UMC Technical Report

SPECTRE

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Abstract

Rising from the Northwest of the United Kingdom, UMC came to answer the call of MATE ROV in eastern Tennessee, with its emerging product, Spectre. This product is the first member in UMC's research and development towards building the best possible ROV given the resources and time restriction. Spectre was fully developed in three months' time.

In this report, we will showcase our product and our company's involvement in its development. From management methods where the latest management and leadership skills were applied throughout the project timeline to the technical approaches of our product, Spectre was a result of homogenous team of engineers who dedicated their efforts in the mechanical field where the body was designed using CAD software to CNC, 3D printed different body parts, while our electrical team focused on building a reliable, sustainable electrical system to integrate into a functioning mechatronics package for Spectre. In parallel, our software engineers developed solutions for image processing. We are confident to showcase Spectre in the International MATE ROV competition.

Figure 1 - UMC ROV team. Counterclockwise starting at the top left: Walid, Shahir, Karakish, Shalaby, Dr. Ahmed, Karim, Aly, Amgad, Ahmed, Saeed.

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I. Company Overview

History being made…

Our company is a newborn start-up found in February 2019 by a group of engineers aiming to inspire the northwest of the UK. UMC seeks to dedicate entrepreneur students with all passion towards the maritime industry, where a full company structure that not only focuses on the engineering aspect, but towards an overall harmonic team to be able to create, invent, represent, and find an acceptable place in the ROV market. Which has the company high board approve the hierarchy shown below.

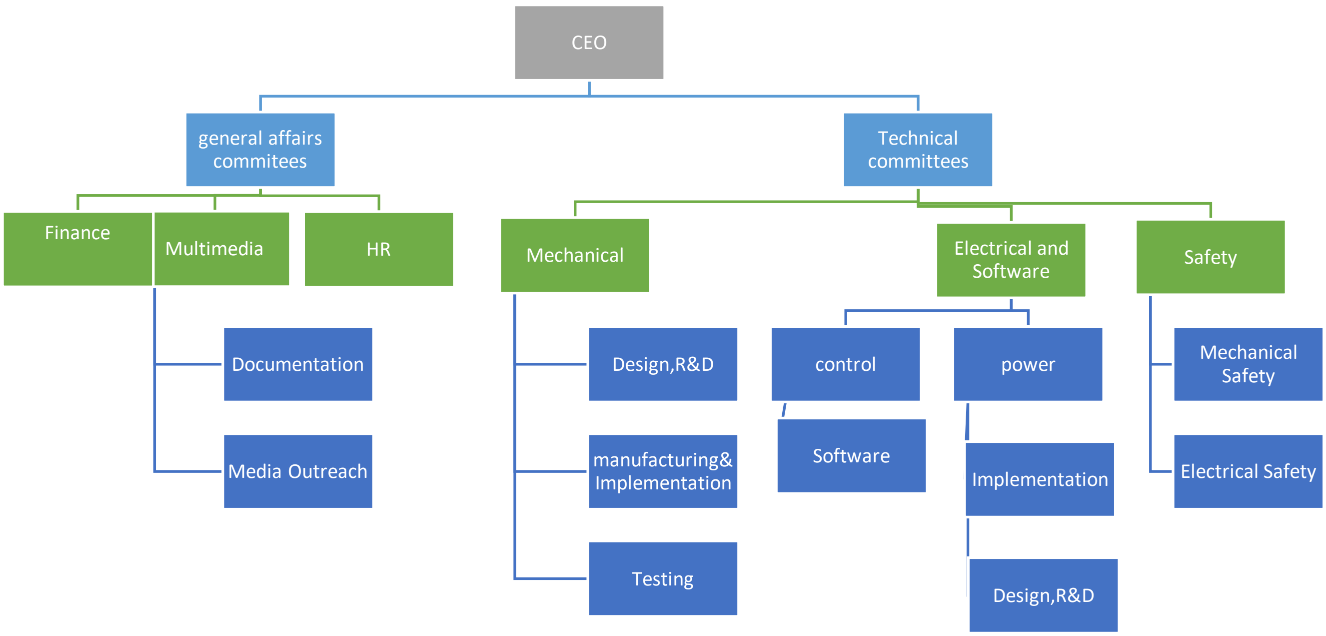
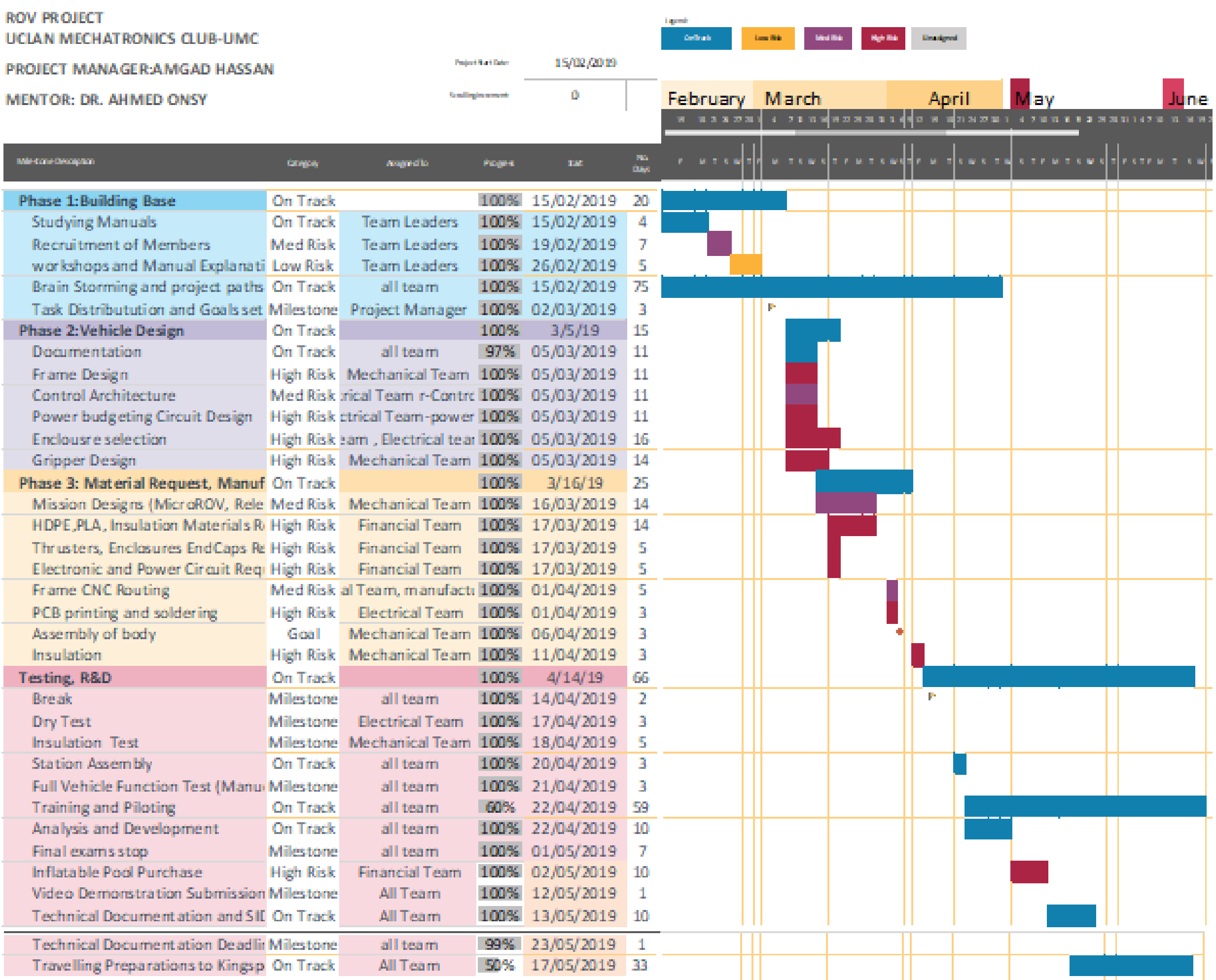


Figure 2 - company hierarchy

This hierarchy shows that our company is divided into two main sectors managed by the team's CEO. The first sector is the technical sector, which is considered to be in the design centre of the team which consists of both mechanical and electrical teams, each team consists of a leader and three team members. To save on labour and overcome human resources shortages, interviews and assessments were made by the high board to assign parallel jobs to team members in the general affairs sector which consists of the finance, multimedia & marketing, and HR sectors. This resulted in a team of nine multi-tasking members.

II. Project Management

In UMC, we believe that a successful project starts by an unwavering trust and a clear line of communication between all team members. By setting realistic short-term goals to keep team members goal oriented, and keeping track of the team's priorities, a timeline was laid out by experienced team members who competed in the MATE ROV competition previously. The following Gantt-chart shows the company's plan in detail.



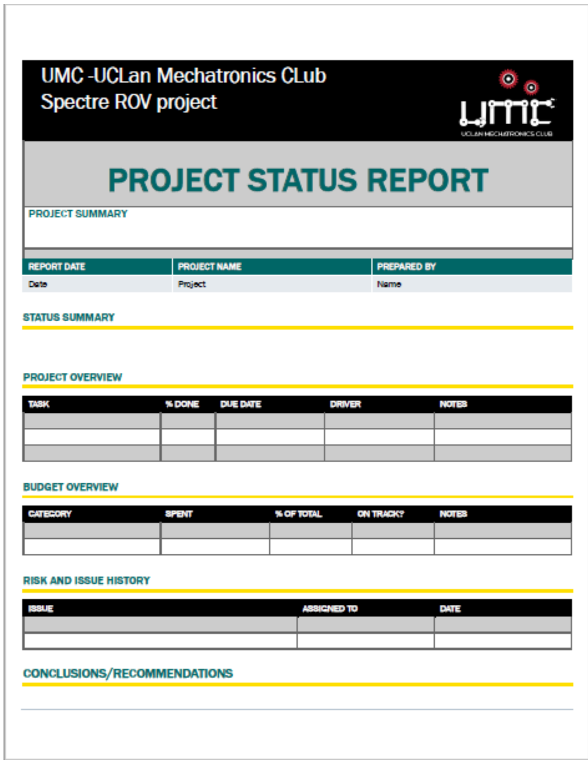
ROV PROJECT
UCLAN MECHATRONICS CLUB-UMC
PROJECT MANAGER:AMGAD HASSAN
MENTOR: DR. AHMED ONSY

Phase 1:Building Base	On Track		100%	15/02/2019	20
Studying Manuals	On Track	Team Leaders	100%	15/02/2019	4
Recruitment of Members	Med Risk	Team Leaders	100%	19/02/2019	7
workshops and Manual Explanati	Low Risk	Team Leaders	100%	26/02/2019	5
Brain Storming and project paths	On Track	all team	100%	15/02/2019	75
Task Distribututing and Goals set	Milestone	Project Manager	100%	02/03/2019	3
Phase 2:Vehicle Design	On Track		100%	3/5/19	15
Documentation	On Track	all team	97%	05/03/2019	11
Frame Design	High Risk	Mechanical Team	100%	05/03/2019	11
Control Architecture	Med Risk	rical Team r-Contr	100%	05/03/2019	11
Power budgeting Circuit Design	High Risk	ctrical Team-power	100%	05/03/2019	11
Enclousre selection	High Risk	eam , Electrical tea	100%	05/03/2019	16
Gripper Design	High Risk	Mechanical Team	100%	05/03/2019	14
Phase 3: Material Request, Manuf	On Track		100%	3/16/19	25
Mission Designs (MicroROV, Rele	Med Risk	Mechanical Team	100%	16/03/2019	14
HDPE,PLA, Insulation Materials R	High Risk	Financial Team	100%	17/03/2019	14
Thrusters, Enclosures EndCaps Re	High Risk	Financial Team	100%	17/03/2019	5
Electronic and Power Circuit Requ	High Risk	Financial Team	100%	17/03/2019	5
Frame CNC Routing	Med Risk	al Team, manufactu	100%	01/04/2019	5
PCB printing and soldering	High Risk	Electrical Team	100%	01/04/2019	3
Assembly of body	Goal	Mechanical Team	100%	06/04/2019	3
Insulation	High Risk	Mechanical Team	100%	11/04/2019	3
Testing, R&D	On Track		100%	4/14/19	66
Break	Milestone	all team	100%	14/04/2019	2
Dry Test	Milestone	Electrical Team	100%	17/04/2019	3
Insulation Test	Milestone	Mechanical Team	100%	18/04/2019	5
Station Assembly	On Track	all team	100%	20/04/2019	3
Full Vehicle Function Test (Manu	Milestone	all team	100%	21/04/2019	3
Training and Piloting	On Track	all team	60%	22/04/2019	59
Analysis and Development	On Track	all team	100%	22/04/2019	10
Final exams stop	Milestone	all team	100%	01/05/2019	7
Inflatable Pool Purchase	High Risk	Financial Team	100%	02/05/2019	10
Video Demonstration Submission	Milestone	All Team	100%	12/05/2019	1
Technical Documentation and SID	On Track	All Team	100%	13/05/2019	10
Technical Documentation Deadli	Milestone	all team	99%	23/05/2019	1
Travelling Preparations to Kingsp	On Track	All Team	50%	17/05/2019	33

Figure 3 - team's Gantt chart

While developing the project plan, we ensured the company's ROV Timeline that each member of the company has a specific responsibility that represents his/her strength. The design process was kickstarted by particular members who were experienced in the design and simulation of underwater vehicles. The testing and troubleshooting company carried out many trials and errors along with the whole project to validate our objectives.

In February 2019, prior to starting the practical actions to build the ROV, members with no previous experience in underwater vehicles were trained from scratch to participate in the competition. By the end of the training, and under the guidance of our company's experienced leaders, they began working within the team. The training helped them learn the process of building an ROV from scratch quickly. The mechanical team started by searching for improvements based on designs available in the market. Beginning by the thrusters, testing many prototypes took place before selecting the best model and desgin. Along the way, leaders and experienced members would offer their feedback to correct design flaws to avoid operational issues that might appear later in fabrication, especially for the mission-based designs.



UMC -UCLan Mechatronics CLub
Spectre ROV project

PROJECT STATUS REPORT

PROJECT SUMMARY

REPORT DATE	PROJECT NAME	PREPARED BY
Date	Project	Name

STATUS SUMMARY

PROJECT OVERVIEW

TASK	% DONE	DUE DATE	DRIVER	NOTES

BUDGET OVERVIEW

CATEGORY	SPENT	% OF TOTAL	ON TRACK?	NOTES

RISK AND ISSUE HISTORY

ISSUE	ASSIGNED TO	DATE

CONCLUSIONS/RECOMMENDATIONS

Figure 4 - project status report

Furthermore, after fabrication, it went through many modifications before finding the most efficient design. The electrical also had a from designing circuit boards, selecting components into manufacturing. However, before starting the fabrication phase, it must be approved from the electrical leader to avoid problems encountered among different companies. The design of the electrical system also has to satisfy the restrictions that the mechanical team put (i.e., the dimensions), that's why weekly meetings were held between the two teams to approve the design of the systems and the suggested modifications. Before integrating the system, unit testing must be applied to every sub-system. Weekly status reports were provided by each team on weekly bases to document each step through the project journey.

III. Mechanical Design Rationale

We started by understanding what we need to provide with our ROV, brainstorming sessions were held at the beginning, and each design idea was evaluated using SWOT analysis and free hands sketch.

After gathering data from ideas and background research, the mechanical team specified the design requirements as stable, lightweight, compact, easily assembled, maneuverable, and cost-effective. We reached a solution that satisfied the design constraints, then we re-evaluated it regarding the missions, MATE manual, weight, and size bonus. Modules such as gripper, image processing unit, drop and release mechanism, cameras, and pneumatic components places were specified, and design was edited.

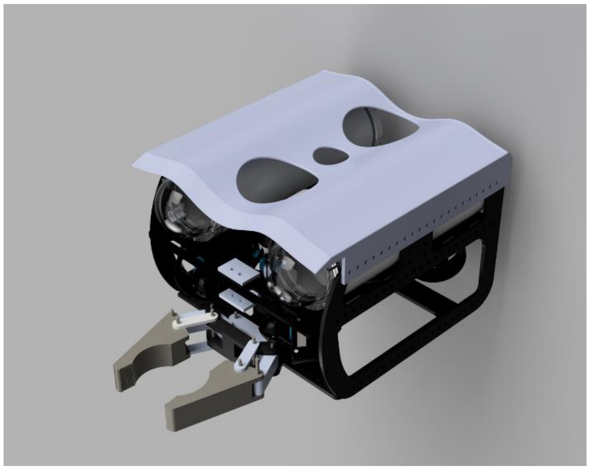


Figure 5 - ROV assembly

A dynamic analysis was performed on the design, which lead to design edits in both side wall lengths, the distance between the bottom and main plate, and the shape of bottom plate as well, ROV is very compact in shape, weights only 13KG. Meetings were held with the electrical team periodically every week to know the sizes of power converters, and control circuits to decide ahead of the dimensions of cylinders.

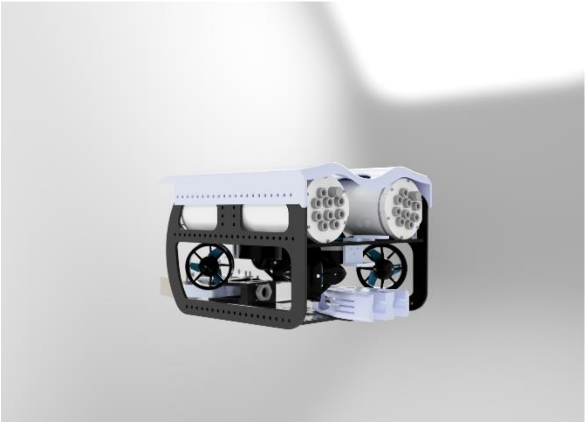


Figure 6 - ROV with microROV showing at the back

Design ideas were transformed to Computer Aided Design files using SolidWorks so editing and assembly Could be done in the most natural way, materials specified, and weight estimation was done using SolidWorks analysis; also centre of mass and center of bouncy was evaluated.

Our designs and mechanisms are based on scientific theories. While designing the 2D and 3D parts we considered the most possible loads that might be applied on it, accordingly we ran a stress analysis on every part to ensure its safety and prevent it from failure by modifying many models to reach the safest and most suitable one.

i. Frame

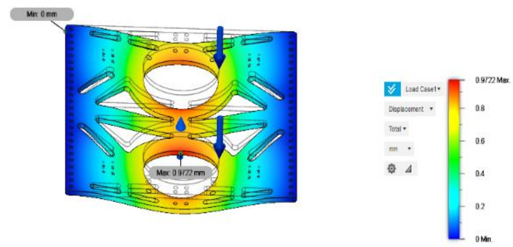


Figure 7 - main plate stress analysis 1

Taking the design constraints as an input, the mechanical team managed to design the frame with only four parts assembled; the frame design contains holes patterns to be modular enough for the added mission's extension modules. Two side walls which carried most of the mission's extension modules, one main plate that carries all the six thrusters, cameras, and electrical enclosures, and for easy cable management, and tether strain relief. Also, one bottom plate that carried the gripper mechanism, pneumatic cylinder, and micro-ROV assembly, material specified to meet the lightweight, corrosion resistance, and toughness requirements were HDPE that has a density of 0.93 and a tensile strength of 32 MPa, also very cost effective. Stress analysis was made on each part to determine the thickness of each plate. We managed to manufacture the all frame on CNC machine in only one run, which helped us to meet our time agenda.
Frame weighted 1KG.

The design was assembled using Aluminum L shaped connectors, 5mm bolts and vibration resistant nuts.

ii. Gripper

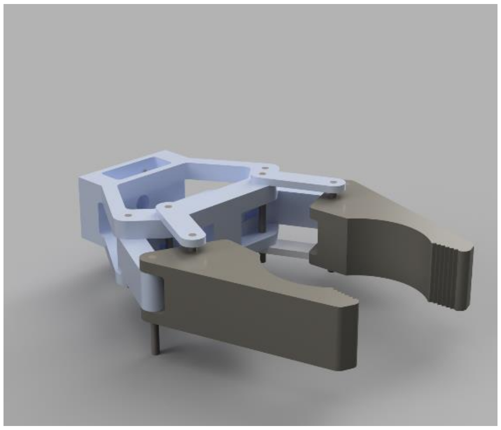


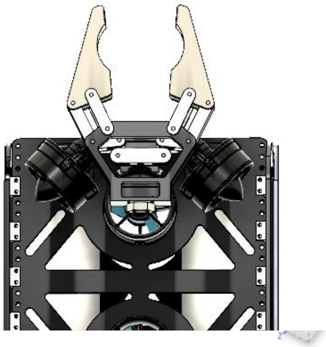
Figure 8 - gripper assembly

ROV is equipped with pneumatically powered four-bar mechanism gripper; our main concern was to design a gripper which is easy and fast to manufacture, opens 90mm linearly to hold almost everything in the product demonstration, compact in shape, and assembled quickly. The gripper's primary actuator is a 25mm stroke pneumatic cylinder that can reach 200N in forward stroke, and 171N in reverse stroke, this provides a gripping force up to 35N on each jaw. Our gripper consists of 7 parts assembled with 5mm stainless steel shafts, an rubber bands are fixed on the jaw balms to ensure the best friction between gripper and objects.

iii. Thrusters

The company considered thrusters as the central portion of budget; two kinds of thrusters were considered versus the ROV power and money budget. Six Bluerobotics T200 thrusters were used, for the ability to accelerate the ROV and to maneuver it flawlessly, with up to 3.5KG thrust force of each thruster. UMC decreased the cost in other areas to balance the high initial cost of T200 thrusters.

iv. Thrusters Configuration



Four thrusters are used in 45degree vector, resulting in 4 motors engaging in forward, backward, twist around the center, and sideways, two thrusters are used for up, and down and pitch maneuvers, thrusters were chosen to be close as much as possible to the ROV center of mass. Special C-brackets for fixing t200 vertical thrusters with the main plate was manufactured.

v. Buoyancy

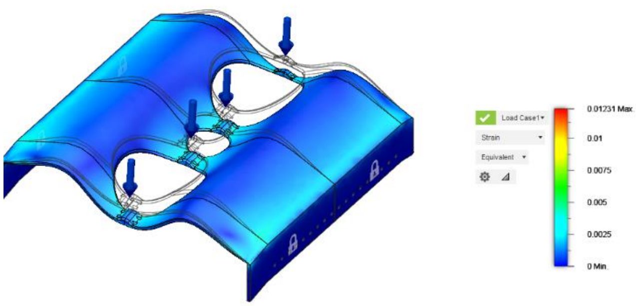


Figure 10 - displacement - effects of buoyancy on the shell

UMC needed an approximately suspended ROV, with a slight tilt forwardly for better maneuvering and handling objects, ROV weights 15kg without a tether, a balanced distribution of electrical components was considered so there is no moment affecting the ROV, buoyancy tests were implemented as follows:

- The ROV frame with cylindrical enclosures was assembled and put into water to monitor the behavior of the vehicle.
- The main electronic components such as buck converters weight were measured, and distributed as 2 in each enclosure.
- Vehicle behavior was watched to be slightly overweighted.
- Floats were added in two ways. First, a shell was designed, and manufactured from high-density foam material, but it made the ROV over buoyant. In the Second trial, the mechanical team attached float units near the center of mass of the ROV.

vi. Sealing

Our company paid attention to the time factor and decided to buy to 4'' Bluerobotics series enclosures; they can reach to 100m in depth, each side of the enclosure is sealed with two face seal O-rings, one cylinder can contain 12 Bluerobotics cable penetrators, and eight on the other. Each cable penetrator is sealed in two steps including sealing from the bottom side and sealing from the top side using epoxy resin material to ensure protection against water, also to act as a strain relief for the tether. One of the transparent acrylic domes is used as camera housing.

vii. Pneumatics

- One compressor and two pressure gauges to measure main line pressure, and tank pressure.
- A pressure regulator to adjust the pressure as needed during missions
- An adjustable pressure relief valve and can stand up to 6 bars of pressure
- A flow controller to control the flow of the release mechanism.
- 5/2-way mechanically operated solenoid valve to control double acting cylinder of the gripper.
- Double acting cylinder to control opening and closing of the gripper end effector.
- Double acting cylinder to control opening and closing of the micro-ROV docking mechanism. 5mm pneumatic tube with push-in fittings for easy assembly.

Figure 11 - air compressor

IV. Mission Specific Features

Our company designed innovative solutions for MATE's upcoming missions.

i. Cannon Lifting Mechanism

a. Mission

The task is to take the canon (8kg underwater) from pool bed to retrieve it to the surface (using our release mechanism), then move the mechanism to the poolside to be taken from the tether man.

b. Design

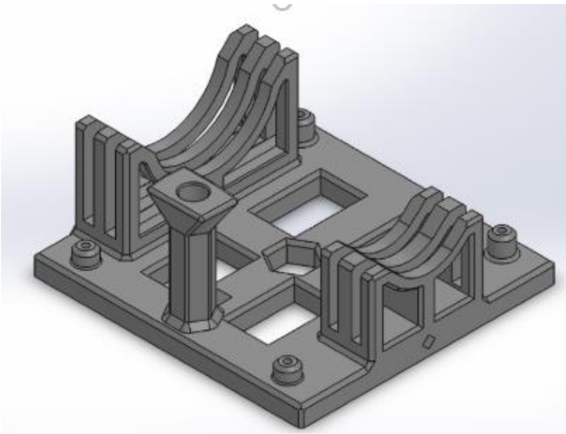


Figure 12 - cannon lifting mechanism base

Our design process is the following. Company has researched the ability of divers to lift heavy objects from seabed to the sea surface. The mechanical reached that design lifting mechanism. The Manufacturing team took this design, select the appropriate material to carry loads without deflection, of failure, which is HDP. We have made it by using only one large hopper ball and it filled our requirements by making the plate of the mechanism long and attaches, the company's lift bag is designed to connect to the cannons by engaging a three-U-shape support in each side of the canons with the difference if the diameters and size of the U-shape support. This mechanism with the ROV by using two tubes of PVC to allow for the controller of the ROV to control and balance the mechanism easily but this attachment is just temporary for the mission then is removed.

c. Calculations

After research about how divers can lift heavy objects from the seabed to the sea surface, the team determined that one liter of air can carry approximately one kg of load underwater.

d. Operating Procedure

The tether man will attach this mechanism with the side walls of the Spectre then the pilot will place this mechanism under the cannon and open the valve to fill the ball, and it will be lifted by the air inside the ball then move and balance by the pilot then the tether man will take the cannon out of the water then remove this mechanism.

ii. Drop Container

This mechanism is used for dropping trout safely underwater, and for depositing the pebbles for dam repair. We designed this mechanism with the safety of living organisms in mind, while also being rigid enough to hold the pebbles. The two main objectives that the drop mechanism was designed on were; the size of the stones and trout, compatibility with the ROV's frame, and the gate actuator design. Which lead our designers to the idea of a cylindrical container with a 6cm inner diameter with insulated dc motor housing included in the container for the control of the gates. The drop mechanism is modular, as it can be fixed on any of the sides of our ROV while the leveling is adjustable depending on the mission. The container's gate is actuated by a 12V insulated DC motor that is controlled by an L298N h-bridge that is taking command from the main Arduino due control board in tandem with mechanical end stops. Which makes it simpler than using any other type of control such as pneumatic control, while the insulated DC motors are lower cost than insulated servo motors.

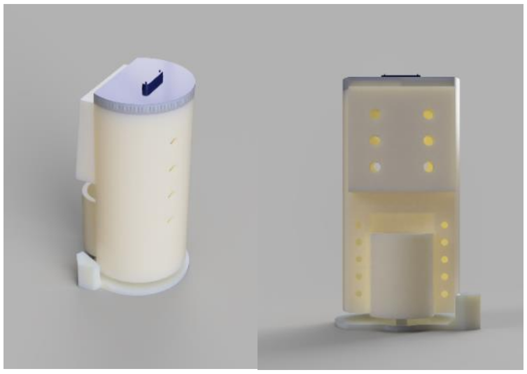


Figure 13 - drop mechanism - actuator

iii. Micro-ROV

Our micro-ROV design is inspired by the great Space Shuttle. It went through several stages. First, the company made three different models of it until we decided to select this model, and the company must make it compact due to the limited availability on the main ROV. It is entirely made in one run using a 3D printer. The print time totaled 34.5 hours. The micro-ROV contains a hexagonal hole feature that is used for the docking process in the base plate of the ROV. A 3D printed part actuated will mate with the hexagonal shaped hole for docking.

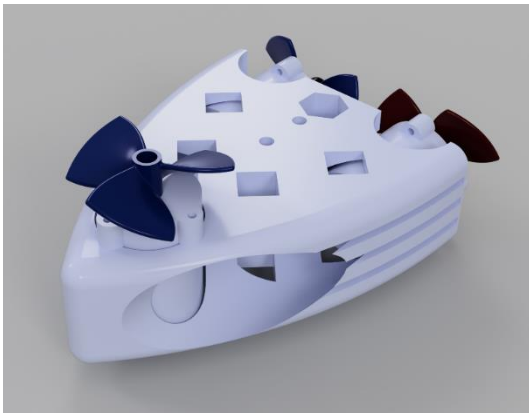


Figure 14 - microROV

The micro-ROV contains a car parking camera which has excellent low-light performance and is low-cost and easy to pot. For thrust, we designed our unique waterproofing method that we use to insulate three DC motors. The mechanical team designed propellers suitable for 3D printing with the same material of micro-ROV. The location of the motors must be selected and taken our consideration to make the motion of it to allow three degrees of motion.

The micro-ROV is connected to the main ROV using a 5m tether that will be collected in a mechanism that is attached in the base plate of the ROV.

V. Electrical Design Rationale

Our vision for the electrical design in our company is to create cost-effective and simple modular elements that integrate into an easy to maintain the ROV system. The main aspects of our design are; the electrical circuit, the power circuit, programming of the microcontrollers, cameras, auxiliary devices, and software.

i. Control and Power Circuits

We have divided our ROV electrical design into control circuits and power circuits. We maintained high customizability in our designs and ensured quality while being low-cost. We also have the programming laid out in a flowchart design.

ii. Overview of Electrical Systems

Our system consists of two sides, the top side, which is the station that is considered the control side. This is an Arduino Mega connected to our joystick via USB shield, which in turn is connected to an Arduino Uno through I2C communication protocol that is responsible for the micro-ROV gamepad. The Arduino Mega sends both joysticks readings to the ROV control unit, the Arduino Due. The bottom side is considered the actuating side of our system, which drives six thrusters via ESCs and DC motors for the micro-ROV and the drop mechanism. Moreover, it contains our main PCB that is responsible for all sensor’s connections and cameras signals and connecting to the tether.

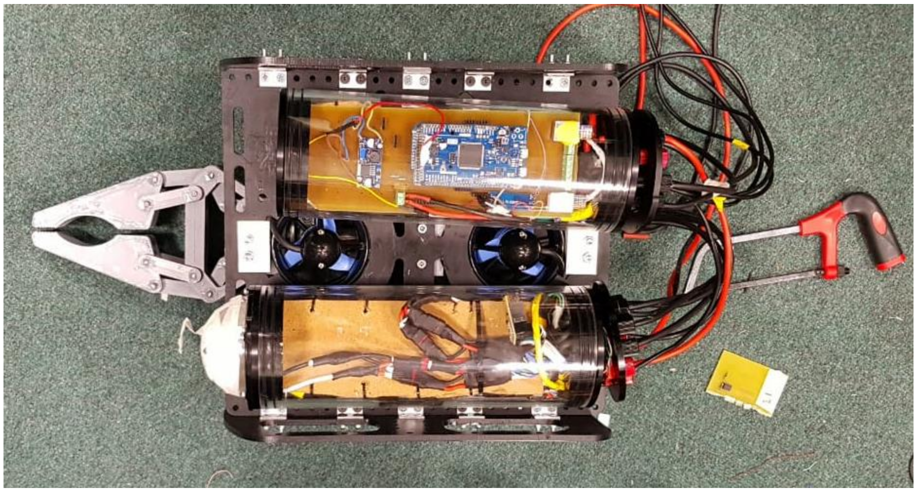


Figure 15 - top view of the ROV, showing some of the electrical systems such as the ESCs

iii. Power Consumption

The power consumption of all electronics is negligible compared to the thrusters' power consumption. By giving the ESCs a PWM signal of limited range between 1200 to 1800 µs, the thrusters will operate approximately at 50% of their thrust force consuming 90 watts per each thruster.

Quantity	Name	Description	nominal voltage	power/pc		total power
2	T200 Thruster	Vertical thrusters	12	180		360
4	T200 Thruster	Horizontal thrusters	12	180		720
6	Speed Controllers	95% efficiency	12	8		48
4	Buck Conveters	95% efficiency	12	8		32
1	Pressure Sensor		3.3	0.004		0.004
1	Temprature Sensor		4	0.00036		0.00036
1	9-Axis IMU Sensor		3.3	0.008		0.008
4	cameras		12	3		12
1	Logic Level Convertor	5V to 3.3V	5	0.36		0.36
1	Arduino Due	Main ROV controller	7	5.6		5.6
1	Metal detector	Inductive Proximity sensor	7	2.1		2.1
3	DC Waterproof Motors	For Micro ROV	12	4.5		13.5
				total power =		1193.572
Fuse Calculations	(120%) (Total Max Power Consumption) / (MATE Voltage) = (120%) (1193.57W / 48V) = 29.83A					

Figure 16 - power distribution table

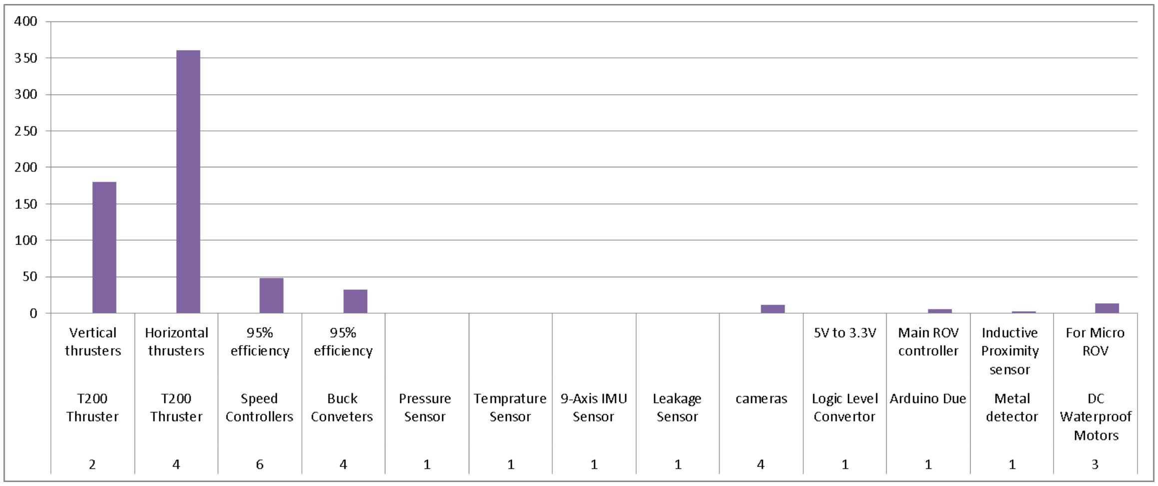


Figure 17 bar chart for power consumption (thrusters at 50% for clarity)

iv. Voltage Conversion

We use four DC to DC buck converters to step down voltage from 48V to 12V. Each of the first three bucks supplies two thrusters, while the fourth supplies the micro-ROV and cameras that operate at 12V, moreover it provides all the electronics embedded in our

PCB that operate at 3.3V ~ 5V, therefore a smaller DC to DC buck converter is used to step down voltage again from 12V to 5V which is the nominal voltage for our PCB.

The primary buck converters can sustain a current of 30A maximum with input voltage range from 38V to 60V by 95% efficiency at full load. Therefore, a fuse of 30A is used to protect our circuit from any overload current.

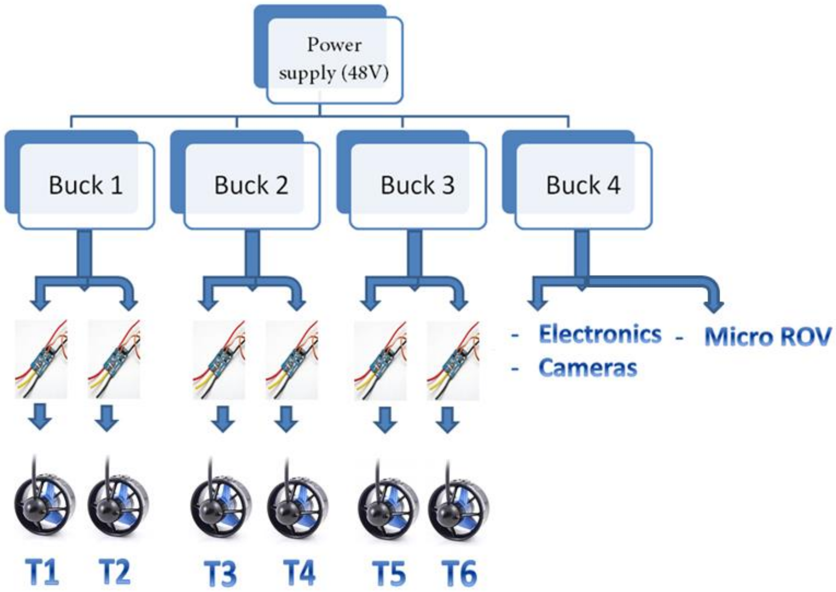


Figure 18 - voltage conversion flow

v. Tether and Communication

Our tether consists of two 10AWG copper wires to carry the 48V supply voltage. We chose 10AWG to reduce the voltage drop to less than 5% at 10 meters. Additionally, we use three Cat5e cables, two to carry analogue cameras' signals and the control signal to the Arduino Due. The last Cat5e cable is used to transmit the feed of a USB camera through an active ethernet connection. This USB camera is used for image recognition.

The communication between the top station and the ROV is done using 3.3V UART. We have found that at the highest baud rate of 2,000,000bps possible for our microcontrollers, this communication is reliable with more than 20m of a pair from the Cat5e. We use a data transfer library that handles data corruption and loss, and we reduced the baud rate to a modest 250,000bps.

vi. Microcontroller Programming

We used best practices when programming our microcontrollers. We avoided using blocking functions to improve response time. We divided all sections of the code into modular functions to make iterations easier. Finally, we used methods to make configuration of the code easy.

vii. Control Interfaces

We use two input devices for interfacing with the ROV. The main ROV is controlled with three-axis joystick. The joystick features 12 buttons, Y-axis, X-axis, and twisting. We use a combination of buttons and the three-axis to cover our five-axis of rotation possible on the ROV. It is connected directly to the station Arduino Mega using a USB Host Shield. For the micro-ROV, we use a separate small gamepad. The gamepad is mounted on an Arduino Uno and connected to the station ROV via I2C.

viii. Cameras connection

Each used CCTV (analogue) camera has two main connections; the power connection and the data connection. While, the USB camera is connected directly -power and data- to a pc.

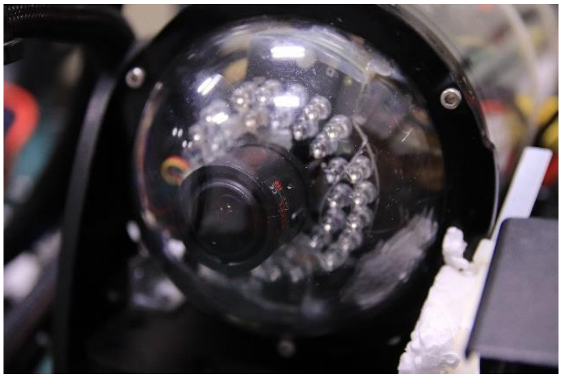


Figure 20 - high resolution main CCTV camera enclosed

a. CCTV Cameras

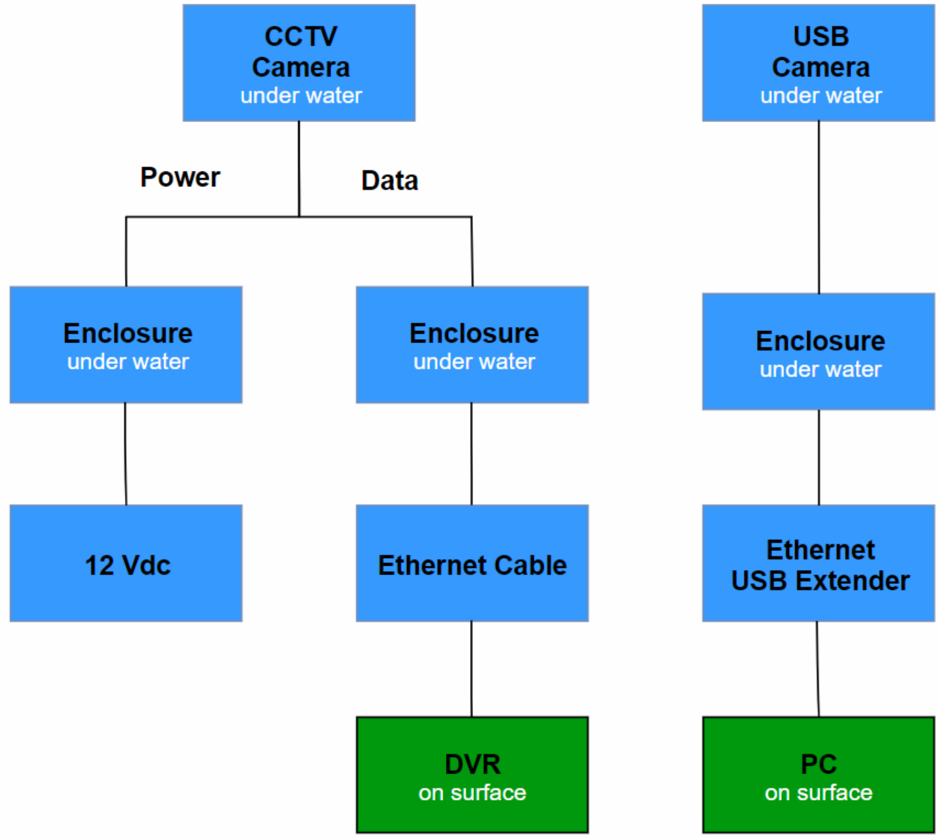
All used cameras need from 12 to 24 volts to operate. The power is supplied to the cameras from the enclosures -through the penetrators- which is already supplied from the dc-dc buck converters.

The data wires of the cameras are connected to the enclosure, and through the ethernet tether, it is connected to the passive video transceiver which is connected to the DVR.

Figure 19 - mission control screen connected to DVR

b. USB Camera

The USB 2.0 protocol can reach a maximum range of 5m. For that, a USB-ethernet extender is used, which converts the USB to ethernet protocol and vice versa on the surface to connect to a pc. This converter can extend the USB protocol up to a distance of 20 meters.



ix. Micro-ROV

Like mentioned previously, our micro-ROV is being controlled by a gamepad that sends X & Y values to the main ROV microcontroller, which gives PWM signal to h-bridges that drive our waterproof DC motors.

PWM or pulse width modulation is a technique which allows us to adjust the average value of the voltage by turning on and off the power at a fast rate.

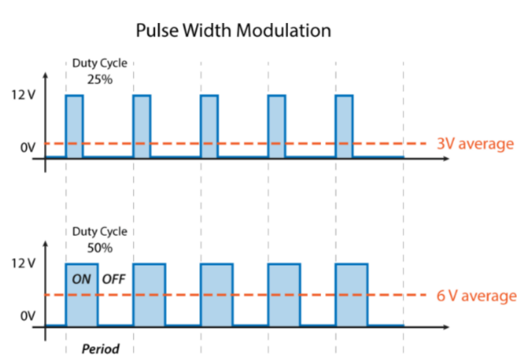


Figure 21 - PWM power modulation

When the co-pilot gives a signal to the micro-ROV to move forward both motors will rotate in the same direction with the same speed of Y value given from gaming pad and the opposite for backward motion, for moving left, we use the X value to decrease the left motor speed and increase the right motor speed, the same concept is applied for moving right. Lastly, we control a third DC motor for vertical motion.

VI. Safety

Our company paid attention to safety regulations to ensure a safe working environment and to prevent fatal accidents from happening. From the first meetings, the company specified a safety officer, table of hazards, risk levels, and Standers of processes.

i. Safety instructions

- Using PPEs such as safety goggles, gloves, and footwear inside the workshop.

- Standards of operating processes were labeled on each machine of the workshop.

Figure 22 - PPE labels - UCLan Wharf engineering & CNC workshop

- During testing the ROV near water, only authorized members could perform tasks near the ROV.

- Use flux to clean welding iron after soldering.

- Making sure fire extinguishers and first aid kits were inside the workshop and on the poolside.

- MSDs for chemical materials like E-boxy and resin.

ii. ROV safety features

a. Mechanical

The frame is secured with antivibration nuts. No sharp edges are exposed on the outside or inside of the ROV body, Thrusters guards from both sides.

Figure 23 - SOPs - UCLan Wharf engineering & CNC workshop

Pneumatic Safety Features: pressure Relief valve is added to the main air lines and set to 8 bars, which is the maximum pressure for the tank. Pressure Regulators are used for the primary air line (set to 2.75 bars), and on the compressor tank (set to 8 bars).

Figure 24 - 8 bar pressure relief valve

b. Electrical

Short-circuit and over-current protection on all DC-DC converters and 30A fuse with an isolated casing are provided. Colour coded cables are used for power and signal transmission across the electronics enclosure. Software interlocking system is designed to prevent all the thrusters from reaching full power at the same time.

Labels: Warning labels are placed on thrusters and moving parts, high-pressure parts. Any electrical components outside water are isolated within labeled boxes.

VII. Conclusion

Through the MATE ROV journey at UMC, we faced and conquered many challenges; we will share some of these to conclude.

Figure 25 - the UMC team discussing plans

i. Technical Challenges

a. First Issue

As mentioned before we are using USB camera in image processing which is known by its short range (up to 5 m maximum).

Solution: we used an extender that converts the connection from USB to Ethernet at the bottom side then from Ethernet to USB again at the top side.

b. Second Issue

While assembling the side wall of the ROV, we found that the bolts' head were interfering with each other

Solution: we solved it by using countersink holes in the ROV body itself.

c. Third Issue

We are using PMMA material, which is known by its high strength, and corrosion resistance, but due to its high cost, the mechanical team decided to use HDPE, which is lower in cost. Unfortunately, HDPE is known for high ductility, which caused non-acceptable displacement on the primary plate.

Solution: we used a 3D printed support located in the middle of the plate, precisely in centre of mass of the ROV to overcome this issue.

ii. Non-technical Challenges

The starting of the team was a challenge, from the perspective of time management, given the time to launch a team with an A-Class product was less than ideal.

However, the biggest challenge was finding a pool in our city to train for the ROV competition and provide a video demonstration prior to qualification to the international competition. The pool was not available until two days before the deadline of the competition where the team decided to use part of the budget to buy an installable frame swimming pool.

VIII. Acknowledgments

UMC would like to thank anyone who helped in making Spectre possible, including but not limited to:

The University of Central Lancashire, for providing full financial and non-financial support.

Dr. Ahmed Onsy, for supporting our company and adopting the company from its launch.

Wharf Building workshop-UCLan, for applying our designs as fast as possible in the most creative ways.

Foundry Court Student Accommodation, for providing a space for ROV assembly and Team's portable pool in tough times.

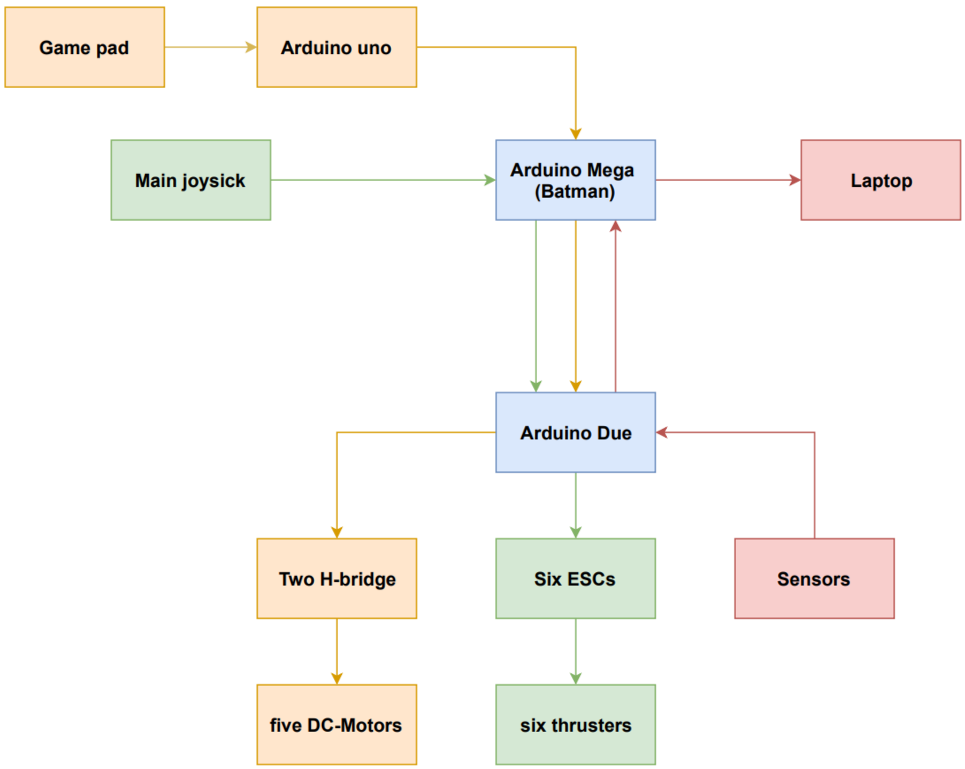
MATE for organizing such a fantasitc competition and providing support for teams from all over the world.

Eng. Omar Moslhi, for giving us the guidelines to learn Image processing techniques.

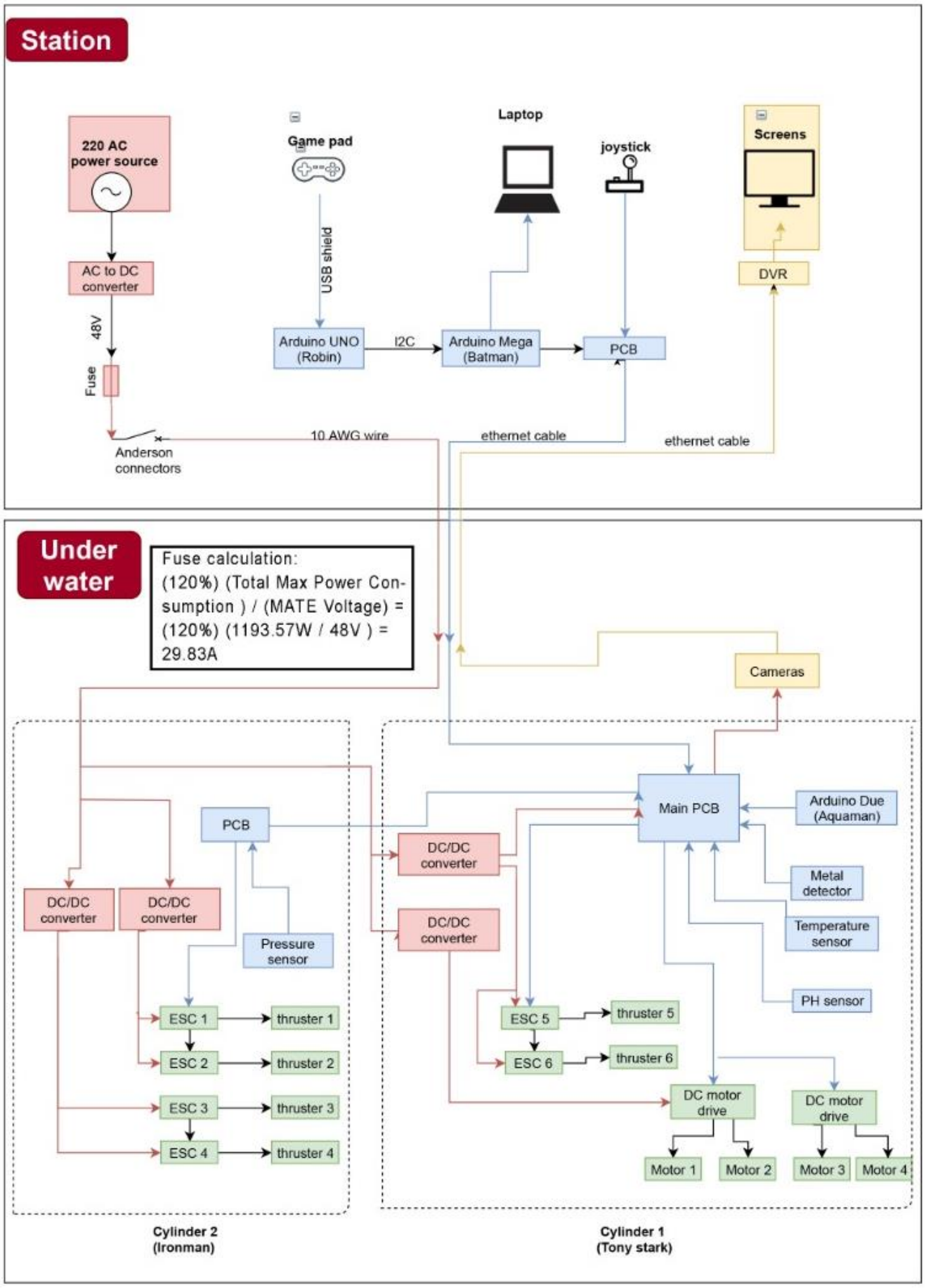
X. Appendices

i. SIDs

a. Flow control



b. Circuits and connections



ii. Budget Breakdown

Category	Item	Amount	Qty.	Total (English Pound)
Thrusters	Bluerobotics T200 with ESC	£ 135.20	6	£ 811.20
Sensors	Pressure Sensor (Insulated) BAR02	£ 70.40	1	£ 70.40
	PH Sensor	£ 16.99	1	£ 16.99
	IMU Sensor	£ 7.00	1	£ 7.00
	Temprature Sensor	£ 5.82	1	£ 5.82
	Metal detector	£ 6.39	1	£ 6.39
Body	4" Insulated Acrylic Tube Cylinders,DOMES - 10 holes	£ 247.20	1	£ 247.20
	4" Insulated Acrylic Tube Cylinders,DOMES - 14 holes	£ 250.40	1	£ 250.40
	Cable Penetrator 6mm	£ 3.20	7	£ 22.40
	Cable Penetrator 8mm	£ 4.00	12	£ 48.00
	Cable Penetrator Blank	£ 3.20	7	£ 22.40
	Cable Penetrator O-ring	£ 1.60	3	£ 4.80
	Filament for 3D printer	£ 14.99	2	£ 29.98
	M4 70mm screws	£ 5.90	2	£ 11.80
Electical	DC-DC Buck Converter	£ 14.99	4	£ 59.96
	Fuse holder 30A	£ 6.49	1	£ 6.49
	fuse 30 A	£ 5.00	1	£ 5.00
	12V 480W Power Supply	£ 24.89	4	£ 99.56
	10AWG Wire	£ 14.99	4	£ 59.96
	Arduino Due	£ 27.99	1	£ 27.99
	Joystick	£ 33.99	1	£ 33.99
	CCTV Camera	£ 30.00	1	£ 30.00
	Camera Connectors to RJ45	£ 9.99	2	£ 19.98
	L298N Dual H Bridge DC Motor Driver	£ 6.99	1	£ 6.99
	Arduino Gamepad	£ 7.60	1	£ 7.60
	RJ45 Connector	£ 1.00	4	£ 4.00
	PCBs	£ 17.00	1	£ 17.00
	8-Channel DVR	£ 45.99	1	£ 45.99
	Car Rear View Backup Camera	£ 11.17	3	£ 11.17
	Arduino uno	£ 6.00	1	£ 6.00
	DC-DC step down convertor	£ 7.99	1	£ 7.99
	14AWG wire	£ 9.60	1	£ 9.60
	Cat5e 20m	£ 5.90	1	£ 5.90
	High amperage connectors	£ 4.99	1	£ 4.99
	BNC Connectors	£ 4.45	1	£ 4.45
	Wire spool	£ 17.99	1	£ 17.99
	Electrical Tape	£ 1.87	2	£ 3.74
	Fuse holder 5 x 20mm	£ 0.34	1	£ 0.34
	7.5 A fuse	£ 0.61	1	£ 0.61
	DC motors for micro ROV	£ 6.00	1	£ 6.00
	Arduino Mega	£ 13.00	1	£ 13.00
	Arduino uno usb sheild	£ 30.00	1	£ 30.00
Sealing	Epoxy Resin	£ 39.95	1	£ 39.95
	O-ring Grease	£ 6.53	1	£ 6.53
	Marine Silicone	£ 5.98	1	£ 5.98
	Gorilla 25ml Epoxy (Pack of 4)	£ 5.00	5	£ 16.57
Pneumtic Circuit	Pressure Regulator	£ 7.00	1	£ 7.00
	pneumatic cylinder	£ 35.24	1	£ 35.24
	Legris Pneumatic Straight Threaded-to-Tube Adapter, G 1/8 Male, Push In 6 mm	£ 2.06	5	£ 10.30
	RS PRO Air Hose Blue Nylon 6mm x 30m NMF Series	£ 33.47	2	£ 66.94
	SMC Residual Pressure Relief Valve, x6mm	£ 8.13	1	£ 8.13
	SMC AS Series Flow Controller, 6mm Tube Inlet Port x 6mm Tube Outlet Port	£ 10.58	3	£ 31.74
	Tube connection	£ 2.13	5	£ 10.66
	Tree connections	£ 4.08	1	£ 4.08
	Pneumatic Straight Threaded-to-Tube Adapter, G 1/4 Male, Push In 6 mm	£ 1.11	5	£ 5.56
	Asco High Foot L Bracket 20mm-25mm	£ 4.50		£ 4.50
	pneumatic cylinder	£ 7.00	1	£ 7.00
	Pneumatikc Tee Adaptors	£ 1.50	4	£ 6.00
	Soloniod Air Valve 5/2	£ 6.99	2	£ 13.98
Mechanical	sheet HDP	£ 40.00	1	£ 40.00
	I shaped aliminum bracket	£ 3.00	2	£ 6.00
	bolts and nuts M5, M6 , M3	£ 15.00	1	£ 15.00
	Tether Sleeve	£ 15.00	1	£ 15.00
	safety labels, flyers	£ 15.00	1	£ 15.00
Travel cost	Flight tickets	£ 630.00	7	£ 4,410.00
	Accomendation	£ 200.00	7	£ 1,400.00
	Transportation	£ 140.00		£ 140.00
Funds	**UCLan**	**£ 5,000.00**		**£ 3,422.00**