to take advantage of these resources.

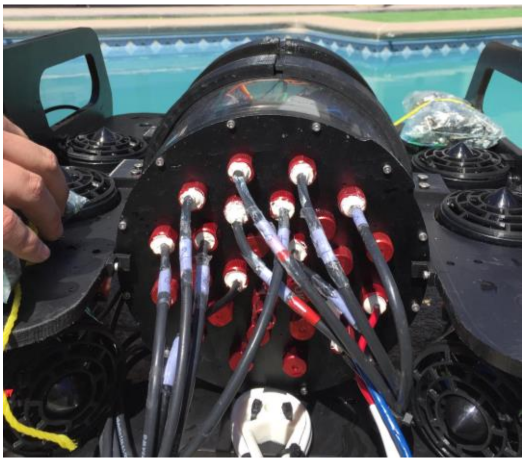

Fig. 8. Back lid of SeaFox-3 with penetrators

Enclosure and sealing

To encapsulate the electronics of our ROV, it was preferred to use an 8" enclosure from BlueRobotics. This was due to the fact that the previous teams had a lot of troubles sealing their enclosures. Consequently we wanted something reliable to learn from. The aluminium cap from the enclosure was drilled with 27 bores allowing connections from the electronics panel to thrusters, sensors and servos. All cables coming through the enclosure are sealed using a penetrators and marine grade epoxy.

Electrical Components

Power distribution

The Seafox-3 ROV prototype is powered by a 48 VDC and 30 A power supply. There is no type of voltage conversion from the surface source until the ROV. Within the enclosure the power line is distributed through several converters to properly power each of the electronic systems. All these converters are divided mainly into two sections. The first is responsible for energizing the thrusters, which require a 12VDC power supply and can consume a significant amount of current.

The other section of converters is used to power the control section and communication systems, composed of many raspberry Pi's, the PCA9685 controller, the Pixhawk controller and a five-port ethernet switch. Most of all these devices are powered by 5 VDC. This section of converters consists of two stages, the first is responsible for lowering the voltage from 48 VDC to 12 VDC, and the second stage is responsible for lowering the voltage from 12 VDC to 5 VDC.

Communication

Another great advantage of SeaFox-3 is how simple is to integrate a new system. That is because all computing systems are connected to a LAN. This is possible thanks to a 5 ports Ethernet Switch inside the electronics enclosure.

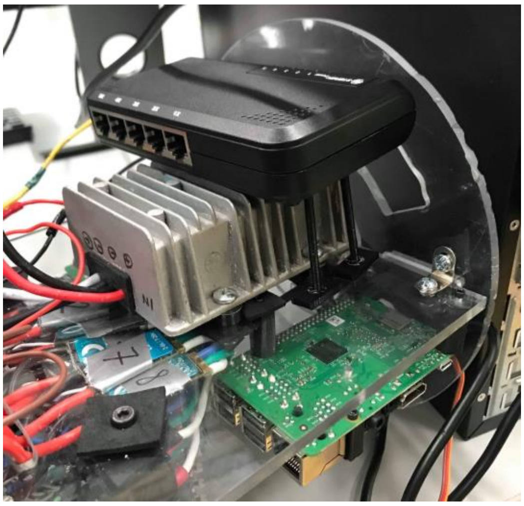

Fig. 9. 5 port switch over 48 VDC to 12 VDC converter

Control System

Our control system makes use of several electronic systems for the control of the vehicle and its functions. One of them is the Pixhawk Px4 controller, a board used frequently for drone control, internally has its own Inertial Measurement Unit and an I2C bus where several sensors can be connected, for example: temperature or pressure. Also this board has an array of PWM outputs which are connected to 8 ESCs, each of them control one thruster.

The Pixhawk Px4 component works in conjunction with a Raspberry Pi 3 board, which establishes a connection within a LAN to control the system remotely. The same raspberry Pi 3 receives a video signal from a camera connected to the same card, this video signal can be viewed from a station connected to LAN network mentioned.

Fig. 10. Rolled tether

Tether

A tether design was one of the major challenges. First we needed to decide how many cables were going to be used. We wanted as few as possible to reduce weight, increase flexibility and avoid drag. The team agreed that we needed at least the power transmission cables and one communication channel. Once we knew the maximum current value going through the power cable, 23.46 A, we examined charts and tools to evaluate the appropriate wire gauge. We decided that 10 AWG ancor marine grade duplex cable could do the job and one twisted pair Cat 5 for communication. To maintain the two cables together pieces of heat shrink was used all along the Tether.

Vision System

SeaFox-3 has 3 cameras. The first one is pointing forward and is mainly used for navigation and objectives localization underwater. The second one is also pointing forward but with a slight angle downward. This is one is preferably used when manipulating objects with the frontal grippers.

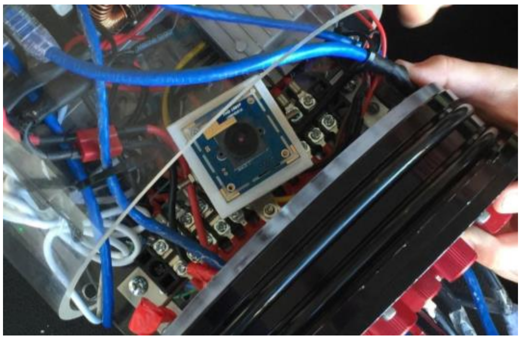

Fig. 11. Camera for downward vision

The last one is pointing downward, this point of view is useful when the SeaFox-3 is required to get aligned in a certain position. All cameras are capable of being connected via usb and each one is attached to a different Raspberry Pi 3, this way the video processing load is divided between all computing systems. All cameras are mounted inside the electronics enclosure so we avoid the need to waterproof them.

Control Station

The control station consists of a single computer or laptop where the video of the camera is shown in the ROV and the main program that allows the control of the ROV is running. If it is a desktop computer, keyboard and mouse are required. A joystick control is the main way to control navigation and we use the Thrustmaster T-flight Hotas X model as it provides the ability for a single pilot to control several degrees of freedom of the vehicle.

Fig. 12. Control station

While the main pilot makes use of the navigation control, the second in command by means of the mouse and keyboard make use of the secondary functions of the SeaFox-3, by means of them we can control the servos and place them to different degrees. It is able to monitor the vision cameras alternate to the primary and also check the value shown by the sensors.

Fig. 13. Electronics enclosure

Software

Topside software

The main software used is QGroundControl, the team chose it because it provides us with an easy implementation. After having all the hardware connected you just have to install it in a computer equipment. This provides flexibility to our system because we can easily change our topside equipment. It also allows you to configure most parameters and preferences such as engine configuration or power preferences, which makes it a versatile and effective tool.

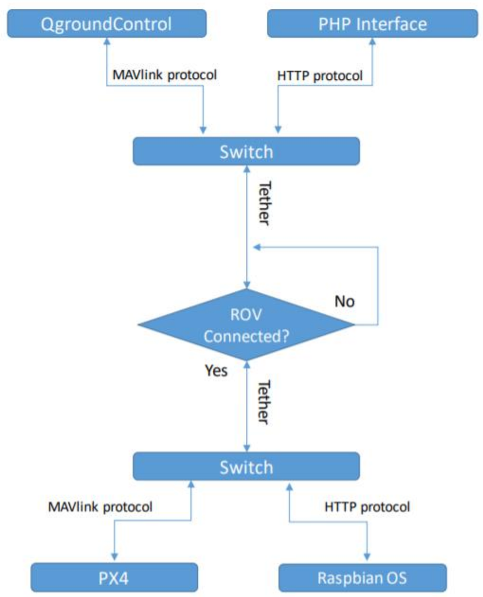

Fig. 14. Software system control

Nevertheless, we knew that QGroundControl wasn't enough to provide us with all the functions required, although it is an open-source software we didn't have enough skills and time. For this reason we searched for a way to complement QGroundControl capacities in a simple but efficient way.

Onboard Software

The Pixhawk controller runs ArduSub. An open source solution for ROV's. All basic functions required to move SeaFox-3 are covered thanks to ArduSub. The Raspberry Pi connected to the Pixhawk runs a companion software dedicated to work along ArduSub.

The rest of the Raspberry Pi's run Raspbian, a Linux operating system based on its older brother Debian. This device fulfills two important tasks. The first is to control all devices out of reach of QgroundControl and Pixhawk such are the examples of grip mechanisms and certain sensors. This is possible through "Apache HTTP server", this allows to create a user interface with the ability to be used from any search engine that is within the ROV local network, using a server hosted within the raspberry pi that is running a code in PHP language.

The PHP script is calling to execute python scripts that are responsible for using the GPIO ports, this acts in conjunction with the Circuit-Python library to speed up the embedding of electronic components. The second important task is to transmit the video of cameras outside the one used by the Qgroundcontrol - PX4 system. This is possible thanks to Motion software, which is a web-server and open-source platform for video streaming. It is also used a Python script and openCV to smooth the video quality and improve its transmission update. It works in conjunction with Apache - Server to send its transmission through the local network and be transmitted by any search engine with its network address as a key to open it.

Payloads

Dual Frontal Grippers

SeaFox-3 has two frontal robotic grippers that allows it to handle objects underwater. Those were designed and 3d printed to achieve an optimus grip and the capability of being powered with waterproofed servos.

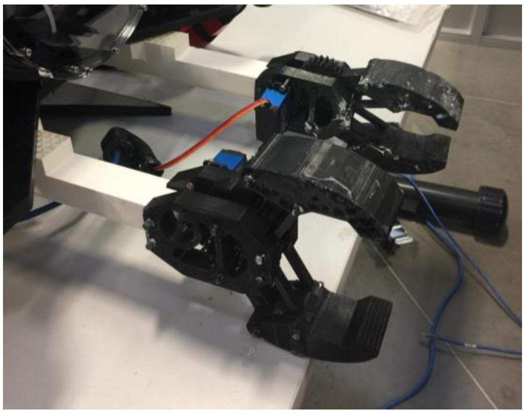

Fig. 15. Dual Frontal Grippers

Transport container

SeaFox-3 has a single tool dedicated to transporting objects that are too difficult or impossible to carry with grippers. This tool is made with a container with two trays that slide with the help of two servos in such a way that the objects located in the first level fall first, and those that are in the second level fall once both servos are activated.

Fig. 16. Transport container

Heavy Lift Grippers

Some objects underwater may be to heavy and bulky to lift them with the main frontal grippers. SeaFox-3 has two retractable hooks, just at the bottom of the frame. This allows the vehicle to carry heavy objects right under the center of gravity and avoid forward tipping.

Troubleshooting & Testing Techniques

As every system was completed, it was tested to determine if it worked. For example, when the voltage converters were installed, they were tested with a multimeter to check voltage levels at the outputs. Each electronic system was also tested separately, the different Raspberry Pi's were reviewed by means of a monitor and they were ensured they fulfilled their operation of capturing video signals.

Fig. 17. SeaFox-3 being tested underwater

One problem we had when testing the operation of the SeaFox-3 underwater, was the power consumption. Until then we didn't have any problems. While performing underwater tests, we noticed that the SeaFox-3 restarted frequently. We were surprised because this behavior did not happen out of the water. Analyzing the electrical diagram and comparing what could be different from testing the vehicle in different environments we realized the problem. We had tried the thrusters at maximum speed but this had been in the air and we did not take into account that under the water the thrusters consume more current because the propellers are subjected to greater drag.

The power consumption of the Thrusters actually exceeds the capacity of the converters dedicated to them. Therefore, adjustments had to be made in the design of the power distribution.

Safety

Company Safety Philosophy

Seafox Inventive has it clear that security in our workspace, safety when using any tools and correct use of PPE are our highest priorities. We are aware that these precautions allow us to produce neat and reliable work. That is why none of the common protocols and warnings are ever compromised for any reason. The security measures are also reflected in the construction of our ROV, either in electrical systems when waterproofing them, or in mechanical systems and chassis, by avoiding any sharp edges that could harm our staff or surrounding components.

Lab Protocols

Our work area must follow certain conditions to be usable and safe. All team members know what these requirements are. Here are our laboratory rules:

- At all times there must be a responsible teacher overseeing the work that is done.
- Before performing any task or modification, this must be consulted with the team's CEO for security reasons.
- The laboratory must be locked up when no one is working.
- Each tool has its corresponding place.
- The use of PPE is mandatory when necessary.
- Everyone should be instructed on how to use an extinguisher.

Fig. 18. Safety signs at laboratory entrance

Training

Every member of Seafox Inventive was gathered in an initial meeting where the project was explained and the roles distributed. After this, everyone was trained in regards to using the laboratory and its tools as well as the correct use of PPE for different activities. A survey was conducted to know the schedules of all the members to determine the hours of work at the laboratory, making it easier to have a responsible teacher to be supervising.

Vehicle Safety Features

Our ROV design pays attention to many safety features in order to avoid causing damage to the user or to the ROV itself.

- The structure was designed on ABS plates that were cut with rounded corners to avoid filing.
- All electronics are placed in a waterproof enclosure.
- Any bondable external system or mechanism was designed or abraded with the intention of avoiding sharp edges.
- The eight thruster motors where mounted with their safety guard.
- The tether is supported with a strain relief to avoid damage to the capsule penetrators.
- The ROV tether has the indicated fuse according to calculations as required for the competition.

Fig. 19. Truster safety guard

Operational and Safety Checklists

i. Pre power check

- Check connections and ensure that no cable is damaged or loose.
- Confirm that the electronic systems enclosure is sealed correctly.
- See to it that the area surrounding the ROV is clear and the tether is unobstructed and untangled.

ii. Vacuum test

- Connect the manual vacuum pump to the vent penetrator.
- Pump until 10 in Hg is reached, and then set timer for 15 minutes.
- Once the time has passed and pressure inside the enclosure remained above 9 in Hg, remove the pump and tighten the vent plug.

iii. Power up check

- Connect tether to power source.
- Verify connection to QGroundControl, then access to the secondary control interface with a browser.

- Ensure that there are people monitoring the ROV before and during the tests
- Establish a safe connection between the control and the thrusters.
- Test external systems and mechanisms beforehand, including grippers, vessel and hooks.
- Check the cameras functionality.

iv. In water check

- Submerge the ROV with care, preferably with the help of two member of the team.
- Make sure that the amount of bubbles present is normal.
- Check the leak detector on a regular basis.

v. In case communication is lost

- If communication is lost, disconnect the ROV from the power source and bring to the surface by the tether.
- Initiate reboot process.

Logistics

Scheduled Project Management

This year there was a lot of growth in the administrative area of SeaFox Inventive, there was a lot of learning about what was the best way to work. We have also learned a lot from other areas and this is what we feel has differentiated us from previous generations. In the beginning, a very general division of labor was made, different teams were in charge of different areas and it was foreseen that each month important progress will be made in a different area. That is, the first month we will take care of the mechanical part, the next month would be related to electronics, the third month will be dedicated to programming and from then on it will be a matter of testing and improving our design.

Fig. 20. Early tasks calendar

After two months we realized our way of operating did not work. Mainly because while certain teams worked hard, others remained without any activity waiting for the results of the first. This was a bad placement of human resources and to correct it, a more flexible way of working had to be devised. What worked best for us was constantly repeating a work cycle. This cycle consists of:

- Planning
- Design
- Search and Purchase of material
- Manufacturing
- Testing

Unlike the previous procedure, our performance increased considerably thanks to the fact that we took into account the time required to make purchases of material. In this way we performed the tasks we could do while new material arrived. This cycle is constantly repeated in each new aspect of the ROV. In this way there were people planning, others looked for material, others built and others tested the finished components.

Company Organization and Assignments

SeaFox Inventive had to reinvent itself during the course of the year to achieve the desired performance and meet its objectives. Members with more experience were in charge of a specific area: mechanics, electronics or programming. This year, in particular, SeaFox Inventive had a large number of new students. After restructuring the team dynamics, the most experienced staff remained in charge of a specific area and novice students could try different types of tasks.

Mechanics	**Electronics**	**Software**
Julio Hurtado	Luis Manuel Torres	Braulio Cabrera
Marco Espinoza	Miguel Garcia	Marian Meza
Jorge Azuara	Alejandra Mendoza	
C.D./Safety	**Image**	**R&D**
Miguel A. Bravo	Luis Esquivel	Ruben Haros
Jocelyn Siono	Alexa Macias	Marco Leal
Mariela Quintero	Kim Manzano	
Logistics	Posible Pilots	
Fernanda Chin	Julio	
	Luis Manuel Torres	
	Marian Meza	
	Miguel Garcia	

Fig. 21. First division of labor in SeaFox Inventive

		Monday	Tuesday	Wednseday	Thursday	Friday	Saturday
Miguel Bravo	PLANNING	2pm-3pm	2pm-8pm	2pm-5pm	2pm-5pm	2pm-5pm	
Julio Hurtado	DESIGN			4pm-5pm		3pm-5pm aprox	
Jocelyn Siono	DESIGN						
Mariela Quintero	SEARCH AND BUY	12pm-1pm			12pm-1pm		
Luis Manuel	MANUAL WORK	9am-12pm aprox		9am-12pm aprox		9am-12pm aprox	
Miguel Garcia	MANUAL WORK	2pm-3pm	2pm-3pm		2pm-3pm		
Marian Meza	TESTS	12pm-2pm	12pm-2pm	12pm-2pm	12pm-2pm	12pm-2pm	
Marco Leal	TESTS	12pm-2pm	12pm-2pm	12pm-2pm	12pm-2pm	12pm-2pm	
Yahir Rubio	PROGRAM	3pm-4pm	3pm-4pm			12pm-2pm	
Juan Pablo	PROGRAM	3pm-4pm	3pm-4pm			12pm-2pm	
Mariana Figueroa	MANUAL WORK			5pm-6pm	3pm-4pm	12pm-2pm	

Fig. 22. New division of labor and availability schedule

Workspace

Almost all work is carried out in an area designated by our university. This area is a work cell, one of several located in the Integration and Testing Laboratory of the Innovation and Design Center building in CETYS University campus Mexicali. It is equipped with mechanical and power tools, lockers to store material, tables with power distribution and computer equipment. This section is restricted only to members who are working on the project.

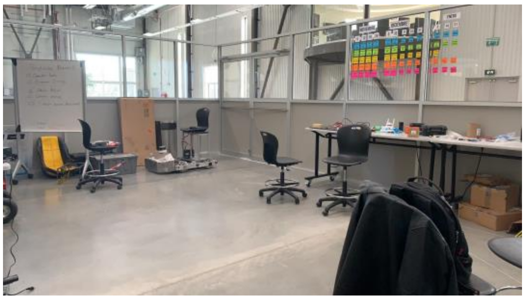

Fig. 23. SeaFox Inventive work cell

Shared media

Likewise, all current members of the project have access to a shared Google drive. There are all files rescued from the first and second generation of engineering students who have tried to consolidate the project of building an ROV. We have learned a lot from all the information contained and we are proud to think that in this year we have increased the stock of technical documentation. We feel that all the acquired knowledge will be very useful to future generations for the development of better prototypes and more interesting functionalities. That is why we value very much the files stored in the Google drive and we take care by backing them up.

Budget and Project Costing

To cover the cost of the entire project this year, the first team meetings focused on creating a simple design and preparing a budget. Many of the components contemplated to be implemented in the SeaFox-3 were reused from the ROV's of past generations. Many of them were in good condition, without having been used to a large extent. After making a comparison analysis, whether it was more convenient to reuse or buy, we decided that it would not make sense not to use components in unusually good condition, especially because they were high cost components.

Fig.24. Hot-dogs selling event

Therefore once we completed the list of materials that we needed to buy, we organized fundraising events. Our main source of income this year was the events we organized. Each week we chose a day to sell pizzas or hotdogs within our campus and it was the students, teachers and employees of CETYS University who very kindly bought them to support the team.

Conclusion

Challenges

One of the challenges was to understand how actuators work under water. There are many ways to move objects out of the water, using cylinders, motors, servos. But inside the water we realized that things got complicated, there was always the question, how to prevent water from entering the systems and it is actually relatively easy to seal a container where there are no moving parts, but due to the function the actuators have this implies that some part or section rotates or slides, therefore it is inevitable to have these risk points.

Lessons Learned and Skills Gained

Among the most valuable lessons is the organization, it seems that this is the key to the successful completion of a project. We tried to be organized from the beginning but we did not know how to do it correctly. From the beginning of the project we divided the team into different areas thinking that we would be more efficient, however we realized that certain teams could not advance in their tasks since they expected the results of others.

We also realized that it is better to have a fixed work schedule. From the beginning the team management wanted to be flexible and this was a relief for all members because many have different responsibilities, but it was also more difficult to coincide at the same time to work in the project as a team.

Future Improvements

Pneumatic Systems

Of course the future improvements of the ROV in general will be focused to make it more hydrodynamic, light and fast. But what most strikes us is to master the technique to design actuators that work underwater. On the one hand we could try to reinstall a pneumatic system as the past generations tried, they had many problems and air leaks, for that reason we prefer to avoid it this year. Although we could install a pneumatic system correctly, it would be more expensive and complex to have precise control.

Better Waterproofed motors

This year we used waterproof servos. However, we discovered that the waterproof label is an inaccurate definition. These servos were designed to withstand submersion at low depths (less than one meter) and for short periods of time. Researching we realized that there are proper and correct ways to seal motors by means of custom designed encapsulations and o-rings fitted on the shaft. However, these implementations require a series of tests and errors. For which we no longer had time this year. In the next ROV we would like to make a series of tests until mastering the technique and thus implement actuator modules made from electric motors to perform different tasks.

Modular Cameras and video processing topside

Something very similar happens with the cameras, we use all the cameras this year inside the main encapsulation. That saved us many problems in terms of prevention of water leaks; however the vision of the camera was often limited. We would like the next year to be able to build many cameras, possibly covered in resin so we will be able to place them in a simple way outside the encapsulation and have different mink modules that can be easy to change position.

One of the disadvantages of having several cameras is that a greater processing capacity is required. This year, all that processing of video signals was carried out within the ROV in different Raspberry Pi’s, and although the boards have very good performance, their capacity was limited. To avoid overloading the ROV’s internal computers, it is intended to use a video multiplexer within the electrical container to connect a large number of cameras and send a single video signal to the surface where it will be processed at the control station.

Senior Reflections

Miguel Bravo

Thinking about everything we did to be part of this competition, I cannot help but be amazed at how much it has made us grow as people and future professionals. Every time I see our ROV prototype I cannot help but feel a great satisfaction, because I know that every detail had to be thought very carefully. I know there is much to improve and I am sure that the following generations will have better opportunities because the team has evolved as the competitions have passed.

Jocelyn Siono

Being part of Seafox Inventive has been a great experience. It all started 3 years ago, when we decided to put together a team that would focus on the development of ROVs, all this to be able to compete in MATE ROV. During the first year of development I learned many new things, since I was new to the company and sincerely I did not have so much experience in electronics, mechanics or any other area of engineering. The first year, I was part of the electronics team where I learned about microcontrollers and certain protocols for programming. The second year, I had the opportunity to belong to the R & D team, but in this I had the opportunity to participate in different areas of the team, both in electronics and mechanics. The third and most recent year, I had to be part of Safety and documentation, however, I was delegated the task of designing the Micro-ROV, which personally was to my liking since my biggest area of interest within the Engineering is mechanical design. Having the opportunity to be in a multidisciplinary team like this, has brought a lot of learning to me both in the academic and personal areas, since it has taught me to work as a team and learn from different topics with the support of my colleagues and mentor.

Luis Manuel Torres

Back in 2017, a group of engineering students attempted to build an ROV to compete at MATE ROV, spoiler alert, they failed. Later in 2018 I joined Seafox Inventive in my freshman year in college, all my other team mates back then were senior year students from whom I learnt a lot and I'm very grateful for that, sadly, we couldn't deliver a finish product in time to participate at MATE, again.

In the 2019 edition, not a lot of people had faith in us, mainly because of our reputation but also because the team had a new administration and the majority of the team members were freshmen with little to none experience in this field. Against all odds, we manage to build a fully functional ROV in time to compete at MATE with a smaller and less academically prepared work team, after all third time is a charm.

To bring all this into a closure, I learnt the importance of perseveration that failure is not a bad thing unless you don't learn something from it. I have no doubts that getting involved in this kind of activities is the best thing a college student can do, it is not only beneficial in an intellectual manner, it is also a great opportunity to get a wider global understanding and vision.

Julio Hurtado

What can I say? This project was my first incursion into the wonderful world of engineering competitions. Like some of my teammates, this is not my first year working on Seafox Inventive; I joined last year as a member of the mechanical design team, and while I didn't really know much about underwater design, I was excited about learning the whole process. Due to time and economic restraints, last year I wasn't able to see any of my frame designs actually come to fruition, nevertheless, I worked until the last moment, and sadly, we didn't achieve our goal that time around. Fast forward a few weeks, a team of students, myself included, decided to restart the project, working with better organization, and members that, while still with much to learn, were enthusiastic all the way to the end. I am really proud of the work we've achieved, and how far we've come considering the record of the team. Regardless of how we bare in the competition, I already consider Seafox Three a massive success.

Acknowledgements & References

Acknowledgements

MATE Center and Marine Technology Society - Sponsoring this year's competition

Eastman Foundation - Their support of the MATE competition

CETYS University and CEID - Their support and provided facilities to Seafox Inventive

Luis Carlos Basaca, Head Coach - His knowledge and guidance

Alvaro Salvador Moreno - His time, experience and support

Our Families - Their continued support and encouragement

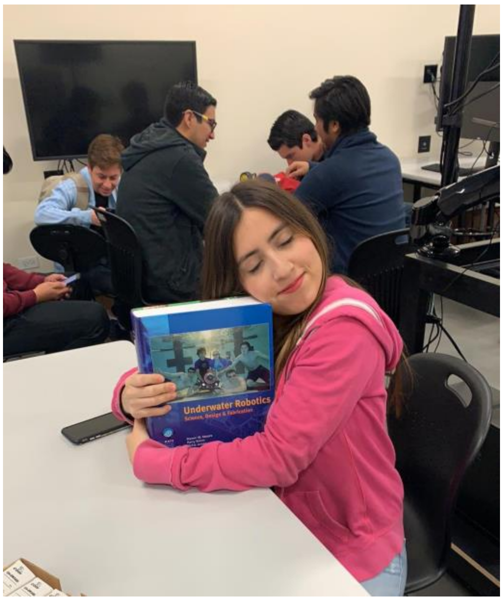

Fig. 25. SeaFox Inventive member with Underwater Robotics book

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Appendices

A. Power Budget

Object	Voltage (V)	Current (A)	Quantity	Unit Power (W)	Total power (W)	Total power without brushless motors (W)
Camera	5	0.22	3	1.1	3.3	3.3
Raspberry PI	5	1	2	5	10	10
Pixhawk	5	0.5	3	2.5	7.5	7.5
PCA9685	5	0.01	1	0.05	0.05	0.05
Thruster	12	11.25	8	100	800	
uRov thruster	12	6.25	3	75	225	
Lights	12	0.9	2	10.8	21.6	21.6
Lights uROV	12	0.0667	2	0.8	0.8	0.8
pH module	5	0.1	1	0.5	0.5	0.5
Servo	4	2.48	5	9.92	49.6	49.6
Total power					1118.35	93.35
MAX current					23.29895833	

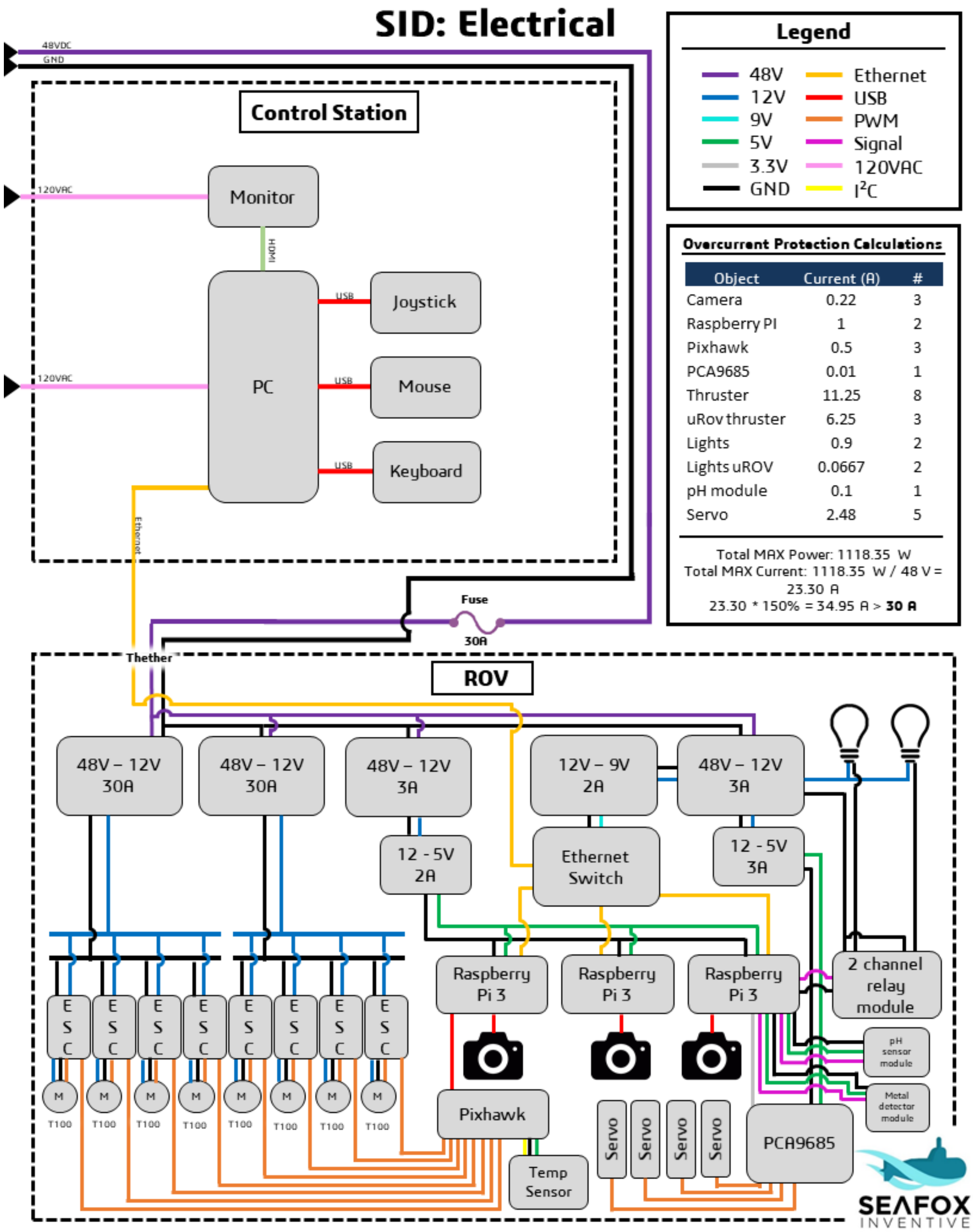
The table shows how 23.46 amps are required to power the ROV at max power. This mean a 30 amp fuse perfectly fits the needs of power security.

Total MAX Power: 1118.35 W

Total MAX Current: 1118.35 W / 48 V = 23.30 A

23.30 * 150 % = 34.95 A > 30 A

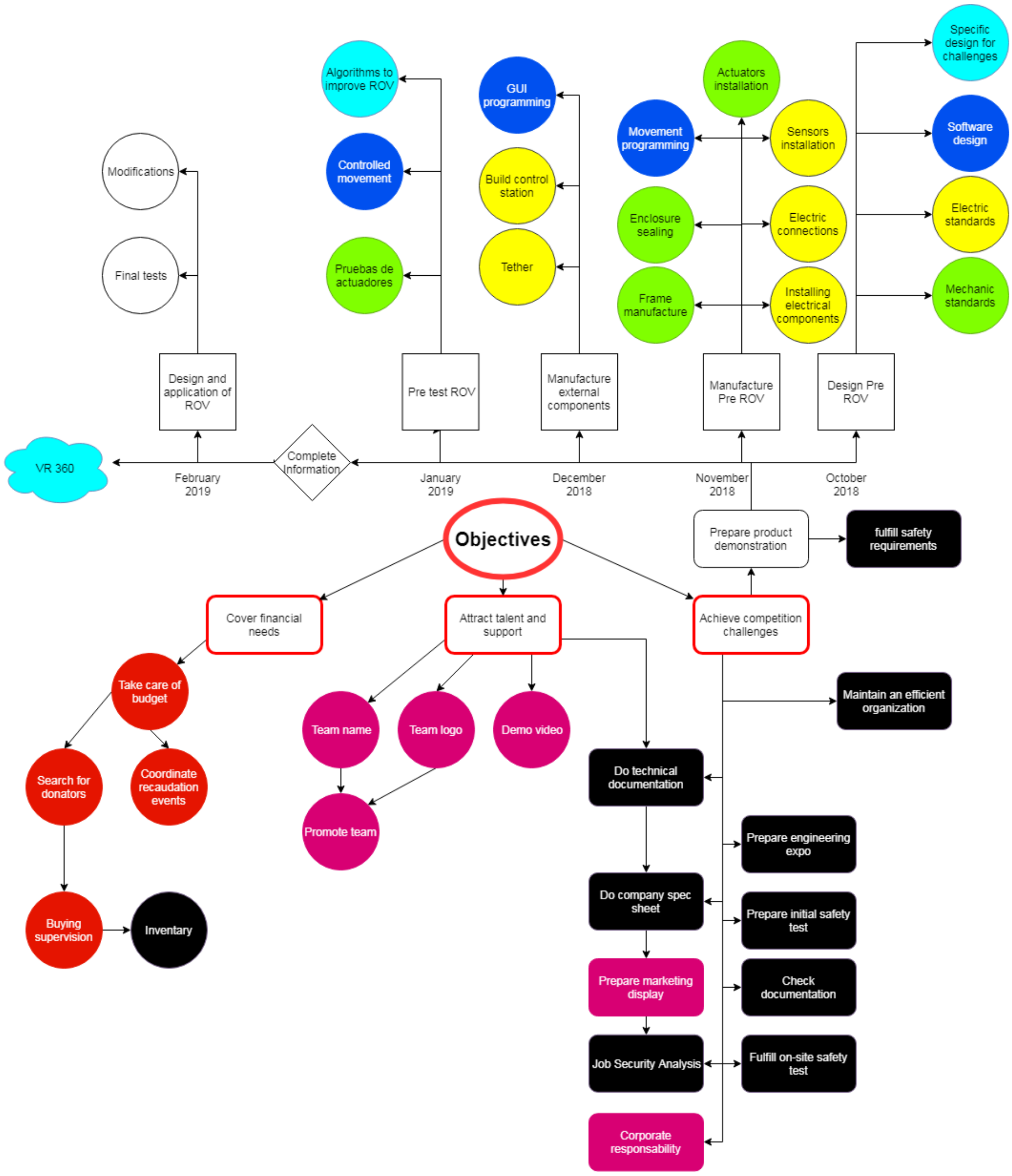
B. SID

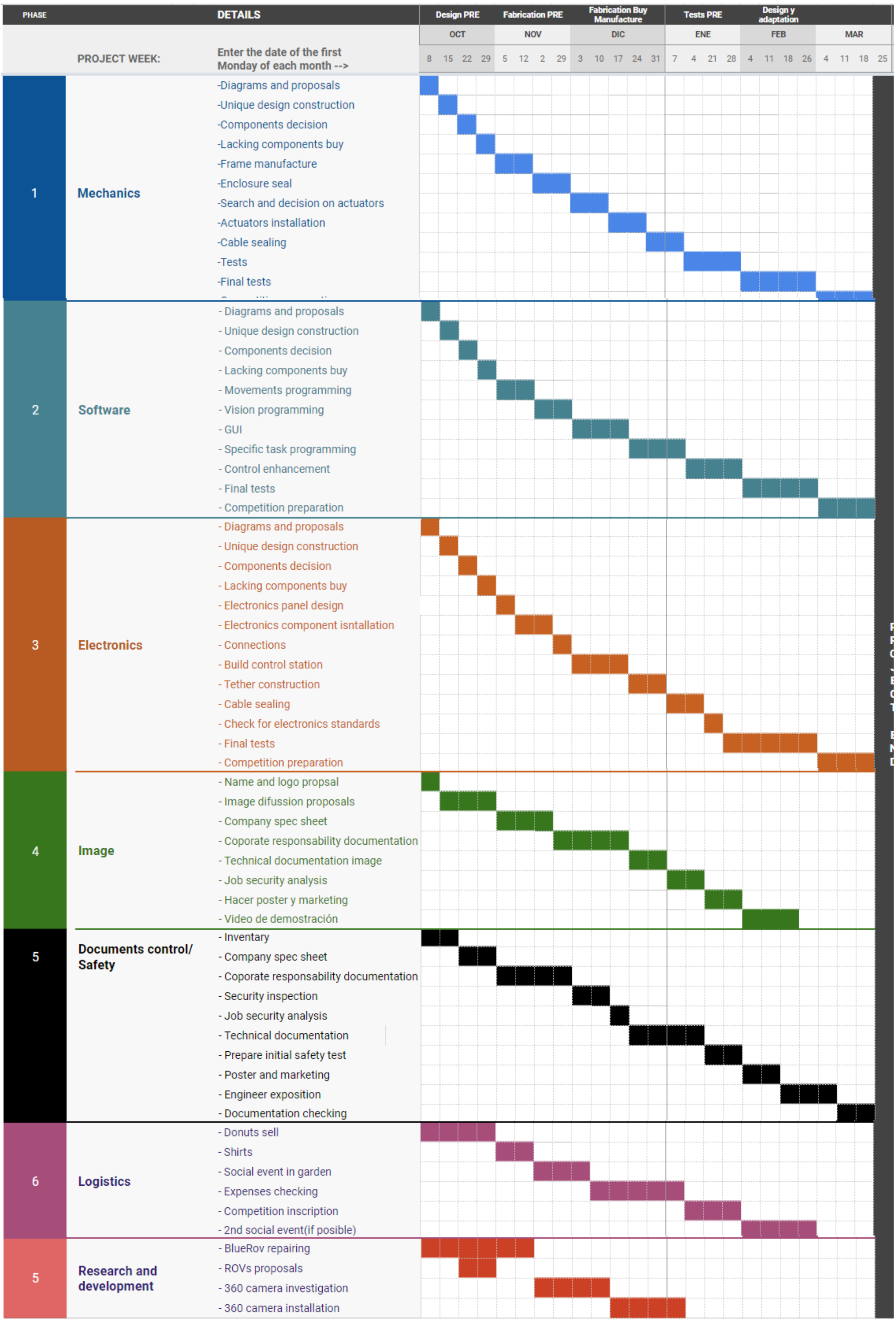

SID: Electrical
48VDC
GND
Control Station
120VAC
Monitor
HDMI
PC
USB
Joystick
Mouse
Keyboard
Ethernet
Fuse
30A
Thether
ROV
48V – 12V
30A
48V – 12V
30A
48V – 12V
3A
12V – 9V
2A
48V – 12V
3A
12 - 5V
2A
Ethernet
Switch
12 - 5V
3A
E
S
C
M
T100
Raspberry
Pi 3
2 channel
relay
module
pH
sensor
module
Metal
detector
module
Pixhawk
Temp
Sensor
Servo
PCA9685
Legend
48V
12V
9V
5V
3.3V
GND
Ethernet
USB
PWM
Signal
120VAC
I²C
Overcurrent Protection Calculations
Object | Current (A) | #
Camera | 0.22 | 3
Raspberry PI | 1 | 2
Pixhawk | 0.5 | 3
PCA9685 | 0.01 | 1
Thruster | 11.25 | 8
uRov thruster | 6.25 | 3
Lights | 0.9 | 2
Lights uROV | 0.0667 | 2
pH module | 0.1 | 1
Servo | 2.48 | 5
Total MAX Power: 1118.35 W
Total MAX Current: 1118.35 W / 48 V = 23.30 A
23.30 * 150% = 34.95 A > 30 A
SEAFOX
INVENTIVE

C. Budget and project costing

Part description	Quantities	Source	Unit Cost	Total Cost
Tether				
Heat shrink 3/4 1 meter	5	steren	2.48	12.40
Ancor Marine Grade Duplex and Triplex Wire 100 ft	1	amazon	118.17	118.17
Cable UTP cat 5e 21m	1	steren	9.76	9.76
Plug RJ45 de 8 contactos CAT 5e, para cable redondo	2	steren	0.26	0.52
Anderson connector	2	lees electronic	12.00	24.00
Control station				
Thrusters				
Printing filament 3D PLA 1.75mm 1kg	2	amazon	22.29	44.58
T100 Thruster	8	bluerobotics	119.00	952.00
zip ties 100 pcs	1	autozone	8.00	8.00
Sealed enclosure				
M10 Cable Penetrator for 6mm Cable	17	bluerobotics	4.00	68.00
M10 Cable Penetrator for 8mm Cable	4	bluerobotics	5.00	20.00
Enclosure vent and plug	4	bluerobotics	8.00	32.00
Penetrator solid	12	bluerobotics	4.00	48.00
Cast Acrylic Tube – 11.75”, 298mm (8” Series)	1	bluerobotics	154.00	154.00
O-Ring Flange (8” Series)	2	bluerobotics	79.00	158.00
Aluminum End Cap (8” Series)	1	bluerobotics	38.00	38.00
Acrilicio 3/16 thick 12"x12"	4		13.99	55.96
JB Weld Marine Weld 20 min	4	autozone	7.76	31.04
Syringe 100 ml	10	farmacia	1.00	10.00
Acetone	11	farmacia	1.00	11.00
Silicone based lubricant	1	autozone	7.76	7.76
Electronics panel				
Voltage converter regulator DC/DC 48V DC descending DC 12V 30A 360W	1	amazon	42.34	42.34
DC 12V / 24V (8V ~ 40V) descending DC 5V 5A 25W	1	amazon	9.27	9.27
Connection Blocks	1	amazon	12.89	12.89
Screws and bolts to fix converters	6	tornillo gigante	0.80	4.80
U type terminal	96	steren	0.10	9.60
Screws, bolts and L's to fix electronics panel	4	tornillo gigante	1.20	4.80
Raspberry Pi Camera	1	amazon	22.99	22.99
Screws to fix camera of raspberry Pi	2	tornillo match	0.26	0.52
Raspberry Pi 3	2	steren	48.99	97.98
Screws to fix Raspberry Pi 3	10	tornillo match	0.26	2.60
Pixhawk PX4 Flight Controller Autopilot PIX 2.4.8 32	1	amazon	71.79	71.79
16 Channel PWM/Servo Driver IIC interface-PCA9685 for arduino or Raspberry	1	amazon	8.99	8.99
Screws to fix connection blocks	4	tornillo gigante	1.00	4.00
USB to micro USB cable	1	steren	6.99	6.99
180degree Fisheye Lens 1080p Wide Angle Pc Web USB Camera	1	amazon	45.00	45.00
Basic ESC	8	bluerobotics	25.00	200.00
Frame				
High density polyethylene 0.375" X 18" X 24" black	6	ebay	14.99	89.94
screws M3 X 12 mm 100 pcs	1	amazon	8.49	8.49
Resine crystal 1kg y catalyzer	1	e vidrio y resinas i	18.62	18.62
Screws to fix frame	20	tornillo gigante	0.39	7.80
Screws to fix clamps	8	tornillo gigante	0.31	2.48
Lights				
Lights	2	amazon	18.99	37.98
Load system				
ABS tube 3" 10 ft ced.30	1	proconsa	6.73	6.73
Power HD LW-20MG Waterproof High Torque Metal Gear Standard Digital Serv	6	amazon	26.99	161.94
ABS cap 3 inch	1	home depot	1.20	1.20
Sensors systems				
Celsius Fast-Response, ±0.1°C Temperature Sensor (I2C)	1	bluerobotics	56	56.00
microRov system				
Nylon bar 4 inch 2" length	1	juntas industriale	240	240.00
O-rings 1/4" 3" diameter	2	juntas industriale	48	96.00
Total				3,074.93

D. Tasks division diagram





E. Early Gantt diagram for different team areas