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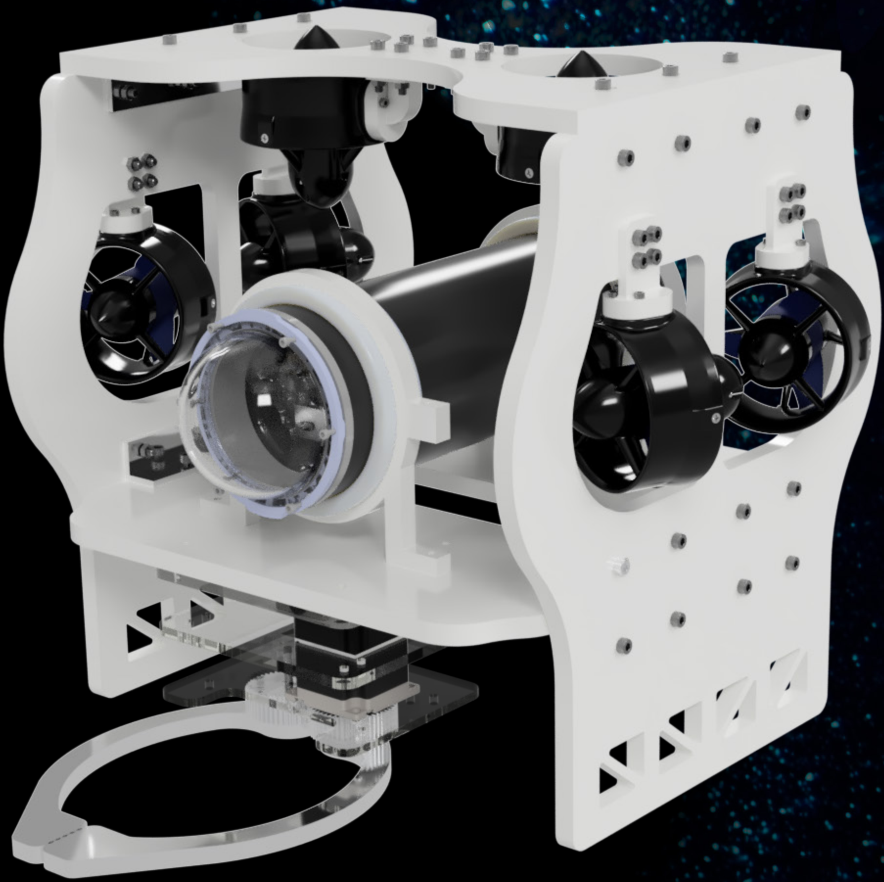
UTEC
UNIVERSIDAD DE INGENIERÍA Y TECNOLOGÍA

BOBELTO

TECHNICAL REPORT

MATE ROV COMPETITION 2022

BLUME TEAM



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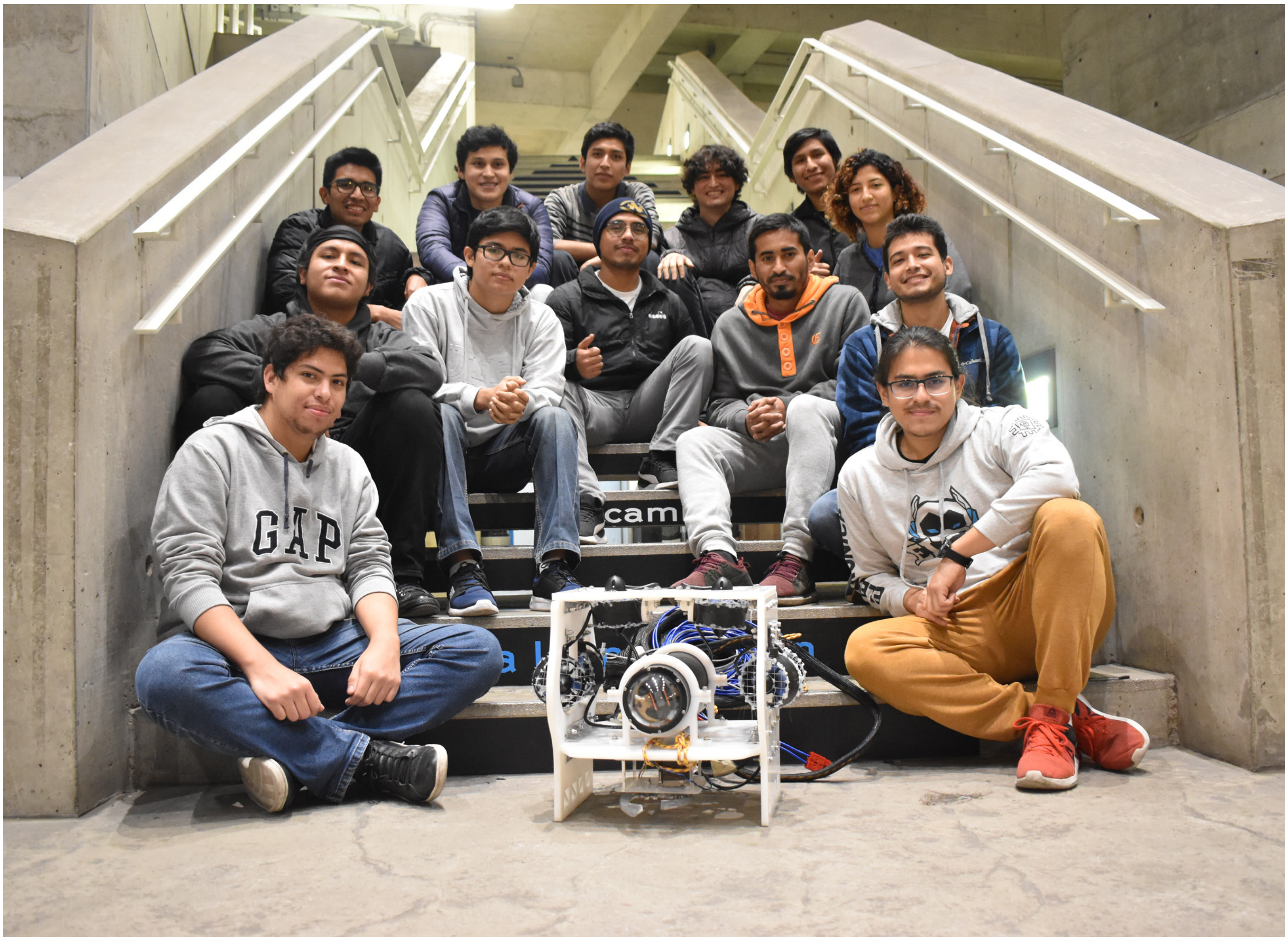
I. ABSTRACT

Blume Team is the first peruvian company to participate in the MATE ROV Competition. It is a multi-disciplinary team of 35 students from different engineering careers, with the vision of protecting and digitalizing water bodies. In this opportunity engineering and operations areas are aiming to tackle the nowadays climate problematics with the invention of an efficient and reliable remotely operated robot - ROV.

Bobelto is the first submarine robot created by this company. Its mechanical, electrical and software structures make this robot upgradable and adaptable to any environment. In order to design, refine and build Bobelto, the engineering team has strongly endeavoured a year and a half to create a robust and optimised version. It is capable of grip, transport and manipulates objects of different sizes, recognise the dimensions and mort fish, navigate more than 10 meters of depth, and much more. This document illustrates the design, iterations and development process of this ROV, mentioning detailed information about its components, as well as learnt lessons and gained experience of each team leader. Also, a description of the company Blume Team, as well as its workspace and workflow, is explained.



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II. DESIGN RATIONALE

i. Design evolution

Blume Team has dedicated a year and a half to the design and construction of BOBELTO. The characteristics of the ROV respond to the challenges established by the MATE ROV, as well as having the environment for its use in subsequent oceanographic investigations and more activities. The first prototype of BOBELTO was made focusing on the use of PVC tubes in order to integrate motors and check their correct control of them. From the beginning, it was expected to use a PlayStation controller. Once the correct operation of the motors and electronic components was registered, the implementation of the mechanical design was continued in the first version of Bobelto, which was developed in CAD with the use of HDPE with a thickness of 12 mm. The housing was thought to be a 6" acrylic tube; however, the mechanical department replaced it with a 4" aluminum tube, since the electric components were reduced and higher depths were planned to be reached.

On the other hand, the gripper has suffered multiple changes in its quantity and design. In the beginning, 2 grippers were planned to use, but for cost simplification and better stability of the structure (both had different weights), only one was used. The design was improving in function of the motor and the force needed, as well as the dimensions of the objects from the tasks. In this way, the model that is presented in the competition has been reached, which also has space to place more objects in the same ROV for future challenges.

ii. Mechanical design rationale

a. Mechanical overview

The main objective of the mechanical department was to design all the components according to the competition requirements. It was taken into account a pressure for a depth of 10 meters and an expected speed up to 2 m/s. For this, two main factors were highlighted: materials with a high cost/benefit value and facility in manufacture with high precision. That is why the 2 materials that are easy to obtain in Peru were selected: thermoplastic polymers and aluminum. These allow rapid manufacturing and prevent corrosion. In addition, these materials have relatively low densities, being the polymer similar to the water and aluminum 2.7 times more. By having a reduction in buoyancy force and a similar weight between both materials, the least possible energy can be deployed. Even more, it was sought to reduce the drag and lift force as much as possible.

b. Frame

The design of the frame sought not only to support the parts used in the ROV, such as the enclosure, the propellers and the gripper, but also to have the ability to float in the water, allowing in turn to incorporate floats that help reduce weight. In addition, to minimize the power used by thrusters, the aim is to have the lowest possible drag and lift coefficients, that means lower resistance and therefore lower power consumption in the turbines.

It is for these reasons that the HDPE material was chosen, which is a material with a low density and allows large dimensions that do not obstruct the flow obtained. This has a positive buoyancy force, which, with the inclusion of floats, allows maximum buoyancy and minimum use of vertical thrusters. Dimensions of 380 x 400 x 600 mm are defined based on 4 walls that support the components of the ROV, seeking a free flow in the propellers without obstructing their passage and allowing their energy efficiency to be greatly increased. Its design was made to withstand the pressure of 10 meters without breaking or deforming, taking a high safety factor. For the manufacture, a cut was made by CNC machining, which allows obtaining the corresponding dimensions and the remaining holes in a precise way.

Figure 1: Bobelto frame

c. Enclosures & sealing

For the enclosure, it was planned to use a geometric shape that generates the least possible resistance and has the greatest volume. Due to this, a cylinder with a dome was selected, which would reduce the drag force and effectively distribute the speeds above and below the enclosure. For its material, it was defined that PMMA acrylic would be used since it has important resistance properties, is profitable, and allows the corresponding transparency for the camera.

The thicknesses selected, based on the calculations of cylinders and hemispheres by pressure, indicate that 3 mm is required for 10 m. Manufacturing these measurements is very difficult because the acrylic would show very fragile areas that would affect it. If it was increased to 7 mm, the manufacturing cost would be much higher. Moreover, in Peru, the cylinders were glued on one edge, something that could affect the limit pressure. Also, the dome factory does not exist and making one was unfeasible since a mold was needed to make them.

For all these reasons, the 4" acrylic dome and aluminum cylinder from BlueRobotics were bought, which came out cheaper and allowed submersion to a depth of 400 meters. The acrylic dome is 12mm and the aluminum barrel is 5mm. This cylinder allows maximizing heat transfer, since, unlike acrylic, aluminum is one of the materials with the highest thermal conductivity. In order to take full advantage of this factor, it was sought to elevate the electronic systems and maximize heat transfer.

d. Thrusters

The objective was to have an average forward speed of 2 m/s. According to technical specifications and the cost-benefit of different thrusters, it was decided to select the BlueRobotics T200. It can generate a force up to 6 kg-f, capable enough to be able to move the ROV at expected speeds. In order to maximize this power output, a 20° pitch configuration was used on the horizontal turbines. This angle allows Bobelto to make turns and not lose too much power to forces generated in directions other than forward. This minimizes consumption per advance and generates greater efficiency in it.

In addition to the 4 turbines for advancement, there are 2 turbines for ascending and descending. Thanks to its parity, it allows stability in movements and the number of thrusters used is reduced to the maximum. Better visualization of the thrusters is in figure 2.

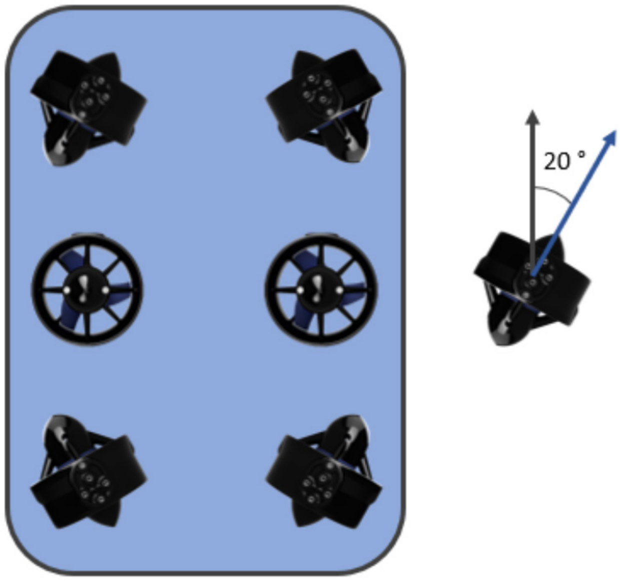

Figure 2: Thrusters distribution

e. Buoyancy

In order to minimize consumption of power, a lightweight was also aimed, being almost entirely compensated by the force of the water (Buoyancy). For this, light pieces with densities of up to 2700 kg/m3 were taken into account, seeking to execute the least possible force by the vertical and horizontal thrusters. The Buoyancy was evaluated based on the most important parts of the ROV: the enclosure, the thrusters, the gripper, and the frame.

Within them, you can see that the enclosure is the heaviest piece of all, which contains the electric components. The thrusters and the gripper, due to their low volume, generate a negative Buoyancy. This is compensated by the frame, which, through a light material, a design with material optimization, and the addition of floats, allows to counteract the effects generated by the other parts. This is specified in the following table:

Buoyancy calculation	Mass (kg)	Volume (L)	Buoyancy(N)
Enclosure	2.41	3.25	8.24
Frame	3.74	5.58	17.92
Gripper	2.43	0.65	-17.54
Thrusters	2.21	1.24	-9.51
Miscellaneous	0.37	0.05	-3.15
Theter	3.14	3.53	3.77
Total	14.30	14.30	-0.27

Table 1: Buoyancy for ROV

f. Gripper design

Being able to manipulate certain objects underwater is required, so 1 gripper was the best option to accomplish these tasks. The most important feature of the design and mechanism was the size of the objects. By varying the diameter between 5 and 180mm, the gripper design team decided to have two grip zones. If the gripper manipulates everything at one point, overstress would appear on the smaller pieces and break them - or even the gripper itself. To achieve this design, it was decided to use a system with two gears connected to the bars. As shown in figure 3, large objects will be grabbed by the inner part and small objects by the end part. The actuator in charge of making this gripper work is a Nema 23 Stepper, which has enough torque (maximum torque of 3.2 Nm) to move the mechanism and hold the indicated parts.

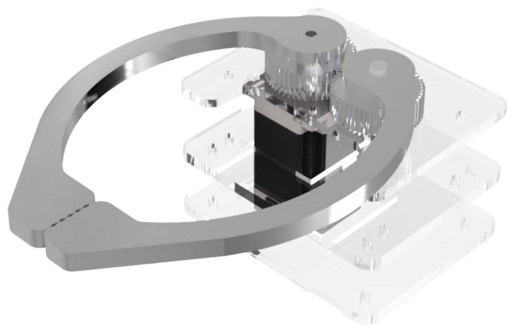

Figure 3: Gripper design

iii. Electrical design rationale

a. Electrical overview

The development of the electronic system of Bobelto has been carried out for a year and a half, considering varieties of microcontrollers (ATmegas, PIC, STM32, among others) and computers (Raspberry Pi, Jetson, Beaglebone, among others). Finally, the electronics department reached a more compact and efficient design for lower power consumption and better use of processing on the main computer, taking away some loads such as multiple PWM and data processing obtained from the sensors. This entire system is capable of being powered from 24 V to 48 V, with a maximum current consumption of 27 A.

b. Topside Control Unit

The ROV computer will be connected to a router via UTP protocol through an ethernet cable. The router's DHCP protocol is configured to accept two devices, the ROV and the surface control computer. The PC-Router connection can be wired, with Ethernet, or wireless, with

WiFi. In this case, ethernet will be used for faster data transfer. The control computer will be able to visualize the obtained data and control the robot through a ROS-based HMI (it will be explained in more detail in the software section). In addition, the computer will be receiving data from a dualshock4 controller and the commands will be as follows:

- **Left Joystick:** will move the robot on its Z-axis up and down.
- **Right Joystick:** will move the robot in the XY plane forwards and backward and rotate around the Z-axis for orientation change.
- **R2 trigger:** being analogous, it will be the one that controls the closing and opening of the gripper with precision.
- **L1 Button:** for better security of movement, rotation about the Z-axis with the right stick will be locked until the L1 button is held down.

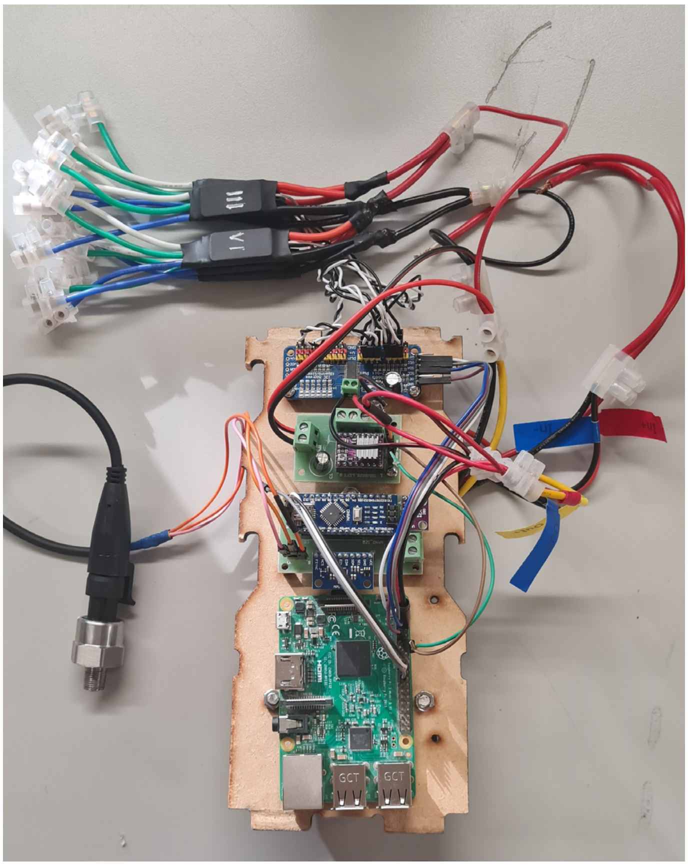

Figure 4: Bobelto circuit

In the power supply zone, there is the fuse holder, within 30 cm from the Anderson Powerpole connector. The fuse we choose is for 30 Ampere, as we can se in the appendix A were we calculated the current and power consumption.

c. Onboard electronics

Inside the robot we have a complex system of control with sensors and actuators reading. For an exact description, this section will be divided by its main components: Raspberry Pi 3b+, ATmega328p, sensors, and actuators with their drivers. Appendix B shows the SID of all the ROV.

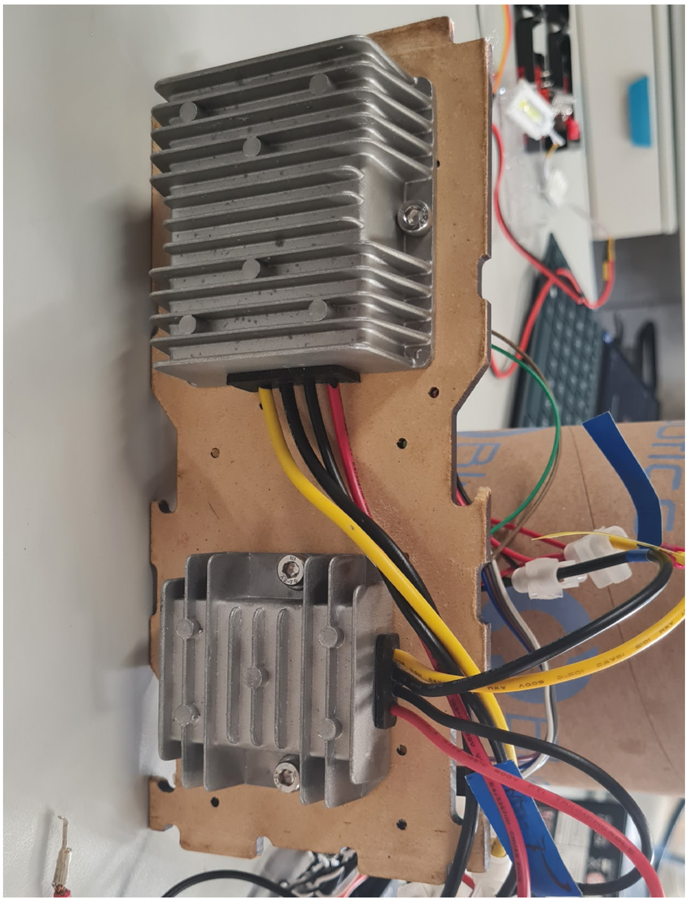

Figure 5: DC-DC converters

We start with the main computer: a Raspberry Pi 3b. It has Ubiquity operating system installed, which has ROS and uses the UTP protocol to communicate with the computer on the surface; the SPI protocol, to communicate with the ATmega328p instantiated in an Arduino NANO module; and the I2C protocol, to communicate with the PCA9685 module. In addition, it is directly connected to the DVR8825 unit for control of the gripper stepper motor.

The ATmega328p is programmed in C through MicrochipStudio. This has an SPI protocol, for communication with the Raspberry Pi; an I2C protocol, for the communication of the MPU9265 and BMP280 sensors; and the ADC, for reading the analog sensor HK3022. The microcontroller is configured to use interruptions by SPI reception for an immediate response.

The sensors are MPU9265, an IMU with a magnetometer to recognize the orientation of the robot; BMP280, to read the temperature and internal pressure of the robot in order to know the state of the inner environment; and the HK3022, used to read the external pressure so that the depth of the ROV can be recognized.

The actuators are six T200, for the movement of the robot in the space; a PAP motor, for gripper control; and LED lights, for underwater lighting. The PCA9685 module is a PWM generator that offers 16 signal output channels. With this, we will control the movement of Bobelto through the six T200 brushless motors. Actuators will be discussed in more detail in the mechanics section. As said before, the robot can be powered from 24 V to 48 V. Inside, it has two DC-DC converters for two parts: one is from up to 48 V to 12 V, for the actuator's power supply; and other from up to 48 V to 5 V, for the sensors, microcontrollers and drivers power supply.

d. Tether system

Bobelto Tether consists of two power cables, an ethernet cable, and a cord. The power cables model is THW 10 AWG, one is used for 24 Volts and the other for GND; the ethernet cable is a category 6; and the cord is nylon, capable of supporting up to 50 kg. The tether is 20 meters long and is surrounded by a braided mesh Cable Sleeve. The Strain Relief in the ROV consists of a cord with a stainless steel hook, linked with a plasticized metal wire tied to the chassis. While on the surface, the Strain Relief consists of the cord tied to a high weight fixed and static surface close to the control station.

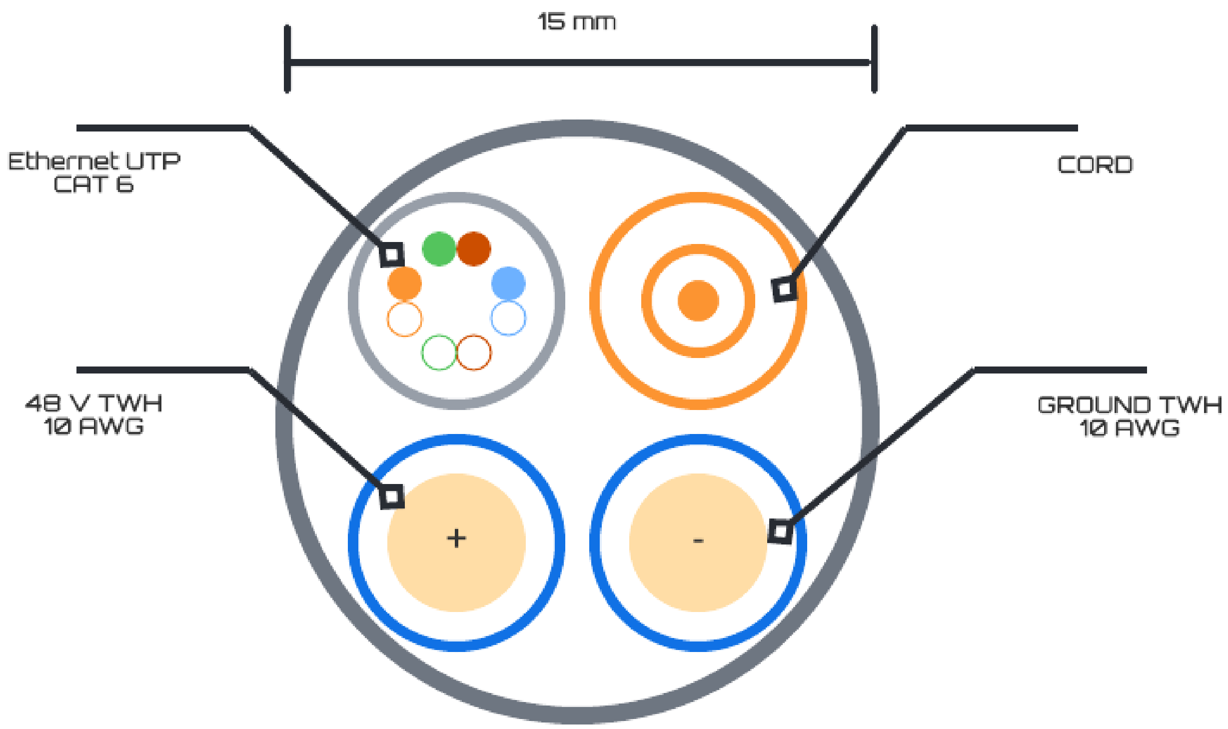

Figure 6: Bobelto Frontend

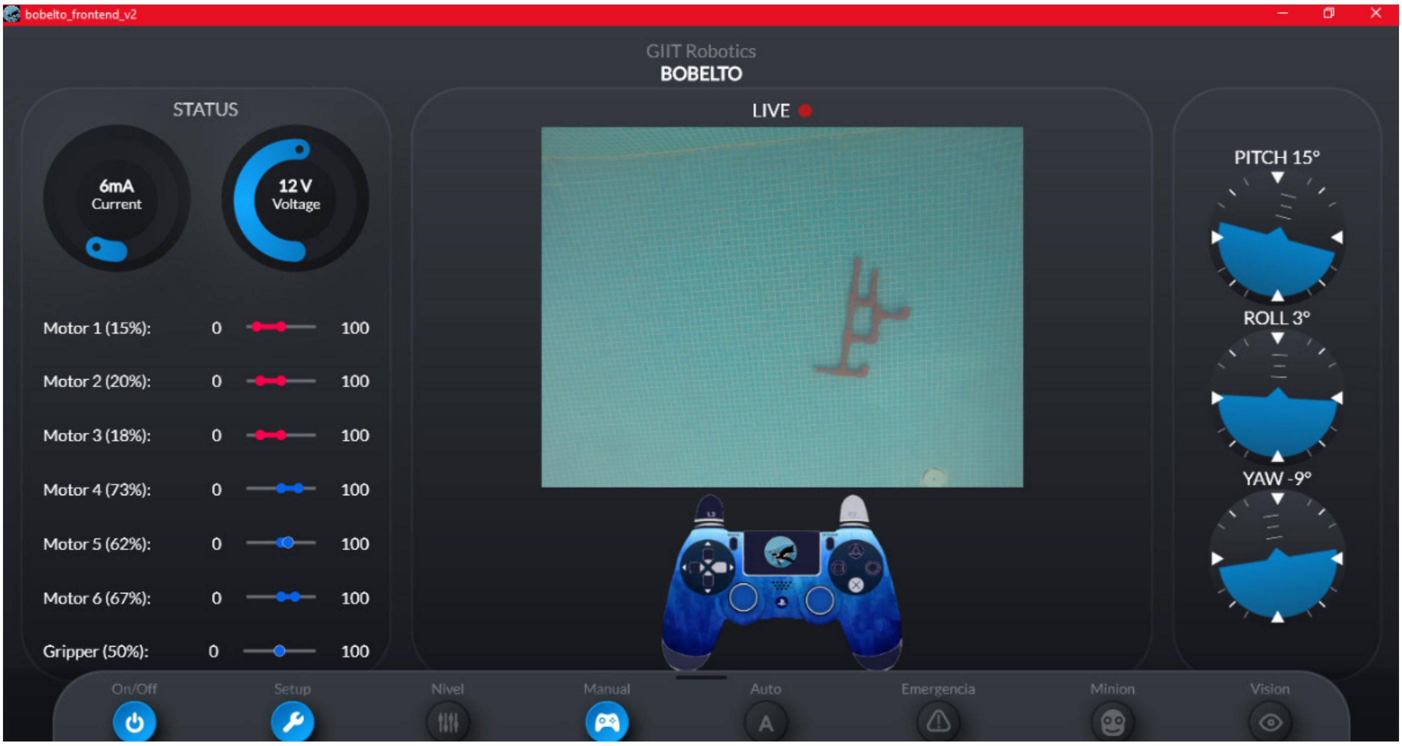

Figure 7: Bobelto Frontend

iv. Software design rationale

a. Software overview

This year's software department is responsible for making use of a ROS kinetic network that provides a unified core of functionality by integrating flutter dart connectivity for the frontend to the control and feedback measurements of the sensors, as well as ROS sub-modules. This contributes to the principles of modularity and flexibility by utilizing specified standard interfaces. Thanks to the efforts of the software department, it may create autonomous modules that integrate reliably into the overall system.

The Software system integrates the functions of command and control, ROV telemetry, digital imaging, image processing and computer vision, frontend displays, and managing input from keyboard and joysticks. The software consists of two primary subsystems: the frontend and graphical interface and the computer vision subsystem.

The front-end development was made based on Flutter and Dart, which focus on compatibility in a variety of platforms making robustness one of the main goals to achieve. The computer vision system focuses on image processing from the data matrixes extracted from the camera to adequately visualize the buoys, cables, and diverse objects in the pool and surrounding the ROV.

Giving a brief hardware overview and as was mentioned before, the image processing, computer vision, and receiver/sending information it is implemented in the laptop that the pilot will control the ROV.

b. Pilot interface

The HMI allows integrating the necessary components for reading the ROV's data into a laptop in a desktop application developed in the Software Development Kit (SDK), Flutter, based on Dart language. This SDK was chosen due to the improvement of the user experience thanks to the large number of libraries that facilitate it. In addition, with this SDK it is possible to launch the application for various operating systems. This, with the aim of giving flexibility and future scalability to the development of the project besides the competition.

The objective of this subsystem, beyond showing the data in real-time necessary for the correct monitoring of the ROV, was to provide a modular and modern approach to the design and distribution of data, with the purpose that its reading was orderly and interactive. Among the data to be displayed is the image received by the camera, the current and voltage received, the orientation of the ROV, veloity of the motors, etc. In addition, the HMI allows the user to select between various modes of operation of the robot.

The source code of the application manages to communicate with them through sockets and a local host on the Raspberry Pi inside the ROV. On the other hand, the SDK allows a modular or independent rendering per element. In this way, an improvement in the performance of the application is achieved.

c. ROS

In order to communicate with Bobelto with the HMI, the Software department uses ROS (Robot Operating System). It is a framework that facilitates this task using a structure of nodes and topics for data transmission. Our communication system is simple and functional. We have two computers configured with a version of Linux that supports ROS Kinetic, as well as OpenCV libraries. The first computer is the raspberry pi 3B+, which is on board. This collects the data from the sensors, such as the camera, and sends the information to activate the actuators, in this case, the thrusters and the gripper motor. Camera data is sent and motion data is received by the raspberry from a laptop. This second computer reads the values from the control knob and sends them to the onboard computer.

d. Computer vision

The vision system is equipped with one stereo camera which is directly connected to the Raspberry by USB. The camera is an ebic stereo camera, with in-house manufactured parts for the support of it. It is housed in the aluminum enclosure from blue robotics. The field of view of the camera is not obstructed because it is located in the front of the ROV. In consequence, the dome acrylic cap allows the camera to view without any obstruction and makes a protective housing for the fluid outside the enclosure.

The application of stereo vision combined with open-source OpenCV libraries allows us to measure precisely the length dimension of the toy fish to then calculate the IBM of the animal. On the other hand, for the detection of morts fishes and life fishes on videos, is used machine learning for object detection.

All the processes were not embedded in the Raspberry because making the computation and inference processes inside the ROV is a huge limitation, that is why all the inference and measurements are made in the laptop on the surface.

iv. non-ROV

Floats need to submerge and emerge, and to do this is crucial to use the principle of buoyancy and change of density. For achieving this movement a float with dimensions of 15 x 86.5 cm being a cylinder. It has four supports on the lower part to stabilize alone as soon as it touches the ground. The mechanism used was based on the density principle. There are two chambers, one with water and the other with air. It was needed to have the exact relationship between buoyancy and weight forces. With this condition achieved, 6 syringes were added to change the density, and also the relation between buoyancy and weight forces. To move the syringes, the mechanism shown figure 8 was used.

This mechanism consist on 6 syringe activated by one DC motor that transports power using a power screw that makes the movement. This DC motor is controlled by the battery and electronics stored in the air chamber. The separation between these two chambers is the plunger, that is sealed by o-rings all over the air chamber.

The Non-Rov Device electronic system consist in two parts: the surface control and the internal system. The surface control is a simple controller. Using an ATmega328p, a single digital pulse from a button is received and an interrupt is activated, were it communicates via UART Tx with a RF Emitter a message for a RF Receiver in the Non-ROV Device. This system power supply consist in the 5 V USB output from a laptop, so it could be near the control station.

The internal system of the Non-ROV Device is controlled by another ATmega328p connected to a RF Receiver via UART Rx, receiving a message from the surface controller. When a message is detected, it activates an algorithm controlling a DC Motor with the H-Bridge L298N. The internal system is powered by four AA batteries, making 6 V of alimentation to all components. It is used a 5 A fuse next to the stack of batteries for safety, the calculation can be found next to the Non-ROV SID (Appendix G).

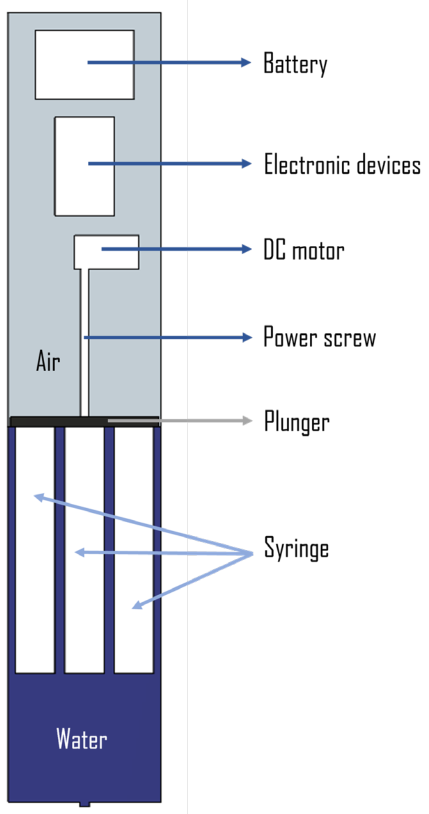

Figure 8: non-ROV mechanism

III. SAFETY

i. Safety Philosophy

Safety guidelines are a priority for Blume Team, each of the subareas and their members work committed to the guidelines published by MATE. In the company, all employees have internalized and ensured compliance with safety policies and the proper execution of work procedures. The work environments provided to each area have been in accordance with the provisions offered by the respective regulatory entities, in this case, the engineering laboratories inside UTEC, opting for remote work and virtual meetings when the situation merited it. Once the health situation was overcome, the company provided safe work areas capable of complying with health requirements such as social distancing and the use of a mask.

Figure 9: non-ROV structure

ii. Lab protocols

In order to safeguard the physical safety of each company employee, specialized laboratories inside the university are used. For most of them, in order to use these spaces, each member must have an authorization that they can acquire after completing a form in which their knowledge of the correct use of all the tools and processes that they can use will be evaluated. In addition, each member of the company must use the assigned personal protective equipment (PPE) at all times when working in the laboratory. The laboratories are properly equipped with all kinds of material that may be needed, each element in the laboratory is numbered and they have a manual and record of use. Ventilation in these spaces is regularized, allowing welding work on electronic material, among others, and minimizing the possibility of the spread of COVID-19. Since some equipment is dangerous to use, there is always an assistant in which all protocol is evaluated.

iii. Training

In the company, the training of new members is carried out through veteran members, who during a period of adaptation will act as guides and supervisors. After this period of time, the new employee must demonstrate mastery of the assigned tasks, which will allow him to work independently. When working in laboratories, all members will supervise each other to ensure compliance with safety protocols.

iv. Vehicle safety features

At Blume team security is fundamental, which is why security measures are implemented as an essential element in the development of Bobelto, and it ensures that it complies with the standards established by MATE. Through the BOBELTO construction process, the structure design is based on a friendly method to avoid sharp parts; in turn, we use blind threads to prevent dangerous situations with the decisive moments of the bolts. To comply with the IP-20 protection on the propellers, meshes are placed to prevent someone from being injured. In contrast, the operation of the propellers is being checked to prevent particles larger than 11.5 mm from entering the body of the propellers and harm. Our electronics team took preventive measures when assembling BOBELTO. They separated the GND cables from PCB (5V) and motors (12V) to avoid burning the motherboard. Also, they isolated screws from the circuits to prevent shorts. Finally, they connected a properly sized fuse (30 amp) within 30 cm of the Anderson Power-pole connectors which blows and cuts power to the ROV in the event of excess current. Epoxy glues and viscous glues seal all the electronic components, keeping them dry and protecting the ROV and personnel from dangerous situations since this type of glue generates a solid surface that does not break when pulling the cables.

v. Operational and safety checklist

Blume team is awared of any possibly accident around any enviroment in which the members are working. In order to maintain any place safe, as well as ensure all security equipment if needed, an operational and safety checklist is created. See appendix C.

IV. LOGISTICS

i. Company organisation and workspace

Blume team is a business organization with a flat structure. It is made up of a team leader and four main departments: Operations, Mechanical Design, Electronics, and Software. For each department, there is an area manager to whom the team members must periodically present the progress of the assigned tasks (Figure 10). This makes meetings more efficient when showing the progress of the different areas in front of the organization's team leader. In these meetings, the leaders together with the team leader will determine if the progress between areas is synchronized and if it meets the objectives set in the development of BOBELTO.

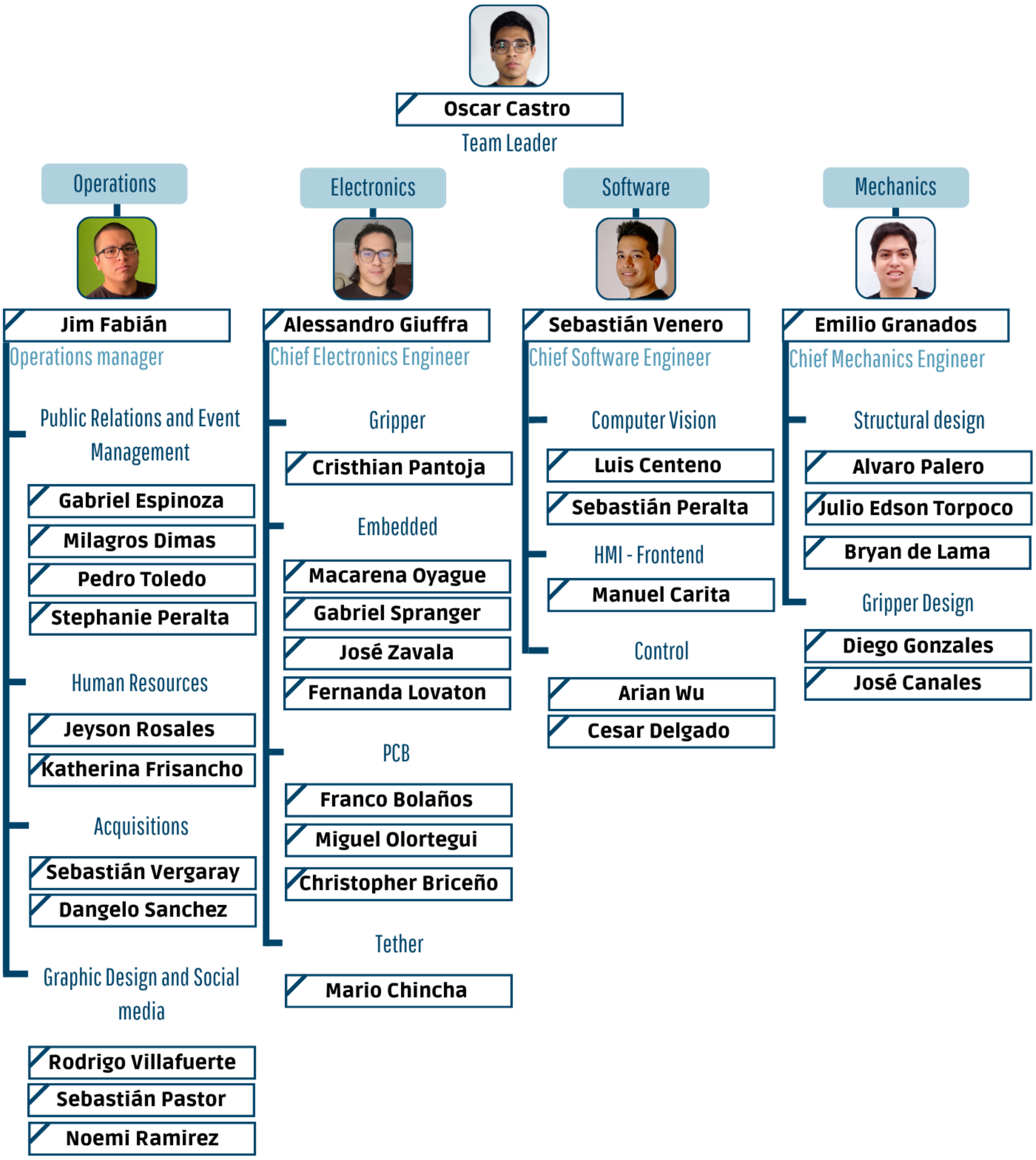

Figure 10: Blume Team organisation

Team Leader
Oscar Castro, 5th Year Mechatronics Engineering with mention in robotics, with 2 years in Blume Team.
Operations manager
Jim Fabián, 4th Year Mechatronics Engineering with mention in robotics, with 2 years in Blume Team.
Chief Electronics Engineer
Alessandro Giuffra, 5th Year Electronics Engineering student, with mention in digital and computing systems, passionate for embedded systems, 2 years in Blume Team.
Chief Software Engineer
Sebastian Venero, 5th Year Mechatronics Engineering with mention in robotics, with 1 year's experience in image processing techniques and ML for computer vision, 2 years in Blume Team.
Chief Mechanic Engineer
Emilio Granados, 5th Year Mechanic Engineer with mention un Fluid Dynamics analysis, 2 years in Blume Team

ii. Project management

For Blume Team, management and communication in its four departments is essential and key to the development of Bobelto. The Mechanical, Electronic, and Software Design departments maintain constant collaborative work and contact the Operations area to coordinate the acquisition of parts and equipment. Weekly, the heads of each area meet with their members to review the pending tasks and assign new ones that must be carried out within established deadlines. In addition, the heads of each department meet with the Team Leader every 2 weeks to report the progress they have made up to that time. In case a department needs more personnel to carry out complex tasks, interdepartmental teams are created that promote teamwork between employees from different departments. Appendix D shows the Gantt chart that represents each phase of the development of the entire project.

iii. Budget and project costing

Blume Team is participating in MATE ROV for the first time, being Bobelto the first ROV the company has ever created. Due to this, part of the budget table was created approximating the costs of certain components mapped from past teams ROVs that participated in previous MATE ROV editions. Apart from that, the travel expenses were also varying, since it was uncertain the number of members that will be in the competition. With the enormous effort of each engineering department, as well as the acquisitions department, the project costing table was not too far from the Budget. In appendix E and F both tables are shown.

V. CONCLUSIONS

i. Challenges

Main challenge Blume Team had developing Bobelto was the leak of components in Peru. In the last years, Bobelto is the second ROV built by a Peruvian team, and the first one to participate in the MATE ROV Competition. There is a lack of access to IP68 components, for example, which made the company to import lots of them, such as the T200 Thrusters, DC-DC converters, Anderson Powerpole connectors, among others.

ii. Lessons learned and skills gained

The previous year, the Operations Area was included, which empowers the team at many levels. The human resources team helped with the recruitment of more members. Also, the acquisitions area allowed us to establish contacts with companies interested in our project and thus get our first sponsors. On the other hand, the team learned that it was necessary to plan purchases in advance and have a backup plan in case these purchases were not made on the established dates. In this way, it is possible to take measures to resolve unforeseen events and thus return to planning without having to alter it. Finally, one of the new values learned by the team is to be honest with the members, to tell the members what is expected of them, and if the way they perform is correct.

The Electronic Department learned about losing fear in testing. They usually don't work with projects in an aquatic environment, so they feared some water could filter and ruin months of effort until the chief mechanics engineer came and said to trust.

iii. Future improvements

Mechanical design is developing a new frame with the goal of enclosing the electronic components in a wing form, helping with less drag and lift coefficient than in the actual design. Apart from that, penetrators must be changed in order to use less glue and still not let water pass through. Finally, have control of the thruster's angle, so all power can be transmitted into movement and not be lost in other directions.

For the electronic control system, the electronic department is configuring, at the moment, FPGA with soft-core processors to optimize the processing speed, reduce space and power consumption, and analyze using the robot in the Peruvian highlands, where non-ionizing radiation can affect electronic devices and produce transitory failures.

iv. Acknowledgements

Carrying out a project on submarine robotics in Peru have been financially difficult. For several months the acquisitions department tried to make contacts with different companies and finance entities. As a result, DyR LEAM, UTEC university, and the mechatronics engineer career made donations, Lima garage lab is our sponsor, and the IBM academy competition was won thanks to IBM aid. We are immensely grateful for all their support. Due to them and the whole team, Bobelto became real.

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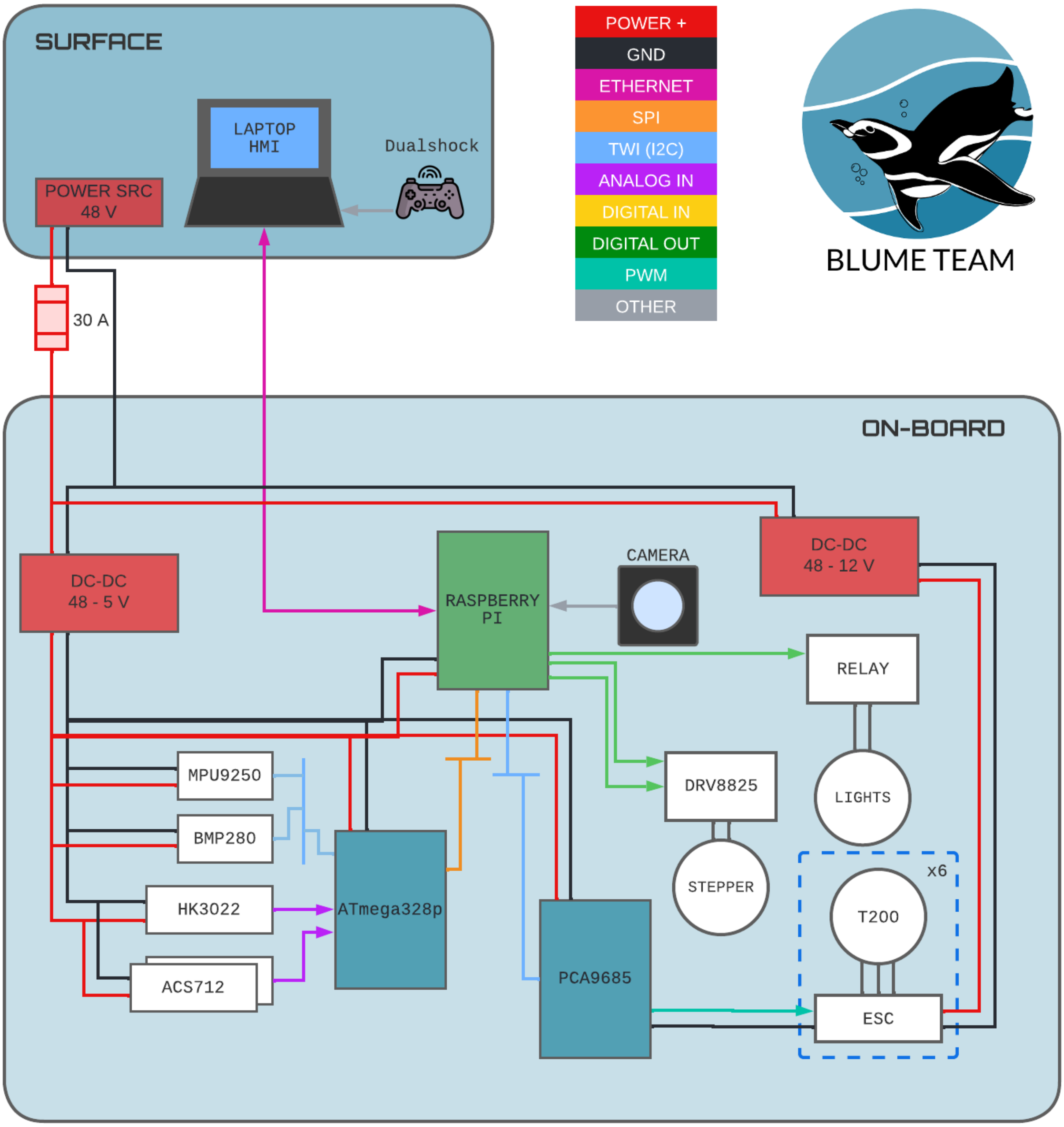
VII. APPENDIX

APPENDIX A

Current consumption

N°	Component	Voltage (VDC)	Current (A)	Power (W)	Units	Total current (A)	Total power (W)
1	Raspberry Pi 4 + Camera	5	3	15	1	3	15
2	Arduino Nano	5	0,019	0,095	1	0,019	0,095
3	T200 Thruster / ESC	12	2	24	6	12	144
4	MPU9265	5	0,039	0,195	1	0,039	0,195
5	BMP280	5	0,027	0,135	1	0,027	0,135
6	HK3022	5	0,01	0,05	1	0,01	0,05
7	Stepper motor + DVR8825	12	1,8	21,6	1	1,8	21,6
8	LED Lights	12	1,8	21,6	1	1,8	21,6
				Total		18,70	202,68
				Fuse calculation		28,0425	

APPENDIX B
ROV SID



APPENDIX C

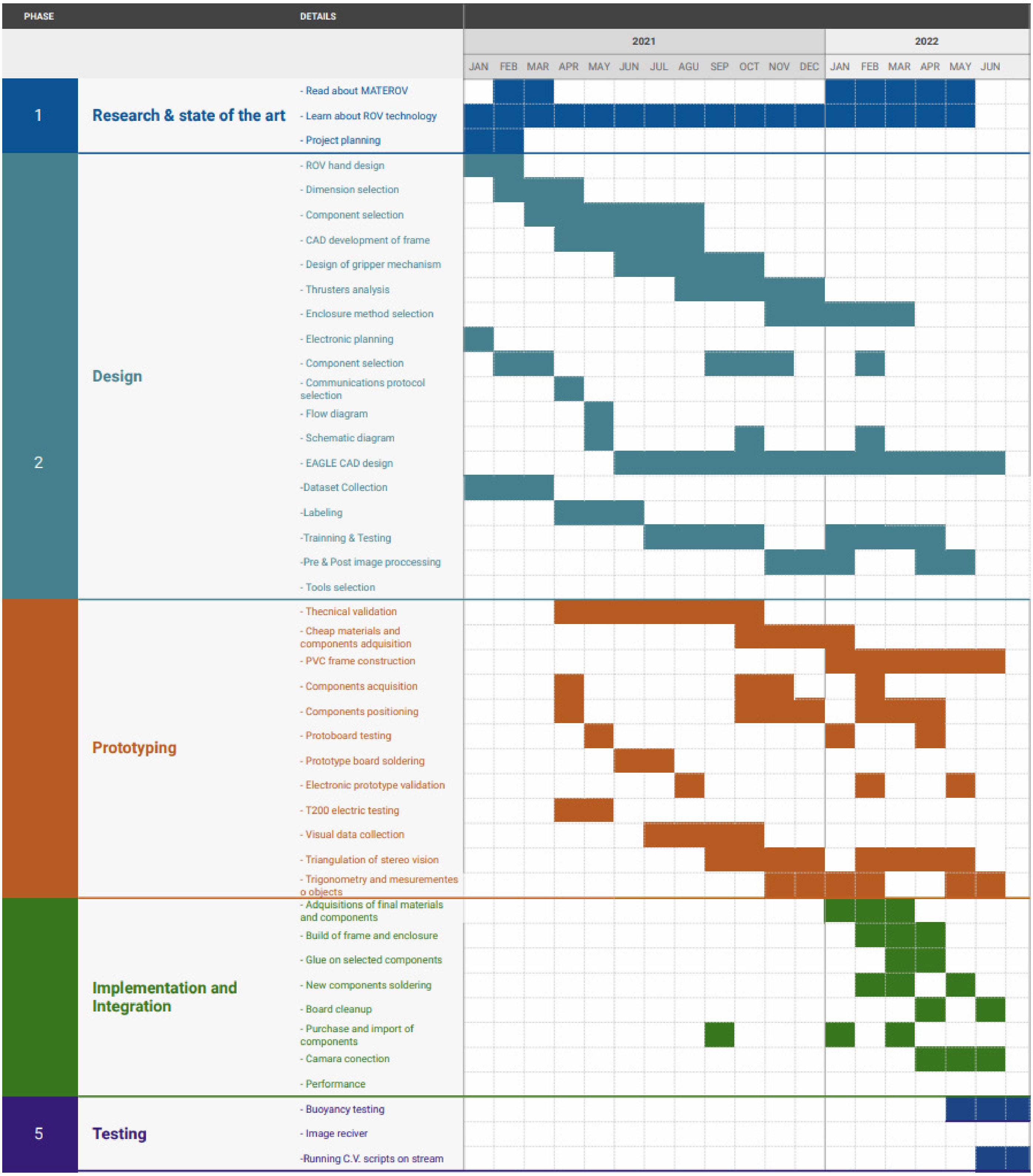
Operational and safety checklist

PROCEDURE	Checkbox
Pre-ignition checks	
Verify that there are only designated crew members on deck.	
Verify that crew members are using PPE's	
Verify that the area is clear and safe.	
Verify that the power supply is disconnected before performing security checks.	
Check that the fuse (30 amp) is not burned.	
Verify that the propellers are free of obstructions.	
The cables are secured, and the electrical connections begin to be sealed.	
Check that the nuts are tight in electronic housing.	
Pre-irrigation checks	
Connect the power supply to the control station and turn on the system.	
Verify that the camera system is working properly	
Verify that the internal pressure is correct for immersion.	
Verify that qualified personnel are coming down to the ROV	
Water checks	
Turn on the system and check the warning lights.	
Check that the internal pressure is stable on the surface	
Recovery checks	
Verify that the ROV is on the surface.	
Qualified personnel for the correct extraction of the ROV to the surface	
Security Officer's Signatura:	

APPENDIX D

BLUME TEAM 2022 PROJECT TIMELINE

School name	Universidad de Ingeniería y Tecnología	**Company name**	Blume Team
Instructor	Ruth Canahuire	**Date**	26/05/2022



APPENDIX E

BLUME TEAM 2022 BUDGET

		Reporting period	
School name:	Universidad de Ingeniería y Tecnología	**From:**	**03/01/2022**
Instructor:	Ruth Canahuire	**To:**	**01/03/2022**

EXPENSES				
Category	Type	Description/Examples	Projected cost	Budgeted cost
Mechanics	Donated	PVC pipe (prototype and testing)	$30,00	$0,00
	Purchased	Screws and nuts	$90,00	$90,00
	Purchased	Structure	$600,00	$600,00
	Purchased	Gripper	$85,00	$85,00
	Purchased	Acrylic housing	$65,00	$65,00
	Purchased	Acrylic dome	$115,00	$115,00
	Purchased	Float	$119,73	$104,50
Electronics	Purchased	T200 turbines	$1.254,00	$1.254,00
	Purchased	LED lights 10W	$7,00	$7,00
	Purchased	Sensors	$40,00	$40,00
	Purchased	Electric Components	$30,00	$30,00
	Purchased	Voltage converter	$36,00	$36,00
	Purchased	Microcontrollers	$40,00	$40,00
	Purchased	Processing inner device	$100,00	$10,00
	Purchased	Gripper motor	$50,00	$50,00
	Purchased	Theter	$200,00	$200,00
Software	Donated	Ebic Webcam	$37,00	$0,00
	Purchased	Google Collab	$20,00	$20,00
	Purchased	Logitech Extreme 3D controller	$52,00	$52,00
	Purchased	OpenCV AI Kit	$130,00	$130,00
Travel	Purchased	Lodging	$900,00	$900,00
	Purchased	Transport	$200,00	$200,00
	Purchased	Travel insurance	$260,00	$260,00
	Purchased	Round trip, Lima - Los Angeles	$5.000,00	$5.000,00
General	Purchased	Material for video demonstration	$300,00	$300,00
		Total Income		$0,00
		Total Fundraising Needed		$9.588,50

APPENDIX F

BLUME TEAM 2022 Project costing

		Reporting period	
School name:	Universidad de Ingeniería y Tecnología	From:	01/03/2022
Instructor:	Ruth Canahuire	To:	23/05/2022

Category	Type	Product	Sources/Notes	Amount
Mechanics	Purchased	Acrylic gripper	Last version	$107,00
	Purchased	Electronic housing	From BlueRobotics	$330,00
	Purchased	Penetrators	From BlueRobotics	$192,00
	Purchased	HDPE frame	ROV structure	$538,00
	Purchased	Screws and nuts	M5, M4, from BlueRobotics	$100,00
	Purchased	Nylon cord	For protection	$14,00
	Purchased	Syringe	Float density change	$18,40
	Purchased	Flota Mechanism	Float movement	$21,33
	Purchased	Float frame	Float enclosure	$80,00
Electronics	Purchased	T200 turbines	6 for ROV	$1.254,00
	Purchased	LED lights	10W - 2	$7,00
	Purchased	BMP280	Inside housing	$4,00
	Purchased	HK3022	Inside housing	$26,00
	Purchased	MPU9265	Inside housing	$12,00
	Purchased	Power cable	THW 10AWG	$94,00
	Purchased	DRV8825	Inside housing	$6,00
	Purchased	Voltage converter	48-12 and 48-5 V	$36,00
	Purchased	PCA9685	Inside housing	$21,00
	Purchased	Arduino NANO	Inside housing	$35,00
	Purchased	Raspberry PI 3	Inside housing	$98,00
	Purchased	Stepper NEMA 23	For gripper	$30,00
	Purchased	Mesh wire	For tether	$65,00
	Purchased	Plastic coated metal wire	For tether	$6,00
	Purchased	DC Motor with gearbox	For Non-ROV Device	$4,00
	Purchased	H-Bridge L298N	For Non-ROV Device	$4,00
	Purchased	Arduino NANO	For Non-ROV Device	$21,00
	Purchased	RF Emitter/Receiver	For Non-ROV Device	$2,00
Software	Parts donated	Ebic Webcam	Inside housing	$25,00
	Parts donated	IBM cloud services	For comp. vision training	$0,00
General	Cash donated	Donated by DyR LESAM	Used for electrical components	$450,00
	Cash donated	Donated by CASAE	Used for ROV construction	$430,00
	Cash donated	Donated by University	Used for travel expenses	$1.000,00
	Cash donated	Donated by Engineering faculty	Used for inscription	$3.000,00
	Cash donated	Donated by members	Used for ROV components	$3.000,00
	Cash donated	Activities made by team	Used for travel expenses	$1.000,00
	Parts donated	Material for video demonstration	Task 1 and 2	$0,00
Travel	Purchased	Lodging	For 7 days (22/06 - 28/06)	$810,00
	Purchased	Transport	Across the city	$200,00
	Purchased	Travel insurance	For 6 members	$254,00
	Purchased	Round trip, Lima - Los Angeles	For 6 members (21/06 - 28/06)	$5.570,00
		Total raised		$8.880,00
		Total spent		$9.959,73
		Final Balance		$1.079,73

APPENDIX G
non-ROV SID