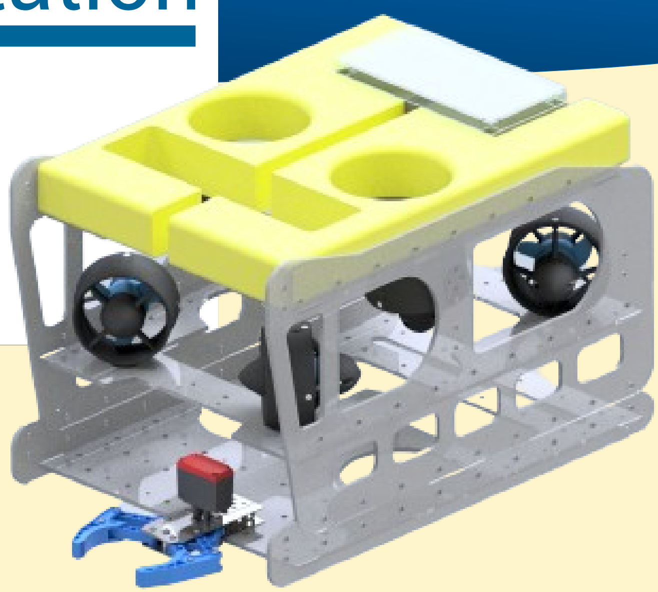
# Mintlaw ROV

## Members

Liam Godsman - CEO
Kyden Widger - Pilot, CTO
Daumantas Dauksas - Programmer
Shaun Cruickshank - HODAM
Blazej Nejman - General Technician
Amy Chalmers - Community Outreach
Lynsey Cromarty - General Technician
Martin Cutts - Photographer
Mr Ali Hynd - Mentor

## Technical Documentation

Mintlaw Academy
Aberdeenshire
Scotland



# Content



MINTLAW ROV

# Abstract

## 1.0


Mintlaw ROV are team of eight S4/5 pupils (15-16 years old) who have a passion for STEM and subsea technology. We formed 'Mintlaw Subsea' following our market research and assessment of the MATE mission requirements for 2024. With it, came a breath of fresh air to the whole team where we decided to make changes to make our vehicle meet industry standards, These innovations include a wide range of changes: having our frame reviewed by industry experts, manufacturing our manipulator with 3d printing techniques to allow for the 30kg servo to be interchangeable as well as including more cameras to have enhanced vision for tasks which require observations. For example this year, where we have to measure the length of a coral restoration area. These missions set out by MATE teach us valuable lessons about the industry and how it links to the environment, an issue which our generation, will be pioneers of in future careers.

Safety is at the heart of our operations within the team. We gather regular feedback from everyone in the company to ensure procedures meet current requirements and that no issues have arisen. Additionally, we have an annual external audit of our safety (by Mr Robertson at Wood) documentation and procedures. To make this information accessible to everyone in a digestible way, we provide 'safety handbooks' to every member with summarised key information. Safety isn't just a word, it's a culture - focusing on how things ARE done, not just how they SHOULD BE done.


Meeting the King at GUH


SUT presented us awards at Subsea Expo

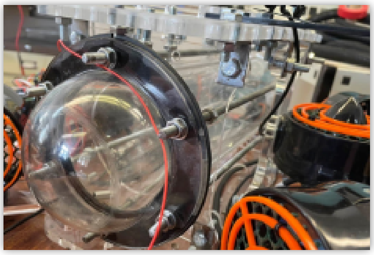
# History



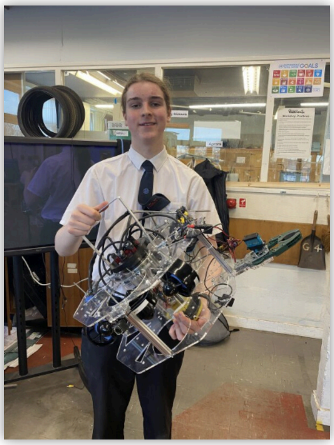
When we started the project in the Autumn of 2019, as first-year students, we all had limited knowledge and experience of engineering. We had 1-2 hours per week of looking at different areas of the vehicle. Learning and working on different aspects, we started to gain a bit of momentum with the project until the Covid-19 Pandemic hit the UK in late March of 2020. Finally, in the Autumn of 2021, when the ban on extra-curricular clubs had been lifted in Scottish schools, we could get back to work.

In two years - as a team - we have grown as people and have made life long friends and colleagues. After our last two MATE mission campaigns, we have expanded our knowledge in the Blue Economy and made connections with international companies who have offered technical, and financial support. That is why this year's vehicle is based loosely off of an industry vehicle.

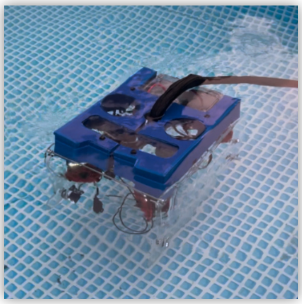
This year we have been fortunate enough to have some once in a life time opportunities presented to us by our friends in the subsea sector such as the opportunity to meet HM King Charles III in October of 2023 at the opening of the new GUH building in Aberdeen. We had the chance to speak with His Majesty briefly about the project and MATE missions. We also attended Subsea Expo this year where we were presented with an award from SUT  for our work with the subsea industry. This is regarded very highly and we are tremendously grateful to have been given these awards and for our work to be recognised.



2022 vehicle with shrouds



2023 vehicle with pilot



2024 vehicle during pool test

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# Roles

1.2

-Liam Godsman – CEO - Grade 11 (S5)

-Daumantas Dauksas – CTO - Grade 11(S5)

-Kyden Widger - Pilot, Safety Officer, CTO - Grade 11 (S5)

-Shaun Cruickshank – Chief of Design & Manufacturing - Grade 11 (S5)

-Blazej Nejman – Chief Engineer - Grade 11 (S5)

-Amy Chalmers - Social Media & General Technician - Grade 10 (S4)

-Lynsey Cromarty - General Technician - Grade 10 (S4)

-Martin Cutts - Photographer - Grade 10 (S5)

Mentors:

-Mr Ali Hynd

-Neil Stagg

Documentation Support:

-Mrs Lois Wappler

Whole team photo at Subsea Expo

Assigned roles within the team this year have been vital to our team's efficiency. Clear roles allow us to clearly know who is best skilled to resolve issues, or who to go to with questions about a particular element. However, we are also keen to ensure that we all learn about each element of the design and keep involved with a bit of everything that is going on to expand our team's wealth of knowledge

# Safety Context

1.3

Mintlaw ROV has a strong safety culture that we have created as a team, ensuring everyone has their say. We believe in operating on the basis of - not just what looks good on paper, rather - the attitudes, values and perceptions people have when approaching work in practice. We take pride in sticking to the procedures we define to minimise risks whilst not restricting the way individuals work. Ultimately, if people decide not to use procedures because they are too restrictive, the procedures themselves are helping nobody; by implementing methods that allow work to flow freely and keep everyone safe, we are able to effectively minimise risks.

Safety officer at poolside with checklist

The job-site safety and environmental analysis (JSEA) is a document set out to detail potential risks, their causes, effects and how to manage them appropriately. Every team member should be familiar with it and by being aware of such hazards leads to less accidents occurring if something is present. If a hazard or unsafe practice is identified, it should be reported using an incident report form. These are made available for anyone to take and fill out - forms should be submitted to the safety officer for review. Next, a first alert document will be published to make the team aware of the recent incident to help prevent recurrence. Furthermore, additional training or safety briefs may be required if an issue is severe enough.

Whilst the construction and maintenance aspect to our work has been covered so far, the operation of our systems is also safety critical. We have implemented numerous procedures at every step to absolutely ensure that all work has been carried out properly resulting in the systems operating safely. To support critical communication, job cards are used to specify what work needs to be carried out, what work has been carried out successfully and by who; Ensuring accountability for all work is crucial for safety and if anything does go wrong, it can be traced back and used as a learning opportunity to prevent it reoccurring. Logbooks for dives and checklists for startup, shutdown and inspection procedures all minimise the event of important checks or steps going missed or unaccounted for.

Overall, the team is passionate about keeping everyone safe and with regular checks and meetings, we do our best to maintain our high standards.

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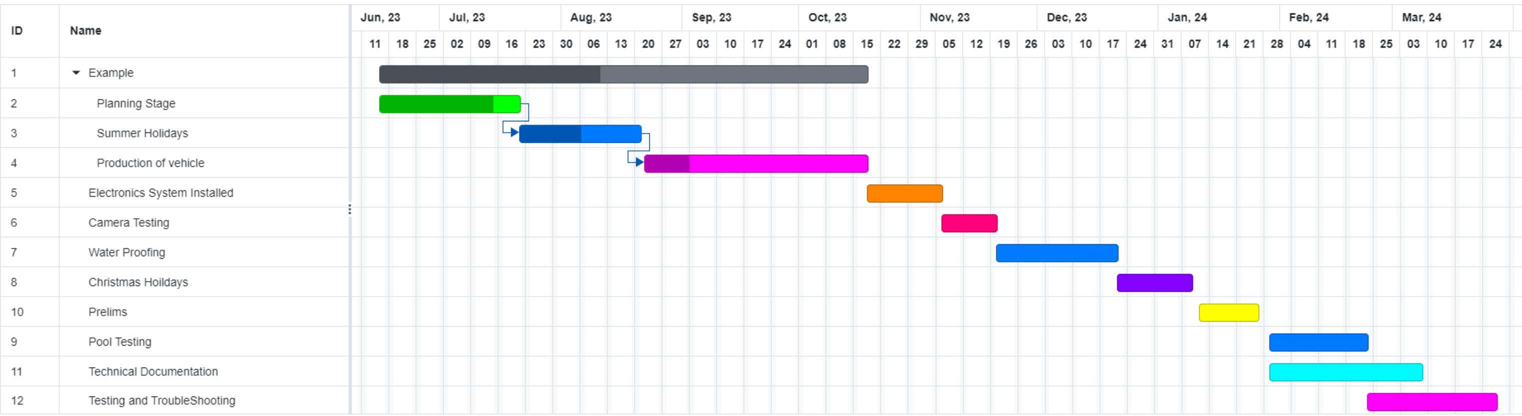
# Project Management

1.4

## Schedule

Our schedule is one of our most important tools. It allows everyone to see what is expected of them and the prescribed milestones to be met. We use Microsoft Teams' tasks function to clearly lay out and organise what needs to be done and assign these tasks to the relevant members with set due dates so we are always running on schedule. We can also use this so the entire team team can see who is working on what and when it should be done by. This is incredibly useful for multiple projects that need to come together and has definitely meant that communication has been easy and seamless even if you cannot have direct face to face communication with the relevant team member.

Our schedule this year has followed a simple motto of functionality first. This means we always prioritise getting things working before looking into the aesthetic of it or looking to further innovate. This is because having a working vehicle with our base systems working makes it easier for us to build on top of in future. Having this schedule also makes us more efficient as a team. It reduces the amount of people standing around not knowing what to do as it is all clearly designated. We choose deadlines by sitting down as a team once a month looking at what needs to be done. We then use everyone's knowledge to set deadlines for what needs done and decide what we want to see at the end of the month.



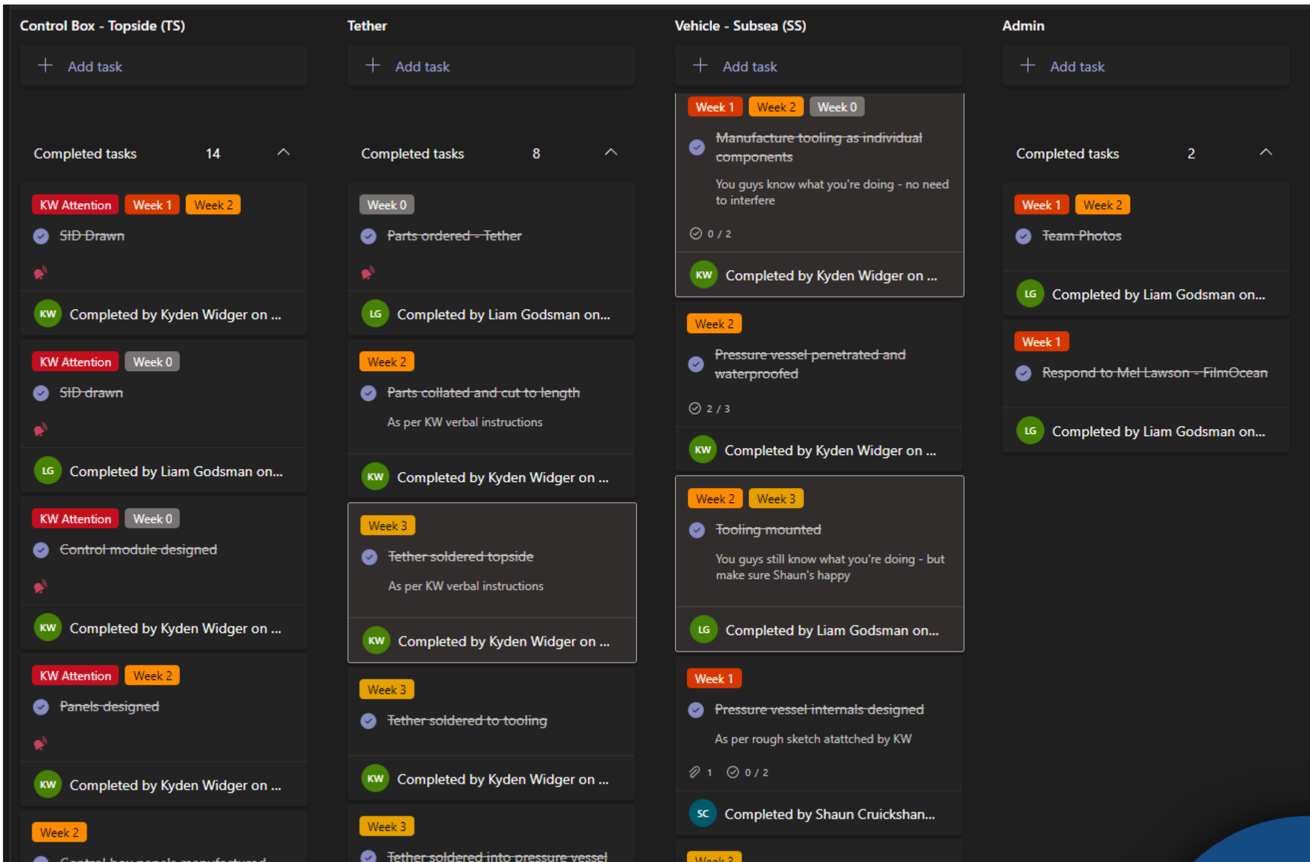

Gantt chart showing 2023 - 2024 schedule

# Resource Management

1.5

One of our main core values is sustainability, this is why we take resource management very seriously. We carefully plan out all of our projects to see what materials we will require so we are not using and buying more than necessary. We also look at what we already have as we do not want to incur inefficient costs or contribute to landfill. We primarily use laser-cut parts for the frame and control box, there is minimal waste as any 'offcuts' can be used for smaller parts or used for side projects to help educate more young people. 3D Printing is another method of producing parts we use. It is especially sustainable due to it being a form of additive manufacturing (this means there is only material being added unlike CNC machining which cuts away at material leaving waste) .

For optimum resource utilisation, our CEO is regularly stewarding conversations within the team to delegate tasks and update our schedule. Scheduling tasks and events is a crucial aspect of our team as it helps keep the project on track for completion, managing everyone's workloads, minimising stress and maximising efficiency. Every member has set roles, suited to their skill-set, to ensure tasks can be completed quickly and to a high standard.

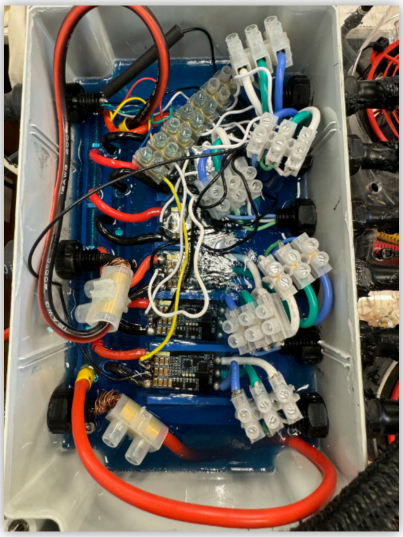



Teams tasks assignment system

# Innovation

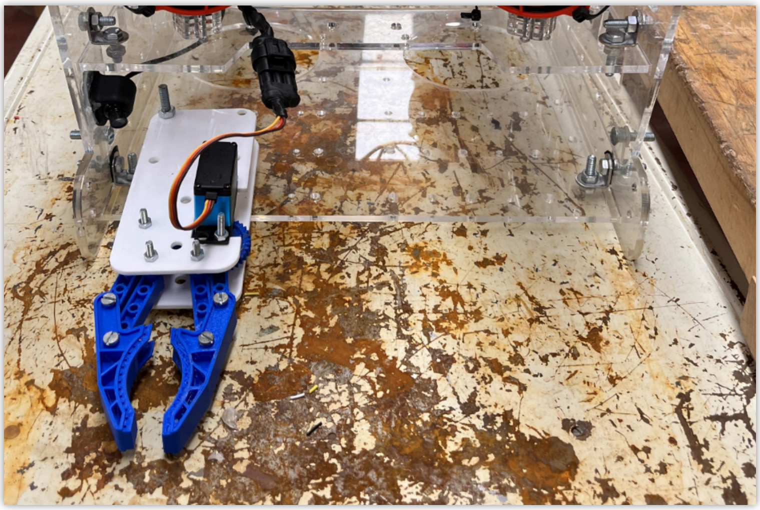
1.6

The innovations we have made over this last year have came about by looking at previous lessons-learned. We look at the main faults in our systems and try to improve them to the best of our ability whilst staying in budget. For example, our pressure vessel had leaked on a few occasions due to the wear and tear from continuously opening and closing it to make changes to the subsea electronics. When water ingress occurred many components were damaged such as ESCs so to prevent this we have incorporated gel into our pressure vessel. This allows the ESCs to function whilst having some protection from a leakage.



First addition of gel to our pressure vessel

The skid of the vehicle is designed to be removed if tooling is not required. This has proven most effective in situations where inspection only is required. The skid is also equipped with a square array of 6mm (about 0.24 in) for quick mounting of tooling at poolside which was an issue during last years performance.



New skid with manipulator

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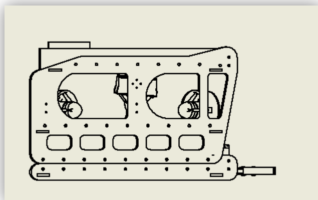
# Design Rationale 2.0

## ROV Overview

After our previous mission campaign (the 2023 regional competition), we decided to take a step back and make major changes. The redesign started in early June at the start of the new school year when we all came to the conclusion that we had to change the position of the pressure vessel since the vertically orientated pressure vessel had many issues. Most importantly the risk of water ingress. So with KC3 we switched to a pressure box rather than a cylinder which allowed us to customise the internals of the pressure box and fill it with silicone gel to reduce loss of electronics if water ingress were to occur.

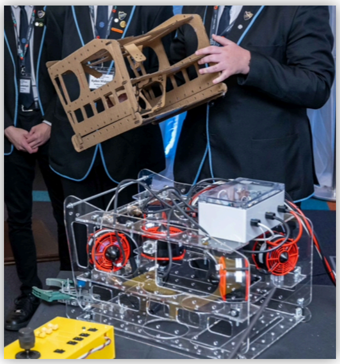


2024 vehicle end elevation

The frame of the vehicle is designed with modulation in mind since every panel is designed with 6mm (about 0.24 in) mounting holes on each side which we make use of when mounting the cameras for visuals and tooling to complete their respective tasks. The panels which make up the outer frame are made from 5mm (about 0.2 in) acrylic. The panels which run horizontal for mounting motors, tooling and buoyancy are all designed with fastening in mind - equipment such as the motor panel having T-100 thruster mounting holes, and tooling having specific mounting for a manipulator.

## Design process

Mintlaw ROV conducts a carefully structured design process prior to the manufacture and design process. When we plan for a project to be manufactured, we first draft on paper, where the engineers will discuss if the designs work efficiently, and they all troubleshoot problems to make our designs as reliable as possible. The next step is to make the designs in CAD modelling such as software like Autodesk Inventor, but we have recently partnered with SolidWorks which we are learning to integrate with our design process. These parts are then ready to be made either using one of the 3D printers or the laser cutter in our workshop. This is great for improving efficiency and decreasing time between ideas and reality because it keeps the cost low. To check dimensions and scale, we render some of our models, as well as this we make models out of cardboard which helps create a visual image which helps decide on what parts or electronics it would be best to design or implement first. We are very grateful for an industry review board to be apart of our design process this year where companies provide us with their knowledge and opinions on drafts which were used when designing this year's frame.



2024 vehicle at GUH

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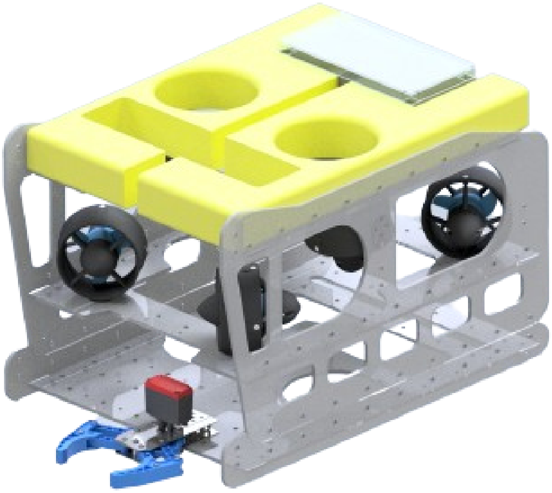
# Vehicle Structure

2.1

KC3 vehicle's structure was based loosely on industry vehicles such as the 'Schilling HD'. The outer skeleton of the vehicle is constructed using 5mm acrylic sheets which are laser cut to our specifications which for the body is precisely 500mm by 260mm (around 19.7 by 10.2 inches.) This is much larger than our last vehicle, which was only 400mm by 330mm (around 15.7 by 13 inches) but the additional room allows for any unseen additions to be added later in the construction (for example when the MATE missions are released) and also produces space for the technicians to work.



Render of KC3 (2024 vehicle)

However, the trade-off of having a larger vehicle was a downturn in the vehicle's strength and rigidity which we soon solved. We created an almost flat pack design for the structure of the panel which holds the buoyancy, motors, and tooling. These are constructed to seamlessly fit together through 20mm (around 0.78 inches) by 5mm (around 0.20 inches) holes which are later secured with the use of brackets, nuts and bolts. The skid of the vehicle is removable just like what can be seen in industry. The skid is constructed with the same concept as the ROV and is used to house the tools for this year's missions; It allows for adaptions to be made at poolside, if necessary, the skid's size is 440mm by 400mm (around 17.3 by 15.7 inches) and is connected to the body using clips to allow for easy removal.

The pressure vessel is a cuboid housing which is mounted on top of the vehicle at the back where, the buoyancy - when attached - wraps around it creating flush finish. All frame and buoyancy components are manufactured in house using our laser cutter which allows for us to be unrestricted by pre-purchased components as well as the use of recycled materials reducing our overall cost.

Pressure vessel first completed for testing

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# Problem Solving 2.2

If an issue arose when inspecting for safety before or during testing, we will go through a series of steps using a mnemonic we developed, DIG LESS, to get us straight to the solution. DIG LESS works as follows:

· **D**efine the problem

· **I**dentify the criteria needed to solve the problem

· **G**ive importance to each issue identified in the criteria

· **L**ist alternative solutions

· **E**valuate alternative solutions.

· **S**elect the best solution

· **S**uccess!

Structured team decision making is a key part to progressing with our project. No matter how well the team can operate, there will always be 'minor snags' and sometimes significant technical problems that were not unexpected. These can be 'roadblocks' to deadlines if not addressed properly. This kind of process can be carried out on an individual or whole-team scale depending on variables.

This has been part of the team's structure when it comes to new solutions for almost two years now and has worked without faults, and keeps new members aligned to team problem solving techniques if they ever get stuck.


ROV board at school with DIG LESS poster

# Vehicle Systems

2.3

Our ROV Systems can be split into sections in many different ways. For the purposes of explanation, power distribution and signal processing will be used. Our power distribution is very straightforward yet ensures safe operation with each system being isolated individually and appropriately fused. Simple flowcharts, showing the way power is distributed and signal is processed, are shown in figure.

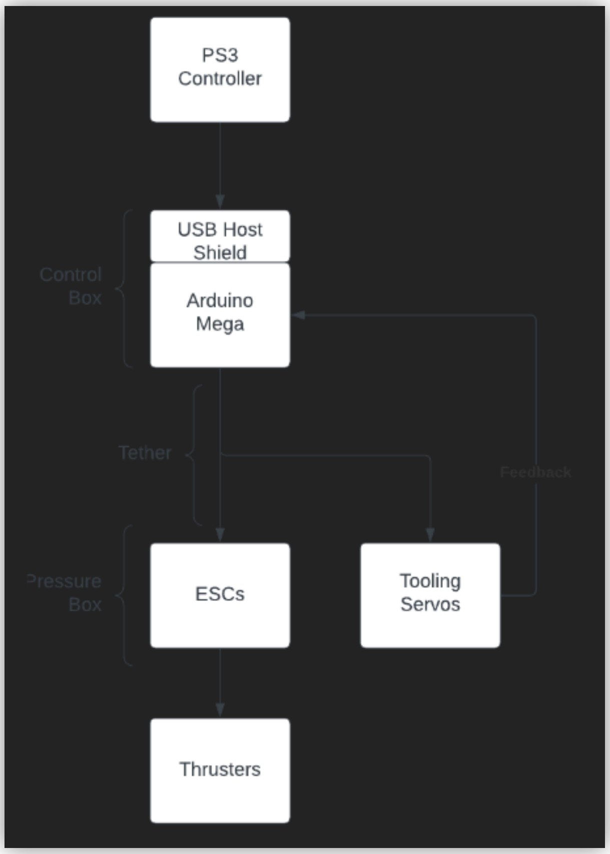


Diagram of ROV electrical system

This year we spent a great effort in optimising our control sequence and reliability, proofing our electronics into more robust systems. This year, we are using one topside micro-controller - an Arduino Mega - to interpret SPI data from a PS3 controller using a USB Host shield. After the controller data is interpreted, data cables from the Arduino Mega connect to an underwater junction in a small electrical box containing ESCs for driving the motors. This is different from last year as we'd removed the underwater controller which was liable to failure, and furthermore we've tackled the issues of intense current draw from the motors by implementing soft start control topside. This was also supplemented by diodes at each electrical controller to properly ground negative electrical current coming from the motors and protect what was once a volatile system.

Our tether comprises of 22 conductors within a 7 cable bundle and is cable-tied at tight intervals to keep it secure. With a length of 20 metres and strain-relieved top and bottom, it suits our style of operation - especially for the MATE missions.

# Control/Electrical 2.4

The Micro controller (Arduino Mega) first goes into an initialisation phase as show below:

```
void loop() {
  Usb.Task();
  if (PS3.PS3Connected) {
    PS3.setLedOn(LED1);
```

This can predefine the values used throughout the program and sets up serial communications which is what we use for debugging to analyse when the code breaks down if it occurs at any point throughout its execution. All of the motors are assigned pins and set to neutral via PWM. There is a 2 second delay to allow the motor drivers (ESCs) to arm, not giving them enough time to arm can cause the motors to malfunction.

```
    rightY = PS3.getAnalogHat(RightHatY);
    rightX = PS3.getAnalogHat(RightHatX);
    leftY = PS3.getAnalogHat(LeftHatY);
    leftX = PS3.getAnalogHat(LeftHatX);
```

It will then enter the main program which controls the motor signal output and manipulator behaviour on the ROV. It first checks if the controller (any PS3 model which is an advantage due to its interchangeability) is connected to the USB shield present on the Arduino and it will indicate it via an LED on the controller that it is ready. As it is connected data from the controller is collected and put into direction variables:

```
void loop() {
  Usb.Task();
  if (PS3.PS3Connected) {
    PS3.setLedOn(LED1);
    rightY = PS3.getAnalogHat(RightHatY);
    rightX = PS3.getAnalogHat(RightHatX);
    leftY = PS3.getAnalogHat(LeftHatY);
    leftX = PS3.getAnalogHat(LeftHatX);
    if (leftY > MAXB) {  //back
      forwardThrottle = map(leftY, MAXB, 255, NEUTRAL, MAXT);
      backwardThrottle = map(leftY, MAXB, 255, NEUTRAL, MINT);
      T1.write(backwardThrottle);
      T2.write(backwardThrottle);
      T3.write(forwardThrottle);
      T4.write(forwardThrottle);
```

Example of PS3 control code


PS3 controller being used at poolside

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# Control/Electrical

```
rightY = PS3.getAnalogHat(RightHatY
rightX = PS3.getAnalogHat(RightHatX
leftY = PS3.getAnalogHat(LeftHatY);
leftX = PS3.getAnalogHat(LeftHatX);
```

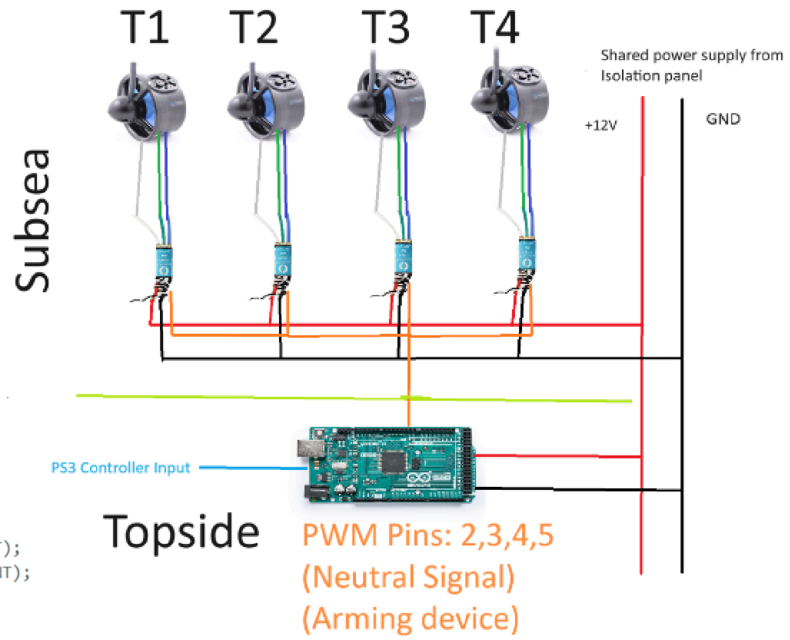
These variables are then used to compare in ‘if statements’ to send directional signals for the motors to operate, this is the simplest method of motor control and still retains precise throttle control:

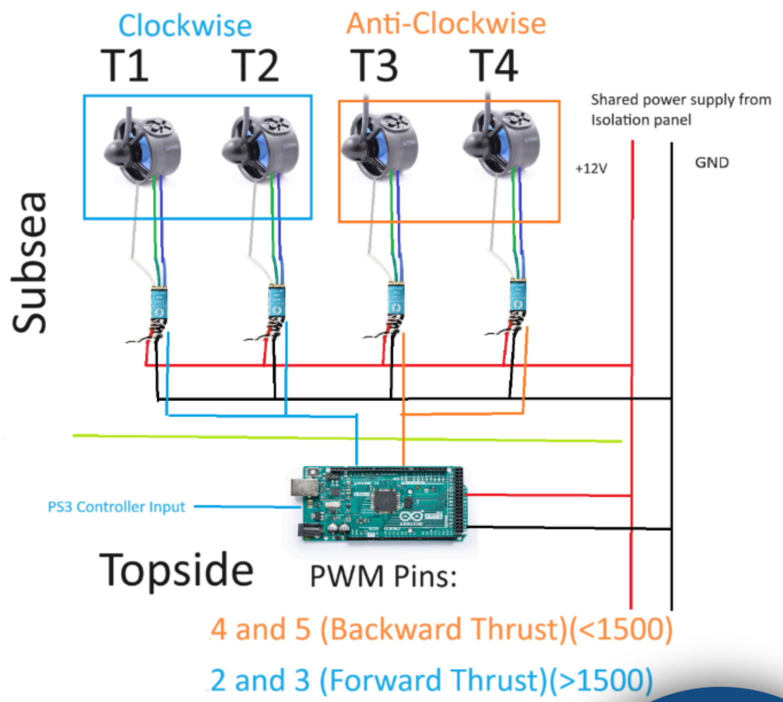
```
} else if (leftY < MINB) {   //forward
  forwardThrottle = map(leftY, MINB, 0, NEUTRAL, MAXT);
  backwardThrottle = map(leftY, MINB, 0, NEUTRAL, MINT);

  T1.write(forwardThrottle);
  T2.write(forwardThrottle);
  T3.write(backwardThrottle);
  T4.write(backwardThrottle);
```

Where the throttle is mapped from neutral to maximum throttle depending on the value of how far in between the joystick's current position is from its neutral position on the Y axis.

To the right an exemplification of the system in operation:

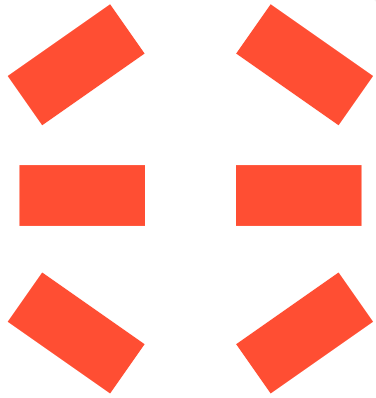


# Buoyancy

2.5

Our buoyancy and propulsion systems have changed to accommodate new changes in the electrical schematic as well, as the accelerometer was removed we have added more buoyancy to the top of the vehicle and heavy weight on the bottom of the vehicle to act as a ballast. The greater difference in buoyant force and weight would ensure a stable centre of gravity for the ROV to execute operations. Propulsion is conventionally set out as two motors control vertical thrust and four control horizontal thrust, each of which within 30 degrees of each other to give optimised efficiency in forward/reverse directions.



Thruster Layout

To ascertain the buoyant force needed to achieve neutral buoyancy we utilised Archimedes Principle.

To which states a general formula: Buoyant Force = Fluid Density*Volume displaced*Gravitational force

First we found it's weight by measuring the ROV with a newton scale and found it's volume and therefore volume displacement:

$Fb = \rho Vg$

| | | |
|---|---|---|
| Fb | = | buoyant force |
| ρ | = | fluid density |
| g | = | acceleration due to gravity |
| V | = | fluid volume |

$Fb=(999)(9.8)(0.00381)$

$=37.3N$

$W = mg$

$75 = m\ (9.8)$

$m = 7.65kg$ (3 s.f)

$Mg - Fb = \rho Vg$

$V=mg-Fb/\rho g$

$=(7.65)(9.8)-37.3/(999)(9.8)$

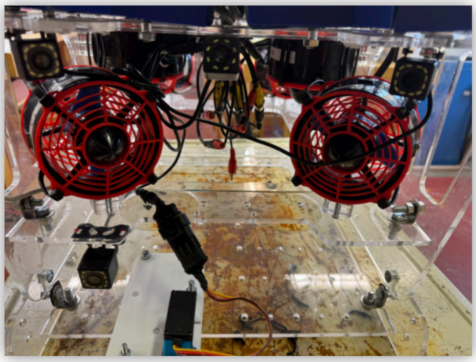
$=0.0038m^3$

# Payload & Tooling 2.6

Cameras

The ROV currently operates with four cameras, one is used for a direct view of the manipulator to complete many tasks required this year. Two cameras are angled at 30 degrees to allow us to have a sense of depth when operating the vehicle. Our final camera is facing forward with a light this will mostly be used for tasks where we need to visually inspect an area - for example such as this year with the coral restoration area.

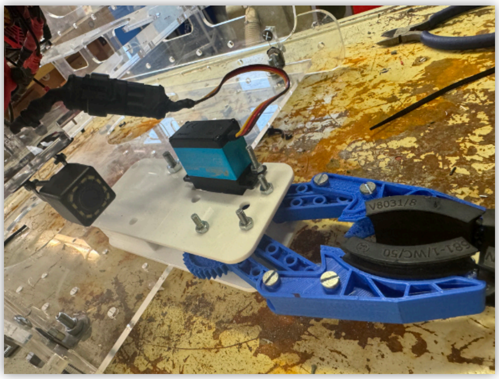
Our cameras are re-purposed car reversing cameras since they are cost effective and have exceptional longevity. This creates a more viable system rather than buying water proof cameras. All these factors work to reduce our costs and improve efficiency.



Camera Layout

Manipulator

The manipulator is specifically designed this year to be quickly and efficiently modified since at the previous competition the servo on our manipulator became uncalibrated and was nonfunctional which was detrimental to the mission. We have improved our design by 3d printing our own claw to allow for the servo to be quickly replaced if necessary.



Manipulator mounted on vehicle

Temperature Sensor

The temperature sensor is one of our key specialist tool which we implemented to allow us to take temperature readings in the pool of its surroundings and cross reference it with temperature data to see the effects of global warming.

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# Prototyping & Troubleshooting

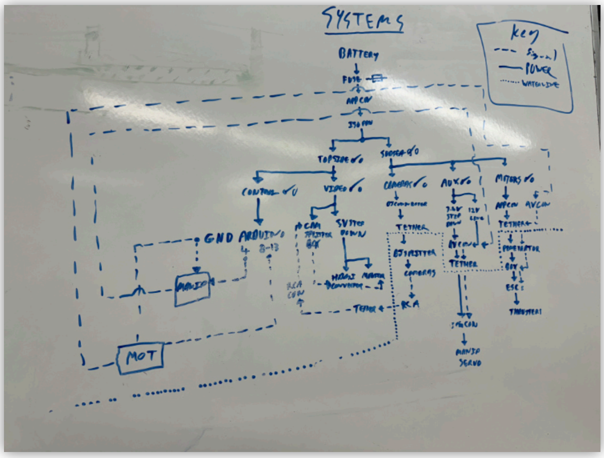
# 2.7

In our design process, we start with sketches on paper to discuss and troubleshoot ideas. Next, we use CAD software such as Autodesk Inventor to make detailed digital models. These models are then made into physical prototypes using our 3D printers or laser cutter, which helps us keep costs down and work efficiently.

To make sure our designs are to the right dimensions, we use computer rendering to see them in 3D. We also make cardboard models to get a better idea of how they'll look and function with real parts and electronics.

By combining paper representations with modern digital tools, we make sure our designs are reliable and cost-effective while still meeting our high standards.

This year we introduced a Design Review Panel which includes industry professionals to help guide our decision when it came to crucial aspects of the project such as the frame where the board was first consulted.




ROV electrical system being first planned out

Discussing preliminary design with his Majesty the King

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# Systems Approach 2.8

When sitting down to our first planning meeting of the year at the beginning of our MATE Campaign, there were dozens of ideas being discussed, some made it onto paper, few into prototypes before finally everything was pieced together into one plan to create KC3. The systems largely follow the same principles as last year as we were pleased with how last year's vehicle operated.

System improvements based on lessons learned:

- Serial Communication was omitted where possible as we found there was a lot of interference in the signal leading to reliability problems. It has now been replaced with more analogue systems and any signal going down the tether went straight to each component using PWM – this has proven to be reliable thus far.
- We decided against using a 4-way camera splitter as it proved very unreliable – as an alternative we are using three individual RCA monitors ran directly from the RCA output of our cameras.
- A cuboid pressure vessel was chosen subsea to house our electronics over the vertically mounted cylinder with two end caps we used last year. This adds stability to the vehicle and improves accessibility to maintain components.
- Aviation connectors have been used topside which allows the tether to be separated from the control box for transportation.
- Wire gauge has been adapted to allow greater current flow without causing the wires to heat up.
- Sealing of components has been more thorough to ensure reliability.

A PS3 controller is an interface many people are already well accustomed with and with two analogue sticks (4 axis) it suits the nature of the vehicle's thruster layout. Our on board temperature sensor allows an added layer of inspection capabilities and are pivotal to specific operations allowing the pilot insight into such data. Feedback from subsea gets automatically processed and cross-checked by the program on the topside Arduino.

# Budget

3.0

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Income | | | Items | | | | |
| Description | Amount | | Description | Amount | Donation value | USD conversion | exhange rate (converted on 21/05/2024) |
| Sponsored Donations | £250.00 | | Control Box | | £300 | $381.00 | 1.27 |
| Previous Funds carried forward | £2,136 | | Monitor | £ - | £100 | $127.00 | |
| | | | Frame & Facia Acrylic | £ - | £175 | $222.25 | |
| | | | Thrusters already purchased | £ - | £580 | $736.60 | |
| | | | Motor ESC | £ 180.00 | £ - | $228.60 | |
| | | | Bottle & connectors | £ 75.00 | £ - | $95.25 | |
| | | | Controllers | £ 40.00 | £ - | $50.80 | |
| | | | Tether | £ - | £250 | $317.50 | |
| | | | Arduino | £ 60.00 | £ - | $76.20 | |
| | | | Servo - Water proof | £ 25.60 | £ - | $32.51 | |
| | | | Cabling | £ 15.00 | £ - | $19.05 | |
| | | | Monitor switch unit | £ 53.00 | £ - | $67.31 | |
| | | | Manipulator | £ - | £45 | $57.15 | |
| | | | Solder iron & solder | £ 30.00 | £ - | $38.10 | |
| | | | Bouyancy Plastic | £ 3.50 | £ - | $4.45 | |
| | | | Electronic Equipment for Ardunio | £ 90.00 | £ - | $114.30 | |
| | | | Rasperry Pi & Screen | £ 80.00 | £ - | $101.60 | |
| | | | Cameras x 5 | £ 116.60 | £ - | $148.08 | |
| | | | TV adaptor | £ 21.20 | £ - | $26.92 | |
| | | | BNC Male Adapators | £ 9.32 | £ - | $11.84 | |
| | | | USB Panel Mount x 2 | £ 6.54 | £ - | $8.31 | |
| | | | Anderson Power Panel Mount | £ 5.49 | £ - | $6.97 | |
| | | | USB 90 Degree | £ 2.69 | £ - | $3.42 | |
| | | | Car Headlight Buzzer | £ 4.95 | £ - | $6.29 | |
| | | | Lithium NICD Battery | £ 19.25 | £ - | $24.45 | |
| | | | RCA Plug x 2 | £ 13.20 | £ - | $16.76 | |
| | | | USB Type B to Type B Cable | £ 3.95 | £ - | $5.02 | |
| | | | Threaded Bar | £ 8.90 | £ - | $11.30 | |
| | | | type D Panel Mount | £ 15.99 | £ - | $20.31 | |
| | | | USB C Cable | £ 7.99 | £ - | $10.15 | |
| | | | Syringe - Tooling | £ 6.49 | £ - | $8.24 | |
| | | | DC Voltager Regulator | £ 8.99 | £ - | $11.42 | |
| | | | Wire connections | £ 6.99 | £ - | $8.88 | |
| | | | Miscellaneous | £ 146.50 | £ - | $186.06 | |
| | | | Registration fee | £ 138.00 | £ - | $175.26 | |
| Total Income | £2,386 | | Total Expediture | £ 1,195.14 | | $1,517.83 | |
| Cash Flow | £1,190.86 | | | | | $1,512.39 | |

## Build/Buy

The question we face when looking for new parts and solutions to problems is build vs buy. As a team we feel it is vitally important that we are environmentally conscious with all our decisions while taking into account economic sustainability.

Our frame was entirely manufactured in house. Outsourcing such a key part of our vehicle simply did not make sense. When using our laser cutter, the whole team takes great pride in showcasing our skills through our manufacturing process which is why for our frame we chose build over buy. This also allows us to have a much more detailed of a fine tuning process and allows us to understand our vehicle more. Part of the challenge is to showcase our skills and by outsourcing our needs we are unable to do so.

# Expenditures

3.1

| | Item Ordered | Price per item | Number of items | Order cost |
|---|---|---|---|---|
| | T200 Thrusters | £ 190.00 | 1 | £ 190.00 |
| | ESCs | £ 28.92 | 2 | £ 57.84 |
| 7401&mkg | 3-Axis Potentiometer | £ 13.19 | 1 | £ 13.19 |
| | Filament - Black | £ 35.21 | 0 | £ - |
| | Filament - Yellow | £ 33.24 | 0 | £ - |
| | Filament - Blue | £ 37.45 | 0 | £ - |
| d=CjwKCAjv | 2-Axis Potentiometer | £ 2.50 | 2 | £ 5.00 |
| &hvqmt=&l | Electronic spray | £ 12.99 | 0 | £ - |
| 21193&hvp | Servo | £ 21.99 | 1 | £ 21.99 |
| rd: Raspber | Nuts and Bolts | £ 42.43 | 0 | £ - |
| -9842-e535 | Wago Blocks | £ 14.44 | 1 | £ 14.44 |
| 2-4141-a62 | Wago DIN | £ 16.99 | 1 | £ 16.99 |
| | Raspberry Pi Outputs | £ 3.30 | 0 | £ - |
| o=&hvqmt= | Rubber trim | £ 10.74 | 1 | £ 10.74 |
| | Peli Case | £ 166.16 | 0 | £ - |
| | HDMI connector | £ 10.66 | 0 | £ - |
| | USB A Connector | £ 5.96 | 0 | £ - |
| | USB B Connector | £ 5.96 | 0 | £ - |
| | 3-Pin Connector | £ 0.77 | 5 | £ 3.85 |
| | 3-Pin Connector female | £ 1.17 | 0 | £ - |
| | 3-Pin Connector Pins | £ - | 0 | £ - |
| | Ethernet connector | £ 5.16 | 0 | £ - |
| OGyXBLXco | Corner brackets | £ 1.16 | 5 | £ 5.80 |
| nS-XhRY3LI | 0mm Acrylic tube (3mı | £ 25.14 | 0 | £ - |
| nS-XhRY3LI | 0mm Acrylic tube (3mı | £ 31.83 | 0 | £ - |
| | Black Rod 120mm dia x | £ 42.30 | 0 | £ - |
| n=1 | Hose | £ 24.99 | 0 | £ - |
| wsAYubgl2 | Data Cable | £ 20.73 | 0 | £ - |
| QQm1eMz! | Power cable (red 20m) | £ 53.99 | 1 | £ 53.99 |
| QQm1eMz! | ower cable (black 20m | £ 53.99 | 1 | £ 53.99 |
| | Silding pots x3 | £ 7.10 | 1 | £ 7.10 |
| | Data Cable | £ 59.51 | 1 | £ 59.51 |
| om) | pressure box | £ 36.32 | 1 | £ 36.32 |
| BlcW69DgB | pin aviation connecto | £ 4.75 | 2 | £ 9.50 |
| BlcW69DgB | 0 pin aviation connectc | £ 4.95 | 1 | £ 4.95 |
| :W69DgBK3 | pin aviation connecto | £ 3.75 | 4 | £ 15.00 |
| | fuse holders | £ 9.69 | 1 | £ 9.69 |
| | M6 bolts | £ - | 0 | £ - |
| | M3 25mm bolts | £ - | 0 | £ - |
| | M4 bolts | £ - | 0 | £ - |
| | vacum forming sheets | £ 29.12 | 1 | £ 29.12 |
| 91354 | cameras | £ 29.17 | 4 | £ 116.68 |
| 282708 | voltmeter | £ 3.25 | 1 | £ 3.25 |
| 5yy1h46VDv | 50A ammeter | £ 7.24 | 1 | £ 7.24 |
| | NEW Connectors x1 | £ 6.90 | 0 | £ - |
| | | | | £ - |
| 5947722928 | Rf transciever | £ 7.99 | 1 | £ 7.99 |
| leloc=10073 | GPS (neo-6m) | £ 5.90 | 1 | £ 5.90 |
| 723&sr=8-1 | GPS | £ 12.99 | 1 | £ 12.99 |
| &qid=16953 | compass | £ 5.99 | 1 | £ 5.99 |
| | servo | £ 14.99 | 2 | £ 14.99 |
| ntype=&pla | battery | £ 23.54 | 1 | £ 23.54 |
| utm_mediu | housing | £ 3.19 | 1 | £ 3.19 |
| sd%2Bcard | sd card | £ 4.49 | 1 | £ 4.49 |
| | | | | £ - |
| utm_camp | camera | £ 24.00 | 1 | £ 24.00 |
| | Servo | £ 14.99 | 1 | £ 14.99 |
| | rasberry pi pico | £ 4.80 | 2 | £ 9.60 |
| _campaign= | voltage booster | £ 7.70 | 1 | £ 7.70 |
| EgLzKfD_Bv | Battery charging board | £ 7.53 | 1 | £ 7.53 |
| 4&CMP=KN | replacement gaskets | £ 6.56 | 1 | £ 6.56 |
| | Multiple | £ 38.45 | 1 | £ 38.45 |
| | Multiple | £ 81.24 | 1 | £ 81.24 |
| &qid=16953 | compass | £ 4.99 | 1 | £ 4.99 |
| | rasberry pi pico | £ 6.30 | 1 | £ 6.30 |
| _1_4?c=ts8 | jumper wires | £ 5.94 | 1 | £ 5.94 |

| Delivery Status |
|---|
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Ordered |
| Delivered |
| Delivered |
| Delivered |
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| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Delivered |
| Ordered |
| Delivered |
| Ordered |
| Ordered |
| Ordered |

| Total Cost of Orders |
|---|
| $ 1,311.35 |

| Available funds |
|---|
| $ 2,381.25 |

| Total funds surplus |
|---|
| $ 1,358.77 |

| Percentage Budget Used |
|---|
| 55.07% |

Order Now

Dont Order Yet

This MATE mission campaign we used a singular excel spreadsheet to track orders. This allowed us to share with our mentor what needed to be ordered and provide a direct hyperlink to it as well. Our mentor also updated this spreadsheet to show us what had been ordered and had been delivered. We chose to do this so that we no longer had to locate parts and query whether something had been ordered. And it provided us with a live update of what we had spent.

# Appendix 3.2

## Safety Procedures

Head of design wearing PPE

<u>Pre flight checklist</u>

**DECK SETUP**

All non-poolside crew step away from the demonstration area
Control box is on table and opened
Tether is uncoiled - no kinks or loops
ROV is in launch area
Check all signal connections – AUX, MOT and AV
Check all power connections – MOT, CAM
Connect battery

**POWER UP**

Turn on MAIN power switch
- Check voltmeter reading for sufficient voltage (12V)

Turn on TOP, VID
- Both screens should turn on

Turn on SUB, CAM
- Camera lights should illuminate, and monitors should display picture

Turn on MOT
- 3 tone beeps should sound

Turn on CON
- Arduino lights should turn on t
- Voltage regulators should turn on Arduino and
- Controller light should illuminate steadily

Wait for seven second initialisation period
- Motors should be responsive to controller

Turn on AUX
- Manipulator should now be responsive

Deploy vehicle in water

**<u>Mintlaw ROV Operation Checklist</u>**

Personnel should complete the following items in order:

- ❑ Check if the systems start-up is permitted
- ❑ Conduct pre-flight inspection
- ❑ Engineer signs off vehicle
- ❑ Pilot conducts pre-flight checks
- ❑ Pilot signs on vehicle
- ❑ OPERATION
- ❑ Pilot conducts post-flight checks
- ❑ Pilot signs off vehicle
- ❑ Pilot completes flight log
- ❑ Engineer conducts post-flight inspection
- ❑ Engineer signs on vehicle

# JSA

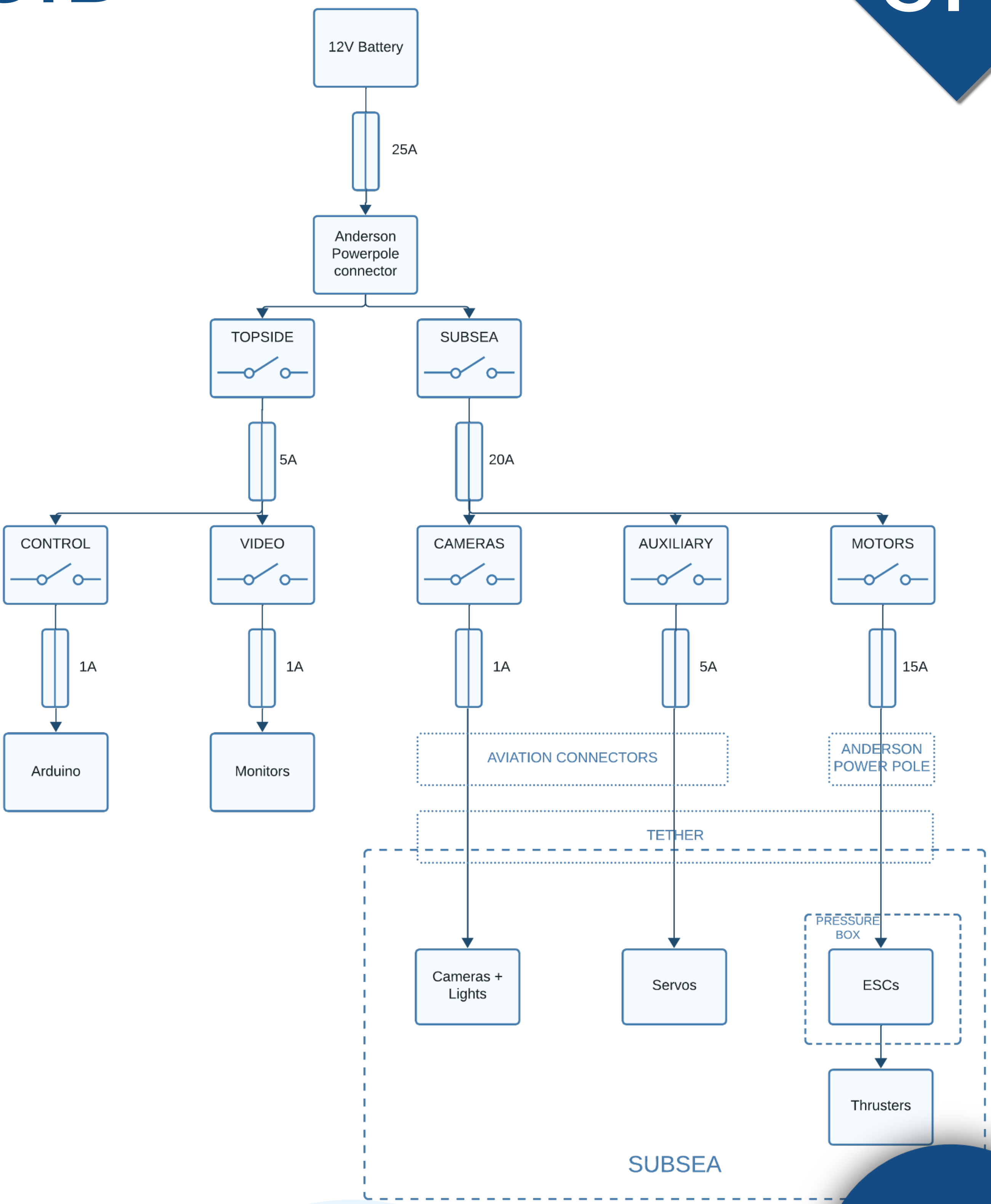
3.3

**Mintlaw ROV Jobsite Safety and Environmental Analysis (JSEA)**

| Identified hazard | Who may be harmed and how | Precautions taken to control risks | Responsible persons |
|---|---|---|---|
| Poolside operation | Persons at poolside could drown if fallen into water and become submerged.<br>Personnel topside and divers could experience electric shocks or burns from short circuits. | There are numerous risks regarding poolside operation. These can be minimised drastically if all the following measures are used:<br>• All personnel poolside should be confident and competent swimmers in case of falling into water<br>• Number of personnel poolside should be minimised to only essential roles<br>• All personnel should be made aware before systems become live<br>• The tether manager should always keep the tether out of harm's way and free of 'kinks'<br>• The vehicle should be launched and recovered with care and communication to the pilot and other crew is essential | Pilot<br>Tether manager<br>Safety officer |
| Trip hazards | Persons in workspace could suffer a trip, slip, or fall injuring themselves. | Any resources used to carry out work to systems should be neatly stored away after use.<br>When operating vehicle, power and data cables should be neatly routed.<br>Tether should be neatly and safely coiled when not in use and when systems are live, tether manager should ensure tether always has slack and is not tanged. | Poolside engineer<br>Safety officer |
| Exposed wiring | Persons involved in live testing/operations could be experience electric shocks or suffer burns from short circuits. | All wiring should be insulated and if control box, safely covered by paneling if unable to properly insulate (i.e. PCBs.)<br>Tether should be regularly checked as part of the post-flight inspection to ensure there are no 'nicks' or kinks.<br>To ensure safety at poolside, control panel should never be lifted in case water enters wiring. | Poolside engineer<br>Safety officer |

# SID

3.4


12V Battery
25A
Anderson Powerpole connector
TOPSIDE
SUBSEA
5A
20A
CONTROL
VIDEO
CAMERAS
AUXILIARY
MOTORS
1A
1A
1A
5A
15A
Arduino
Monitors
AVIATION CONNECTORS
ANDERSON POWER POLE
TETHER
PRESSURE BOX
Cameras + Lights
Servos
ESCs
Thrusters
SUBSEA

# Acknowledgements

3.5

Miss Wappler has provided invaluable support towards our technical documentation with respect to our grammar and spelling

We are incredibly grateful to Michael Wachucik, AberMedia for photographing many of our key industry engagements

# References

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