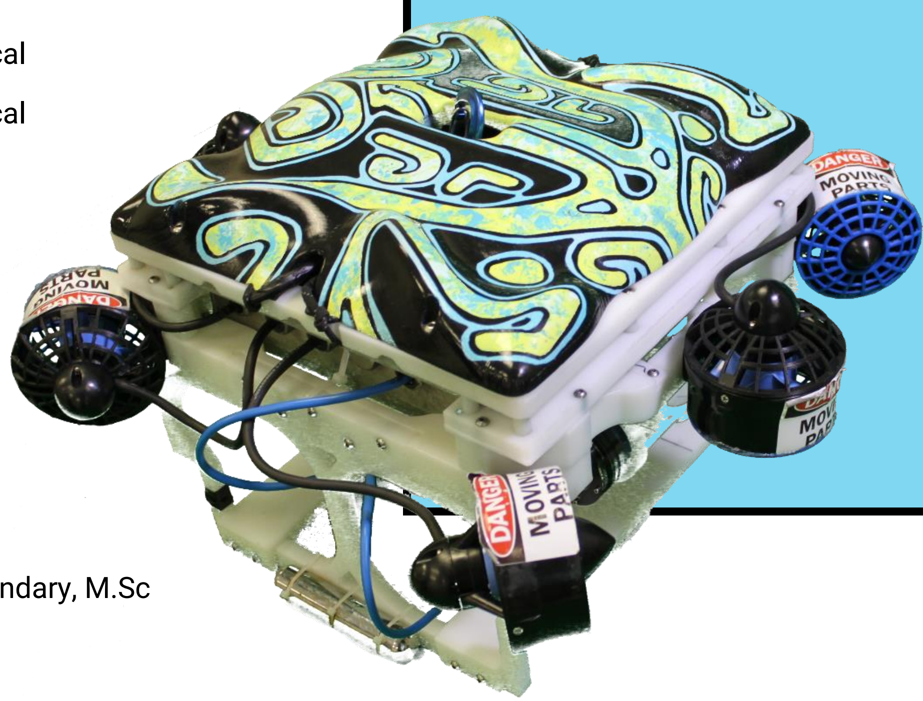
Eastern Edge Robotics

Employee Information

Name	Role/Discipline
Michaela Barnes	Chief Executive Officer
Stephen Chislett	Chief Financial Officer
Keely Lullwitz	Chief Safety Officer
Nick Graham	Chief Technical Officer – Electrical
Tybalt Lea	Chief Technical Officer – Mechanical
Keith Sutherland	Chief Technical Officer – Software
Christian Samson	Pilot
Sarah Dawe	Administration
Biko Brideau	Electrical
Mark Belbin	Electrical
Aaron Kennedy	Mechanical
Nathan Hollett	Mechanical
Liam Gregory	Payload
Stephen Snelgrove	Payload
Andrew Troake	Software
Charity Talbot	Software
Josh Kearney	Software
Julia Dawe	Software



Company Mentors

Paul Brett, B.Sc (Hons), B.Ed Post Secondary, M.Sc

Heather Conway, BBA, MBA

Joe Singleton, P.Eng

Anthony Randell, B.Eng

Memorial University, St. John's, Newfoundland and Labrador, Canada

MATE International ROV Competition 2018

Abstract

Eastern Edge Robotics is a multi-disciplinary company focused on developing underwater robotic solutions for real-world problems. Our company has been developing Remotely Operated Vehicles (ROVs) for 16 years, securing four previous contracts from the Marine Advanced Technology Education (MATE) Organization. In 2018, Eastern Edge Robotics has custom designed an all new product, ROV Florizel, in response to the Washington University Applied Physics Laboratory's (APL) Request for Proposals (RFP). This ROV is named in honor of the 100th anniversary of the sinking of the SS. Florizel, a prominent vessel in Newfoundland's history.

ROV Florizel, or Flo for short, has been optimized to not only meet, but exceed all safety requirements set forth in the RFP. Flo was designed to operate in the extreme ocean conditions found in the Pacific Northwest, while still remaining compact and light for ease of transport. The ROV is combined with a payload system custom designed to complete the Aircraft, Earthquakes, and Energy missions outlined in the RFP.

Eastern Edge is comprised of 18 employees organized into five departments, allowing the company to maximize employee skills and focus on individual ROV systems. Combined, our employees have committed over 8,000 hours to planning, designing, and testing ROV Florizel to create a system that is highly efficient and modular to fit the client's needs. ROV Florizel was designed at a Fair Market Value of $5,376.12.

Figure 1: *Company Employees. Photo Taken at the Marine Institute*
(L-R): Mark Belbin, Biko Brideau, Nathan Hollett, Charity Talbot, Tybalt Lea, Christian Samson, Stephen Chislett, Liam Gregory, Andrew Troake, Josh Kearney, Stephen Snelgrove, Michaela Barnes, Julia Dawe
Missing: Aaron Kennedy, Keely Lullwitz, Keith Sutherland, Nick Graham, Sarah Dawe

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1.0 Safety

1.1 Safety Philosophy

At Eastern Edge Robotics, safety is our top priority. The company strives to ensure that all employees, the public, and other stakeholders are within a safe working environment. The focus of the company's approach is an open safety culture, encouraging employees to present safety concerns when noticed. Senior employees mentor new employees about workplace hazards and how to safely complete tasks. Eastern Edge promotes safe work practices to ensure safe working procedures are a priority for all activities. The company's open safety culture pertains to the company's safety philosophy: Nobody gets hurt.

1.2 Safety Features

ROV Florizel exceeds all safety requirements outlined in the 2018 contract. Flo's safety features include, but are not limited to: a 30 A fuse within 30 cm of the ROV power supply; thruster guards designed to prevent 12.5 mm diameter entry and 2 mm clearance on both sides of the propeller; smooth round edges on all vehicle components; warning labels on all moving parts and power connections; and strain reliefs on the vehicle's tether on both sides. Flo also integrates hardware and software kill switches to put the ROV in safe mode in case of emergency. The company continues to use threaded inserts to replace nuts and protruding bolts. This year the vehicle buoyancy block has been painted bright colours, increasing the vehicle visibility for employees working nearby. Florizel's frame was designed to be ergonomically friendly while lifting.

1.3 Safety Protocols

Before every work day and ROV launch the company completes a Job Safety and Environmental Analysis (JSEA) and Operational Safety Checklist (OSC). JSEAs and OSCs are completed prior to starting work and are addressed in Toolbox Talks. Toolbox Talks allow for open discussion of work to be completed and the potential hazards associated with the work. The JSEA encourages personnel to follow safe working procedures and reminds the employees of the importance of wearing Personal Protective Equipment (PPE). This year the company has added a compressed air operation section to the JSEA. Copies of the JSEA can be found in Appendix A, and a copy of the OSC can be found in Appendix B.

In 2017 Safety Passports were introduced as a method of recording employee health and safety training. The safety passports identify tools and equipment that the employees are permitted to work on and are given after receiving training from a senior employee. For each tool on the passport, the junior employee is shown the associated PPE, receives a verbal explanation of safe operation, receives a demonstration of the correct operating procedure, and is then monitored using the equipment. The safety passports contain a section for training and certification where the employee can state any formal health and safety training they have received, such as First Aid. Employees are required to obtain proper authorization on their passport before using any piece of shop equipment.

To ensure shop safety at all times, Eastern Edge has posted a list of employees who are certified in First Aid and the level of certification they have received. If an incident occurs the injured or bystander are able to find a first aid attendant immediately. Hazardous products that are used by the company are contained within a cabinet in the company storage room. Outside of the cabinet, the Safety Data Sheet (SDS) handbook is stored outlining the hazards and first aid instructions for said products.

2.0 Design Rationale

The company designed Florizel's vehicle, electrical, and software systems by first considering the overall mission requirements. Each task was then evaluated on how the systems needed to be designed to implement solutions. Eastern Edge promotes the flow of innovation through brain-storming sessions, led by the company CTOs. Departments then design and model each system while ensuring cross-system compatibility. Designs are then manufactured with an iterative prototyping process, which entails theoretical and scientific testing. Once designs are finalized, they are integrated and tested in Flo's architecture. The systems are designed to be modular to allow for user flexibility. Eastern Edge strives to provide the end user with a product that is easy to use and maintain.

2.1 Vehicle Systems

Chassis

When designing the chassis, Eastern Edge aimed to create a sturdy and robust frame to withstand the environmental conditions of the Pacific Northwest. The employees in the mechanical department began the chassis design process by comparing previous models to find weakness and errors. Last year's chassis lacked rigidity due to a lack of support braces; Florizel's frame integrates more structural braces while maintaining a skeletal structure. This skeletal structure provides open space for tooling and camera view. The chassis' symmetric design allows for bi-directional operation, maximizing Flo's payload capacity.

Florizel's chassis, seen in Figure 2, consists of sixteen High-Density Polyethylene (HDPE) pieces, all individually manufactured on a Computer Numerical Control (CNC) router by Eastern Edge employees. HDPE was chosen as the construction material for Florizel over materials such as aluminum due to its lower density and high tensile strength. The company has a stock of HDPE from previous contracts, therefore these resources were allocated to the chassis to reduce costs. The pieces are assembled using bolts and heat-set inserts. Florizel was designed such that the heat-set inserts were placed on the opposite side of the part, opposed to last year's design in which inserts were placed on the adjacent side of the part. This forces the bolt to pull the insert through the part, instead of pulling the insert out of the part. Changing the placement of the inserts provided a more secure connection of the joints.

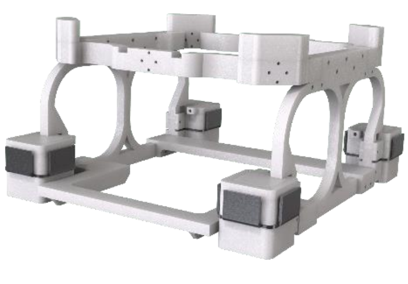


Figure 2: Rendering of Chassis

Buoyancy

To obtain neutral buoyancy underwater, Flo employs a fixed flotation and ballast system. This counterbalances the weight of the frame, electronics, and tooling. Additionally, Flo achieves hydrostatic stability by positioning the flotation and ballast at a maximum distance between the top and bottom of the vehicle, respectively. This keeps the Center of Buoyancy (CB) vertically above the Center of Gravity (CG), which generates a restoring moment to neutral orientation after roll or pitch.

This vehicle's flotation is built out of a low density material, Divinycell foam, which takes advantage of Archimedes principle to provide an upward force on the vehicle. Divinycell was further chosen for its high durability, low water absorption, and ability to be machined into free form topologies using the companies CNC router. The main buoyancy block, seen in Figure 3, is machined into a streamlined shape using a biomimetic model, allowing it to ascend and descend quickly without experiencing unstable drag. This buoyancy block is modularly assembled allowing the vehicle to be modified for buoyancy in salt and freshwater as per APL's RFP. For ballast, the company chose a system of modular lead weights attached at various points on the frame. The system modularity allows the vehicle to be quickly trimmed for optimal stability under various payload conditions.

Figure 3: Top (left) and Bottom (right) of Buoyancy Block

Propulsion

The company chose to use Six Blue Robotics T200 thrusters for propulsion on ROV Florizel. Reliability was the primary consideration for using commercial thrusters over built in house thrusters. The company has found these thrusters to continue to work, mission after mission, with little need for maintenance. With the slightly larger size allowances in this year's RFP, the thrusters were moved farther from Florizel's centre of mass. This means that the ROV has a higher thrust to power ratio than in previous years. The thruster configuration, as seen is Figure 4, provide five degrees of freedom (surge, sway, heave, yaw, and pitch). The configuration design was inspired by standard industry practices [1]. Based on the types of tasks presented, Eastern Edge decided to keep the thrusters fore and aft to give the pilot pitch control. Heavy payloads, attached fore or aft, would cause an imbalance in the attitude of Florizel. By having pitch

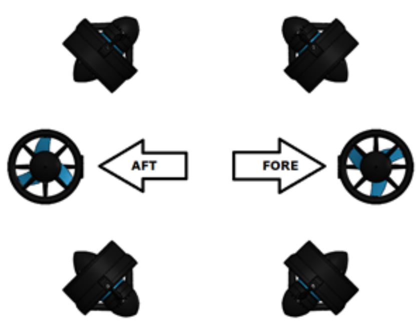


Figure 4: Thrust Configuration

control, the ROV can be kept level despite the required payloads. The thrusters are modular allowing them to be replaced in the rare case of a failure.

Cameras

Florizel's camera assemblies were designed for ease of assembly, maintenance, and protection of the electronic components. Last year's camera assemblies had the camera and motor separately waterproofed, with a belt mounted to facilitate rotation. The belts often slipped because the motors would rotate in their clamps. The motors would also eventually fail due to problems with waterproofing. The new assembly puts the camera and motor in the same enclosure.

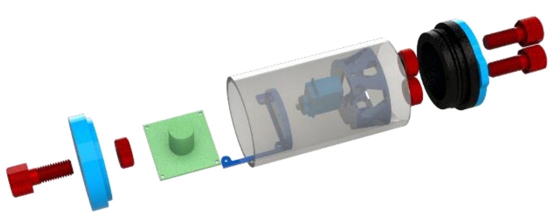


Figure 5: Camera Assembly Exploded

The camera assembly is installed in a Blue Robotics 2" Acrylic Tube and is sealed with their Flange and End Cap (Figure 5). The camera is attached to a 3D printed part that is directly screwed into the servo motor. This eliminates the actuation problems from the previous year. The motor is then attached to a 3D part that is screwed into the aluminum flange. This makes it so that the entire camera assembly can be removed from the tube for maintenance. A vent plug has been installed in the far end of the tube that allows air to exit the tube when the assembly is installed. The plug is then closed so that the camera tube maintains surface pressure when underwater. Flo has a camera mounted on the fore and aft of the vehicle to facilitate bi-directional movement. The cameras rotate such that the pilot can choose to look out or back through the chassis.

To meet previous contracts, Eastern Edge used Raspberry Pi single board computer based camera modules, also known as Pi Cams. The Pi Cams provided high levels of configurability, easily integrated with image processing software, and had a wealth of information for troubleshooting online; however, the company found that these cameras were bulky, were relatively expensive, required additional components to integrate, and had very poor image quality in underwater environments.

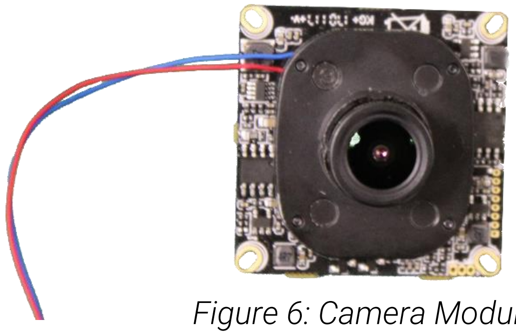


Figure 6: Camera Module

Florizel integrates a camera module based on the Hi3516 single board computer and the IMX322 image sensor (Figure 6). This module maintains the ease of software integration and configuration, while being less expensive, easier to integrate physically, and is better suited for underwater video streaming. There is reduced red-light intensity in underwater environments [2], which leads to a strong green ting to appear on underwater video; this new camera module colour corrects for this effect, while also auto-adjusting video brightness, which is a great improvement over the Pi Cams.

Electronics Enclosure

The company chose to use the same enclosure for a second year as the ROV's primary electronics enclosure. This layout is large enough to accommodate the central electronic components and is rectangular for ease of installation and maintenance. The bottom and walls are aluminum, acting as a sink for the heat generating components, like the DC/DC converters. The lid is 12.5 mm acrylic with a recessed O-ring in a face seal against the aluminum flange of the enclosure. The O-ring was designed as per the Parker O-ring Handbook and is 5 mm in diameter. The company custom makes the penetrators for all wiring leaving the primary enclosure. This is achieved by boring out a ½" stainless steel seal bolt with built in O-ring face seals. The wire is then encased in the bolt with potting compound.

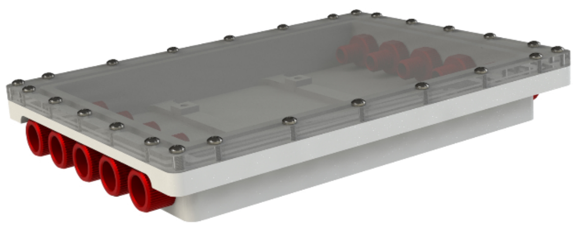
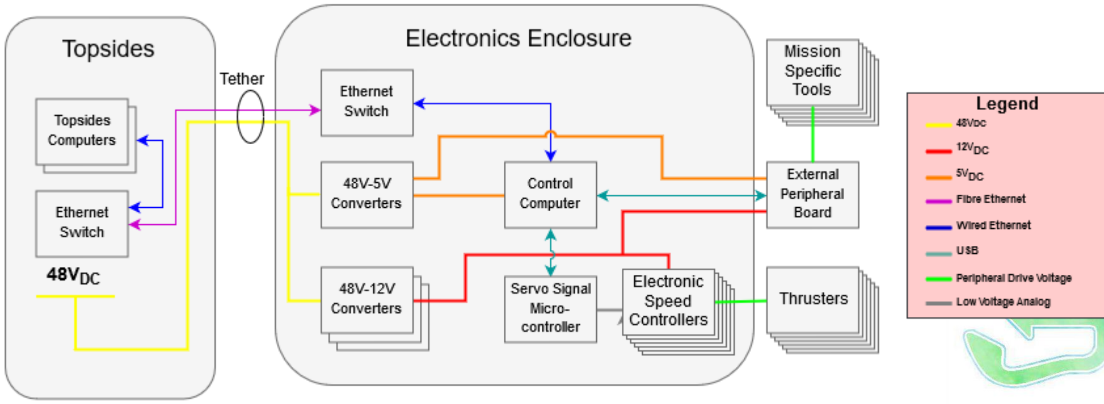


Figure 7: Rendering of Peripheral Board Enclosure

An external peripheral enclosure was developed to hold the tooling electronics, allowing for a more modular user experience. As mission tasks change, payloads need to change as well. This new external peripheral enclosure allows for the electronic elements of the payload to be changed without having to open the primary enclosure. This enclosure is also rectangular, to make it easier to fit the various circuit boards that it would be required to hold. Displayed in Figure 7, the box was manufactured out of HDPE using a CNC router and the lid is 12.5 mm acrylic with a recessed O-ring, like in the primary enclosure. The secondary enclosure is thin to keep it high and out of the view of the cameras, so smaller penetrators were required. The company opted to use Blue Robotics aluminum penetrators with potted wires due to their reduced size and reliability.

2.2 Electrical System

The core electronic system architecture onboard Florizel builds upon the contract winning architecture that Eastern Edge has used for the last two years. The system is designed around a gigabit Ethernet network over which the pilot, science officer, and any technicians working on the system can access the ROV's main control computer and camera feeds simultaneously. Florizel's electrical distribution system is designed to be robust and easy to service, while the communication system onboard makes adding additional functionality and tooling capability simple. An abridged System Interconnect Diagram is included below, and the full SID is included as Appendix C.



Topsides

In the past, Eastern Edge has utilized an enclosed Topsides Control Module (TCM) for ease of transport. It housed all of the necessary components for piloting and monitoring an ROV, but was unnecessarily complex for the majority of work that Eastern Edge performs. While this system was convenient for completing product demonstrations, it weighed over 310 N, and was thus too heavy to be lifted and transported by one employee. This year, the topsides system was redesigned in modules to allow a pilot to deploy Florizel quickly and efficiently with minimal deck crew.

The topsides system is designed to be lightweight, modular, and easy to use for testing. It includes a data processing laptop, an ROV control laptop, a small control box (Figure 8), and an extra monitor for displaying information to the pilot. This setup allows the pilot to test the ROV with only the dedicated control laptop and control box. Additional monitors and data processing laptops can be seamlessly added to the system to support more complex missions. As well, each individual component in this system is lightweight, meaning that the entire set-up can be deployed by one employee.

Figure 8: Topside Control Box

Tether

Florizel's tether is 8 mm in diameter and 14 m in length, and contains two 16 AWG conductors for power transfer, one optical fibre pair for communication, and one optical fibre pair for redundancy. The tether is neutrally buoyant in freshwater with mass of 890 g, and was created from extra stock that was graciously donated by Leoni-Elocab for the 2016 contract. Eastern Edge chose to re-use stock tether this year, rather than buying or building a new tether, in order to reduce the cost of the vehicle and to avoid disposing of functional stock material.

This tether was chosen for its low weight when compared to Eastern Edge's tether for the 2017 contract; however, this reduction in weight comes at the cost of available power for the ROV. While electrical resistance was an issue in the 25 m tether used in the 2016 contract, Eastern Edge is confident that the available power will not be a limitation for Florizel. By reducing the length of the tether to 14 m, the associated reduction of resistance increases the available power at the ROV from 511 W to 913 W.

Additionally, a ¼" pneumatic hose runs alongside the tether to aid in the completion of lift-bag based tasks, but does not enter the ROV's electronics enclosure.

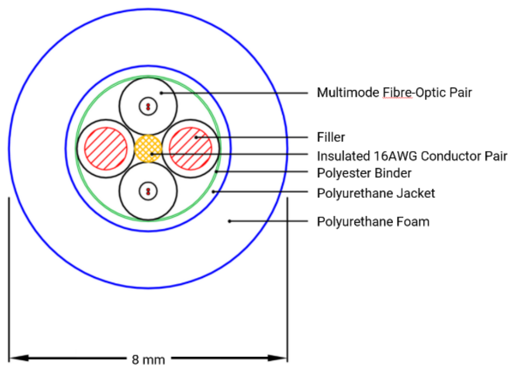


Figure 9: (Left) Cross Section of Tether. (Right) Tether and Pneumatic Tubing

Power Distribution

Florizel's power distribution system is made up of multiple parallel DC-DC converters, which convert the 48 V nominal input power down to regulated 5 V and 12 V busses from which all onboard electronics powered. The 5 V bus powers the computing, controlling, and sensing components onboard the ROV, and is supplied by a compact 60 W DC-DC converter. The 12 Volt bus powers Florizel's thrusters, tooling motors, cameras, and the Ethernet switch. In order to ensure safe operation in various component failure situations, this bus is supplied by three parallel 48 V - 12 V DC-DC converters, which can theoretically provide 1260 W to this bus.

Communications and Computing

Florizel's communication system is built upon a modular network of independent computers. The control and data processing laptops, the main control computer onboard the ROV, and the ROV's external cameras all communicate over an Ethernet network. The backbone of this Ethernet network are two Fibre-Optic switches, one on topsides and one within the ROV. Florizel's main control computer, a Raspberry Pi 3B, communicates serially with two microcontrollers to interface with external devices: one microcontroller for interfacing with the thrusters and one microcontroller on an external peripheral board contained in the secondary enclosure for completing mission-specific tooling tasks. This modular system allows for cameras to be easily swapped for maintenance, and for the mission specific peripheral board to meet the needs of future clients.

External Peripheral Board

To increase tooling capacity, an external peripheral board was designed and fabricated to allow an acoustic transmitter, four stepper motors, and an electromagnet to be added to the ROV (Figure 10). This custom printed circuit board features its own microcontroller, which communicates serially with the main control computer within the electronics enclosure. Despite adding some complexity to the system architecture, this board allows for contract-specific payload systems on the ROV to be swapped out without opening the main electronics enclosure. This allows Florizel to support an even wider range of missions with minimal additional configuration.

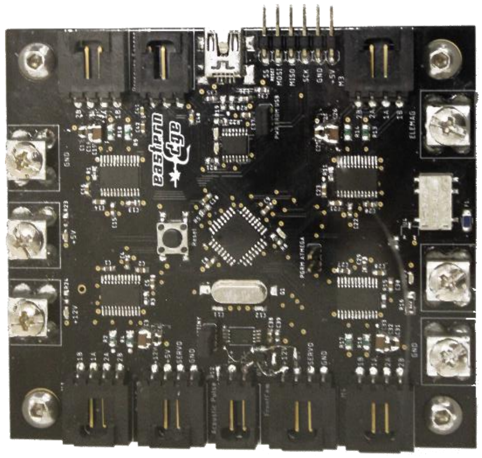


Figure 10: Peripheral Board

Layout

The onboard electronics are designed to be simple to modify and service. All wires from the external penetrators pass through accessible terminal blocks, such that the entire electronics assembly can be taken out of the ROV in a quickly and easily for testing and troubleshooting. The electronics assembly has further been divided into a power distribution and communications section, which can be easily separated for maintenance. Isolating all high-power motor controllers and payload items from the communications equipment also limits the electrical noise present in the system, which allows Florizel to conduct more reliable environmental measurements.

2.3 Software

For the 2018 contract Eastern Edge Robotics has developed an entirely new control software architecture for Florizel. The new control software was is simple and intuitive to provide ease of use to the pilot, and to simplify development and maintenance for the user.

For the previous two contracts, the company developed vehicle control software written in the Java and Kotlin programming languages. While this software is well tested and functional, it is complex and difficult for new employees to work with. This year, the software department has transitioned to developing its main control software in C++ as it is a flexible language with excellent libraries, support, and documentation. As well, it is familiar to many of the company's development team and was the optimal choice for onboarding new developers. Some programs on the control and data processing laptops are written in Python, as Python allows for faster prototyping.

Control Architecture

The vehicle control software was designed with simplicity and modularity in mind, allowing for easy communication between the different components of Florizel’s distributed computer network. To achieve this, the control software uses the Mission Oriented Operating Suite (MOOS) library to handle communication between the devices. Eastern Edge uses an open source library rather than custom writing this section of code because it is reliable and reduced development time. The MOOS library creates a central database that holds all control and sensor variables, and allows for the status of all of the ROV systems to be monitored. This allows the software to be written as individual applications that focus on completing a small task, without worrying about the computer that will execute that task or about the other tasks being completed in parallel.

User Interface

Much like the vehicle control software, the user interface has been designed in modules. This allows different contract tasks to be quickly designed and tested independently from the rest of the ROV system. The main control Graphical User Interface (GUI) has been designed using the Fast Light Toolkit (FLTK) library, and gives the pilot full control over the power levels to each of the degrees of freedom of Florizel. This GUI provides a kill switch to disable all ROV systems, and interfaces with the mission specific devices such as the depth sensor.

Separate, independent software modules handle camera display on topsides, which is built upon the free and open source video streaming program mpv. GUIs have also been written for the science officer to use on the data processing laptop, which are written in Python and utilise the OpenCV library. The networked system allows for these applications to have full access to the current video feed and status of the ROV, meaning that the science officer does not have to interrupt the pilot when collecting and processing data.

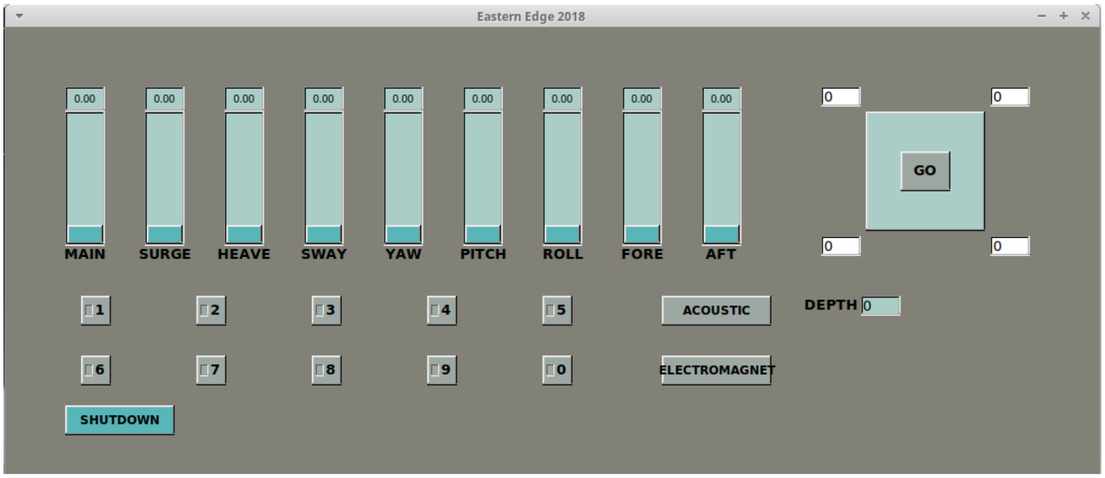


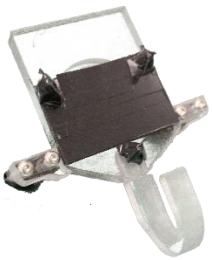
Figure 11: Control Graphical User Interface

2.4 Mission Specific Payload

Primary Manipulator

An electromagnet is used as the primary manipulator on Florizel for its versatility and precision of release. This manipulator is used to carry a variety of payload as is allows for tools to be switched out quickly or to be dropped when needed.

Lift Bag



The Lift Bag is composed of a variable buoyancy bladder attached to a release mechanism and an anchoring hook. The anchoring hook is attached to the Primary Manipulator and can be used to anchor to debris or wreckage. The bladder is then inflated using an airline built into the tether. The release mechanism, composed of an independently powered motor attached to a pin and a frequency selective receiver. The receiver detects a specific frequency, sent from the ROV, and sends a signal to the motor to pull the pin, releasing the lift bag from the anchoring hook.

Ocean Bottom Seismometer (OBS) Levelling System

The OBS Levelling system is designed to efficiently level the OBS platform with ease. Four stepper motors are mounted to the bottom of the ROV at the same distance and direction as the corners of the platform. Stepper motors were chosen for their fine motor control and high torque. Conical attachments are attached to the motors with magnets, such that they can be removed during other missions. This system allows all four corners to be levelled at once, reducing time that would be spent travelling from one corner to another.

Inductive Power

The inductive power coupler release mechanism uses one of the four stepper motors to turn and release a catch holding the coupler to the bottom of the ROV. The mechanism was developed uses existing elements of the ROV to reduce the overall weight of the ROV. This also allows the pilot to complete several tasks before resurfacing.

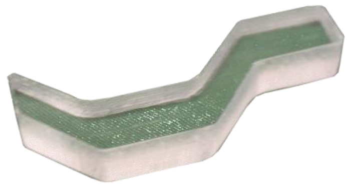
Height Measuring Device

To measure the given height on the mooring line, Eastern Edge has installed a pressure sensor on Florizel. Water pressure increases with water depth, therefore the distance from the bottom can be determined by calculating the change in pressure.

Acoustic Doppler Velocimeter (ADV) Holder

Two 3D printed hooks hold Eastern Edge’s custom designed ADV on the ROV until it is attached to the mooring line. Once attached, the ROV thrusts downwards to release the ADV.

Tusks



This simple and multipurpose tool is made of two Lexan hooks attached to the Primary Manipulator. The Tusks can be used to position the mooring and turbine base, as well insert the turbine and lock the IAMP.

Image Recognition Software

In order to perform the image processing task for the airplane mission, an open source image library called OpenCV was used. This library was used to collect a video stream, isolate the required colours, and identify the shape using a contour method. This method identifies outlines of shapes on a screen and returns the shape on the plane's tail based on the amount of corners of the shape.

3.0 Logistics

3.1 Project Management

Eastern Edge Robotics operates on a vertical company structure while maintaining a horizontal line of communication. A vertical structure ensures that senior employees are able to mentor and guide new employees, while the horizontal line of communication allows a departments to work together and streamline development. Figure 12 below breaks down the organizational structure of the company.

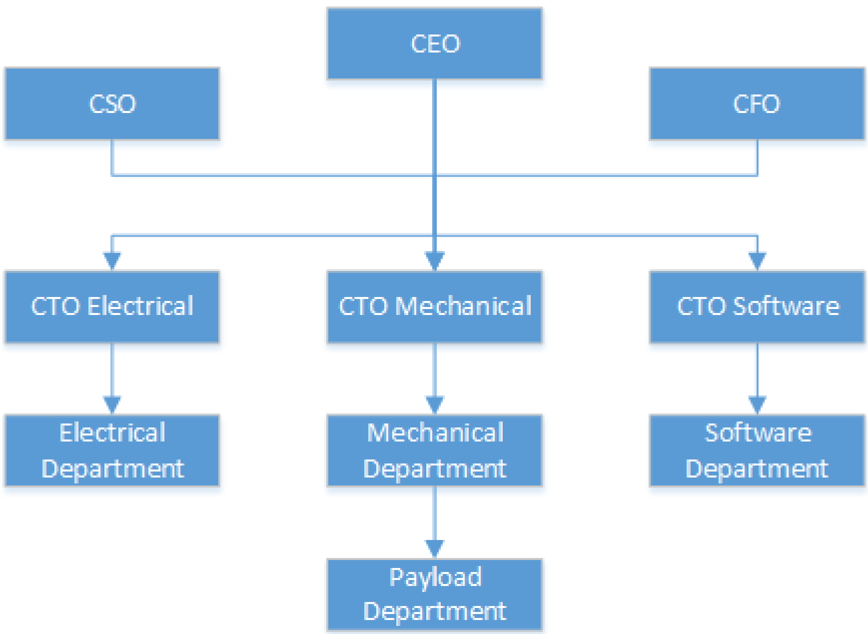


Figure 12: Eastern Edge Robotics Organizational Breakdown Structure

The company is organized into five departments: Administrative, Electrical, Mechanical, Software, and Payload. The administrative department consists of a Chief Executive Officer (CEO), a Chief Financial Officer (CFO), and a Chief Safety Officer (CSO). The CEO manages the company by maintaining an overarching view of the project and all its components. The responsibilities of the CEO are to assign roles, consult with department leads, and develop and enforce a schedule. The CFO regulates the budget and our retained earnings. All purchases must be approved through the CFO, who keeps a record of all receipts and invoices. The CFO's largest responsibility is to track expenditures throughout the year and generate the Fair Market Value (FMV). The CSO is responsible for upholding all safety procedures and protocols outlined in Eastern Edge's safety philosophy. All safety documents, including the OSC, safety passports, and the JSEA, are maintained and archived by the CSO.

The company consists of three Chief Technical Officers: the Electrical CTO, Software CTO, and Mechanical CTO (overseeing the Mechanical and Payload departments). Tasks are assigned to department employees by their CTOs, based on goals set by the company. It is the role of the CTO to oversee system development within their department and meet deadlines as set by the CEO.

Employees are assigned to departments based on their discipline, skill set, and interests. Some employees work within multiple disciplines as they are interested in developing new skills, or to allocate resources to maintain the schedule. Management roles are assigned based on seniority and experience.

3.2 Scheduling

Eastern Edge Robotics began working on a proposal for the 2018 contract in September, 2017. Before the year began, the CEO, in consultation with the CTOs, developed a Gantt Chart with the project's key milestones. This chart, broken down by department, can be viewed in Appendix D. This chart intended to give employees an overarching view of the project and facilitate joint deadlines between departments. To meet key deadlines, department CTOs assigned tasks through the project management software Asana. This program allowed administration to track progress throughout the year, as well as keep all departments up to date on current projects.

In late September, Eastern Edge held an orientation to recruit new employees. Throughout October, the company's focus was new employee safety and skill training. In November Eastern Edge began the design process in all departments. After returning from the winter break, the finalized designs were not complete, leaving the company two weeks behind schedule. Through January, strict deadlines were set on Asana to get the company back on schedule. Around this time, the software department was developing the ROV control software and mission specific software. By February machining and manufacturing had begun for the mechanical, electrical, and payload departments. System integration began in March, meeting the deadline set at the beginning of the year. Late March, Florizel was in the water and operational. From there on Eastern Edge has been piloting, testing, and refining the ROV.

3.3 Budgeting

Preliminary

In September, CTOs were asked to provide a list of materials required and the approximate costs, along with a 10% margin for unexpected costs. This information was then used to develop a preliminary budget for the year. Early in the year, the company set a goal to reduce the total vehicle expenditures and the Fair Market Value compared to previous contracts. The goal was to make a high-quality and operational product at a reduced cost to the client.

The company increased the allocated Mechanical budget in order to replace Robertson top hardware with Hex top. This switch was made to match standard industry practices. This cost was countered by reusing materials such as the thrusters, or using materials the company already had in stock such as HDPE. The budget was followed by setting internal controls in place to track purchases and inventory for each department. All expenditures were approved by the CEO and tracked by the CFO. The CFO maintained a detailed record of all purchases and inventory across all departments.

EER Preliminary Budget 2018		
Vehicle Expenses	Mechanical & Payload	$1,014.00
	Electrical & Software	$1,190.28
	General and Administration	$500.00
Vehicle Budget Total		$2,704.28
Travel Expenses	Flights (20 people. $800/person)	$16,000.00
	Hotel Rooms (11 rooms, $1512/room)	$16,632.00
	Rental Vehicles & Gas (3 vehicles, $650/vehicle)	$1,521.00
	Misc. Travel Costs (17 people, $370/person)	$6,290.00
Travel Budget Total		$40,443.00
Total		$43,147.28

Table 1: Preliminary Budget Summary

Costing

The total vehicle expenditures cost the company $2,932.89. While this is slightly over the original preliminary budget set at the beginning of the year, it was still a significant reduction compared to the company's previous contract bids. During the design phase, the company decided to switch from the previous bulky topside control model to a lighter and transportable laptop. Through making this decision, the company weighed the benefits of a smaller topside module against the risk of going over budget. Ultimately this purchase was approved because this laptop will be used in the years to follow, therefore reducing future expenses.

The purchase of this laptop was offset by reducing costs in other departments. Components such as the thrusters and main electronics enclosure were deemed operational, and were therefore re-used. Employees took resources from company stock materials, such as HDPE that was purchased in 2017 and the tether that was donated by Leoni Elocab in 2016. The Fair Market Value of the ROV is $5376.12, another significant reduction compared to previous Eastern Edge Robotics products. The ful breakdown of the FMV can be found in Appendix E.

Florizel Fair Market Value	
ROV Total	4214.18
Topside Total	1161.94
Fair Market Value	5376.12

Table 2: Florizel FMV Summary (CAD)

EER Vehicle Expenditures 2018	
Mechanical & Payload	$1,272.32
Electrical & Software	$1,122.93
General and Administration	$537.64
Total	$2,932.89

Table 4: Vehicle Expenditures Summary (CAD)

EER Travel Expenditures 2017	
Flights (17)	$9,243.66
Hotel Rooms (11 rooms, 7 nights)	$10,780.00
Rental Vehicle (3) & Gas (estimated)	$1,521.00
Misc. Travel Costs (estimated)	$5,920.00
Contingencies	$694.39
Total	$28,159.04

Table 3: Travel Expenditures Summary (CAD)

4.0 Critical Analysis

4.1 Testing and Troubleshooting

Eastern Edge Robotics recognizes that a rigorous testing and troubleshooting process is key to creating a robust and reliable product. For this reason, the company tests and troubleshoots every component and system prior to integration. By testing components and systems independently, problems can be isolated and resolved quickly and efficiently. The chassis was prototyped in Solidworks prior to construction, and a Finite Element Analysis (FEA) was performed to locate any weaknesses in the structure. The electrical and software departments bench tested the onboard and topside systems prior to integrating with the ROV. Simultaneously, the mechanical department tested the electronics enclosure and penetrators to locate and eliminate potential leaks. The payload department prototyped and tested tools on the 2017 ROV until Florizel was ready for the water. Throughout the testing process, each tool is modified based on the pilot's suggestions. Throughout these tests, employees were able to identify weakness and flaws in individual components that were fixed prior to integration.

After all systems are integrated into one product, the ROV is tested at our tank facilities in the Marine Institute. Our pilot will spend hundreds of hours practicing mission tasks, continuously noting ways to improve different systems or tools. The company records and monitors the ROV's performance, searching for ways to improve the client experience.

4.2 Challenges

Technical Challenges

During evaluation of the missions in the 2018 RFP, the company identified the need for multiple powered tools to efficiently complete tasks. The company quickly identified that the number of penetrators needed to wire these tools exceeded the number of penetrators available on the main electronics enclosure. Different solutions were considered, such as potting multiple payload wires through a single penetrator. This solution meant that if a single payload or motor needed to be replaced, the entire system would have to be re-wired and re-potted. Eastern Edge was focused on maintaining a modular design philosophy, which includes the ability to swap payloads based on client needs.

To address both the issue of limited available penetrators and the need for a modular system, the company designed a second peripheral enclosure housing a single PCB. This enclosure and board exist solely to run powered payload and can be switched out at any time. This solution allows the client to change payload systems for varying missions on the fly.

Non-technical Challenges

At the start of the 2017-2018 contract year, Eastern Edge faced challenges with communication. With 18 employees, it was difficult to communicate important notices and messages concerning company information, upcoming meetings and events, and progress updates. The company had multiple communication pages and chats set up on different platforms, with the issue being that not all employees were on all platforms.

After identifying this problem, Eastern Edge created and moved all communication to a Slack workspace. This platform allows the company to create different channels for each department or project. Employees can choose to get notifications for channels that are relevant to their individual projects, while still staying up to date on other projects within the company. Slack also allows direct messaging between employees and file sharing. Administration can now easily reach all employees concerning group activities such as meetings, travel, and outreach events.

4.3 Lessons Learned

Liam Gregory, New Junior Employee

Over the past several months my abilities have truly been tested. Joining the company I did not fully know what to expect in terms of workload or responsibilities, but I am quite happy with the way things unfolded. I have learned a wide array of technical skills, while also greatly improving my communication skills.

Before joining the company, I had only ever thought about the theoretical when designing something, but suddenly I also had to thing about the manufacturing of the product as well. My mindset shifted dramatically from what I wanted to happen, to what I thought I could realistically fabricate. The CNC Milling Machine, for example, can only cut one side of a material; do when designing a part I had to be careful not to add a cut to both sides because it simply would not work. This greatly improved my problem solving abilities as well as my technical abilities because it forced me to look at a problem with limitations on my solution.

Aside from the technical skills that were gained throughout the year, I also saw an improvement in my communication abilities. This improvement was caused by attempting to explain my thoughts to mentors and other employees. No one knows what is in your head except you, but through proper communication your ideas can be conveyed to others.

I must credit the majority of my personal improvements this year to my time spent working with Eastern Edge Robotics. Through the mentorship and comradery, I was able to improve not only my technical knowledge, but also my interpersonal relations. I cannot wait to see what else I will learn during my time with this company.

Christian Samson, Departing Senior Employee

The experiences I have had during my four years with Eastern Edge have taught me many personal lessons that have led to the further development of my skills. An important technical lesson I learned early on was the nuances and time consuming nature of the manufacturing process. Before joining this company, I believed the longest part of component construction was the design stage. Through my experiences on Eastern Edge, I realized that in reality manufacturing often takes the most time. Many issues can occur during the machining process. After machining, parts may require additional cutting and cleaning. I have learned to manage my time better, balancing the schedules of design and manufacturing to reflect this lesson.

I have had the pleasure of working with a wide variety of people with various skills and background throughout my career with Eastern Edge. Like any professional environment, this sometimes comes with interpersonal issues. I have learned to step back and look at the issue from other employee's perspective. I try to find common ground and look to compromise with the other employee, rather than focusing on the difference in opinions. By better understanding my co-employees, I have learned how to resolve these issues. Eastern Edge has boosted my confidence in both my technical and interpersonal skills and I have valued my time with this company.

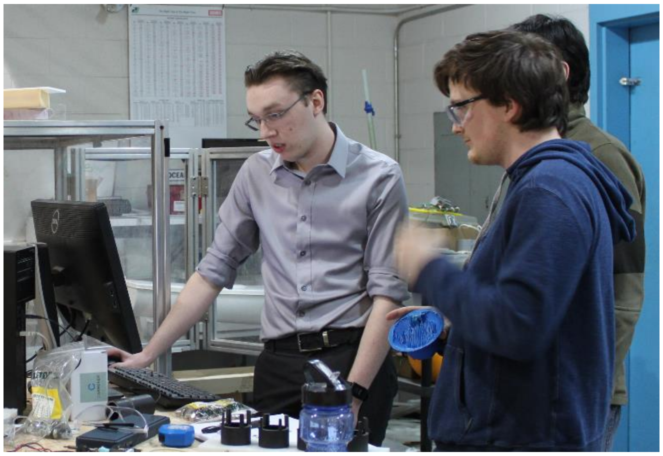


Figure 13: Christian Samson (left) teaching junior employees Stephen Snelgrove and Liam Gregory how to use the CNC router.

4.4 Future Improvements

Reflecting on this year, Eastern Edge can improve upon training junior employees and knowledge retention from year to year. The company has realized that often senior employees will take on large workloads and not delegate tasks due to a lack of time for teaching. This means when senior employees graduate and pass on the company to more junior employees, skills and company knowledge are not retained. For example, this year our software department was left to junior employees with no experience working with or navigating the control software. A lack to documentation, instructions, and training from the departed senior employees left the junior employees without much information. This lack of knowledge can be seen in other areas, including the use of specific software and equipment, as well as general knowledge of ROV systems.

An improvement Eastern Edge will implement in the next contract year is to allow time in the schedule for involving junior employees in skills-based tasks. Senior employees will take the time to show junior employees what is being done and how it is being done, as well as allow the junior employees to try the tasks themselves. The company will also invest time into creating documentation for future years. Senior employees will keep log books containing information such as how design choices were made, how bugs in the system were fixed, and information on the ROV systems. Not only will this be useful for the new employees, but it will also help senior employees make informed decisions based on their past experiences. Taking photos and creating instructional documents on how to use different equipment in the shop will help new employees develop skills.

5.0 Acknowledgements

Eastern Edge would like to thank the following organizations for their monetary support in the development of Florizel, Company travel to Washington, and of the MATE ROV Competition both regionally in Newfoundland & Labrador and internationally: Atlantic Canada Opportunities Agency; Crosbie Group Limited; Department of Tourism, Culture, Industry and Innovation; Fugro GeoSurveys Inc; Hibernia Company Ltd; Husky Energy; Kraken Robotics Marine Institute of Memorial University; Memorial University Faculties of Engineering and Science; Statoil Canada Ltd; SubC Imaging; Subsea 7; and Women in Science and Engineering Newfoundland. Eastern Edge would also like to thank the following organisations for donating software or material resources: Asana; GitHub; Leoni-Elocab; and Solidworks.

Finally, the Company extends a heartfelt thank you to our mentors Paul Brett, Joe Singleton, Anthony Randell and Heather Conway for their time, administrative support, and unwavering encouragement, as well as to the MATE Center for making this all possible.

6.0 References

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Appendix A – JSEA

Job Safety & Environmental Analysis

Memorial University, St. John's, Newfoundland and Labrador, Canada

MATE International ROV Competition 2018, Explorer Class

Task: Launching ROV, Flying ROV and Recovering ROV

Written By:	Christian Samson	Date:	28-April-2017
Verified By:	Michaela Barnes	Date:	30-April-2017
Approved By:	Keely-Shaye Lullwitz	Date:	31-April-2017

Steps	Hazards	Controls
Housekeeping	- Tripping hazards - Leftover tooling	Elimination: Remove left over materials from previous company or user and unnecessary debris on floor to prevent trips and slips. Personal Protection Equipment: When preforming cleanup, wear appropriate safety gloves, safety glasses and CSA Ohmic rated steeled or composite toe boots.
Pre-flight Setup	- Improper connections leading to electrocution -Pneumatic air hazards	Elimination: Insulate all electrical equipment before entering work station. Administrative Controls: Make sure air compressor is properly adjusted and hooked up with releases unhindered Personal Protection Equipment: Wear appropriate safety gloves, safety glasses and CSA Ohmic rated steeled or composite toe boots.
Launch	- Improper protective barriers surrounding pool - Slipping Hazards - Open Water Hazard	Elimination: Remove access water from work area Substitution: Use buddie system when launching ROV into the pool in replacement of protective barrier, preventing employees from falling into water. Ensure one hand of buddy is on the upper body of the deploying employee and the other is on locked down object. Personal Protection Equipment: Use Personal Floatation Device when launching ROV or on deck of the pool.
Flight	- Tether tripping hazard	Elimination: Organize tether in company standard figure 8 pattern to prevent tangling during launch.
Recovery/Post Flight	- Thruster rotational Hazards - Falling Hazards - Tripping Hazards	Elimination: Ensure Thrusters are off to prevent injuries involving associated rotational hazards. Administrative Controls: Ensure tripping hazards are known and eliminated to the best of the worker's ability. Continue to use buddy system to protect employees falling into the pool.
Post Flight Teardown	- Un-safe shutdown	Administrative Controls: Follow Safety Checklist for proper teardown order and insure all hazards are minimized.

Appendix B – OSC

Operational Safety Checklist

Memorial University, St. John's, Newfoundland and Labrador, Canada

MATE International ROV Competition 2018, Explorer Class

JSEA Completed? ☐ Yes ☐ No Date completed: ____________________

Employees Involved: ____

____

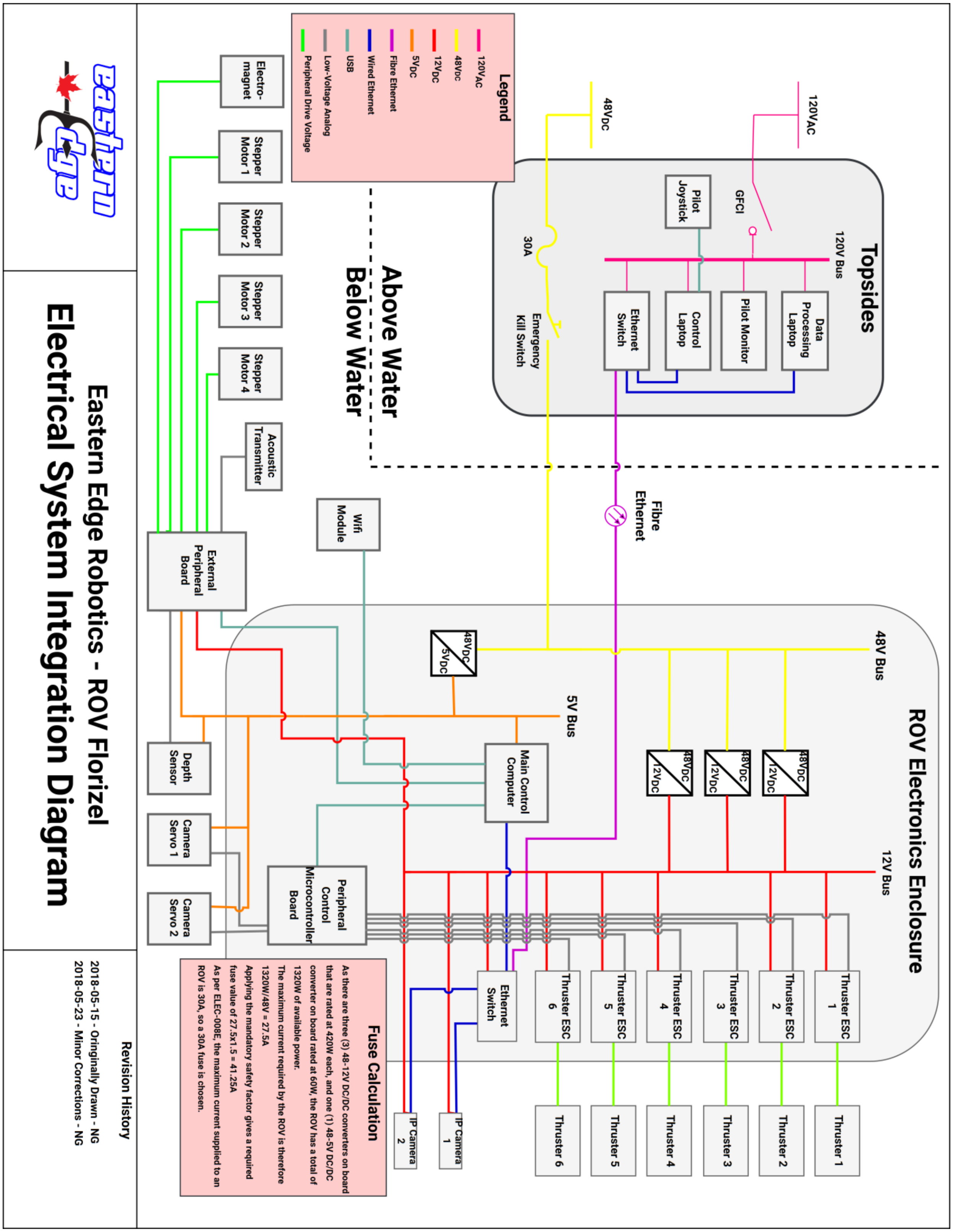
____

Pre-Mission Safety Checklist	
Complete?	**Task**
	Tether is neatly coiled and clipped in company standard figure 8
	Vehicle power switch is in 'OFF' position
	Deck Crew is wearing Eye Protection, Personal Floatation Devices and Work Boots
	Topsides is fully charged and spare charger is brought
	Access hazards are removed
	Air compressor is properly adjusted and hooked up with releases unhindered

Teardown Safety Checklist	
Complete?	**Task**
	All power sources safely powered off and disconnected
	Tether is neatly coiled and clipped in company standard figure 8
	Excess water removed from vehicle
	Access hazards are removed
	Access air is releases from air compressor

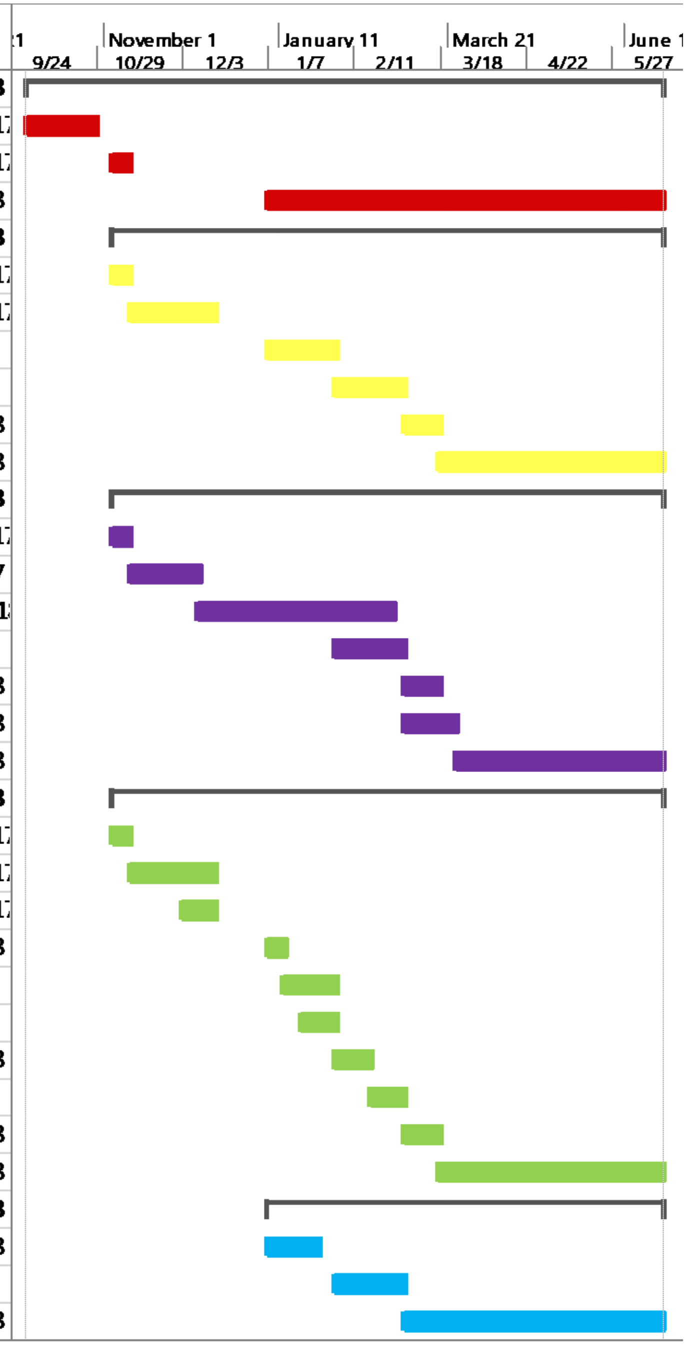
Operational Safety Hazards
No hands on vehicle without software locked
No excess tether left uncoiled on deck
Be cautious of slip hazards generated by water from vehicle, tether, etc.
Keep wet objects/personnel away from Topsides
Any cabling or connections should be both secure and tidy
Use proper lifting techniques when carrying equipment from work area

Appendix C – SID



Appendix D – Gantt Chart

ID	Task Name	Start	Finish
1	**Administrative**	**Sat 9/30/17**	**Sat 6/16/18**
2	Orientation and Training	Sat 9/30/17	Sat 10/28/17
3	Develop Budget	Sat 11/4/17	Sat 11/11/17
4	Documentation, Presentation, and Display	Sat 1/6/18	Sat 6/16/18
5	**Electrical**	**Sat 11/4/17**	**Sat 6/16/18**
6	Preliminary Budget	Sat 11/4/17	Sat 11/11/17
7	Electrical System Design	Sat 11/11/1	Sat 12/16/17
8	Component Research and Sourcing	Sat 1/6/18	Sat 2/3/18
9	Component Testing and Assembly	Sat 2/3/18	Sat 3/3/18
10	Total System Integration	Sat 3/3/18	Sat 3/17/18
11	Testing and Troubleshooting	Sat 3/17/18	Sat 6/16/18
12	**Software**	**Sat 11/4/17**	**Sat 6/16/18**
13	Preliminary Budget	Sat 11/4/17	Sat 11/11/17
14	Communications Research	Sat 11/11/1	Sat 12/9/17
15	ROV Control Software	Sat 12/9/17	Mon 2/26/1
16	GUI and Topside Development	Sat 2/3/18	Sat 3/3/18
17	Total System Integration	Sat 3/3/18	Sat 3/17/18
18	Mission Specific Payload Software	Sat 3/3/18	Sat 3/24/18
19	Testing and Troubleshooting	Sat 3/24/18	Sat 6/16/18
20	**Mechanical**	**Sat 11/4/17**	**Sat 6/16/18**
21	Preliminary Budget	Sat 11/4/17	Sat 11/11/17
22	Chassis Design	Sat 11/11/1	Sat 12/16/17
23	Camera Tube Design	Sat 12/2/17	Sat 12/16/17
24	Material Research and Sourcing	Sat 1/6/18	Sat 1/13/18
25	Chassis Machining and Assembly	Sat 1/13/18	Sat 2/3/18
26	Camera Tube Manufacturing	Sat 1/20/18	Sat 2/3/18
27	Penetrator Machining and Potting	Sat 2/3/18	Sat 2/17/18
28	Electronics Enclosure Leak Testing	Sat 2/17/18	Sat 3/3/18
29	Total System Integration	Sat 3/3/18	Sat 3/17/18
30	Testing and Troubleshooting	Sat 3/17/18	Sat 6/16/18
31	**Payload**	**Sat 1/6/18**	**Sat 6/16/18**
32	Brainstorming and Research	Sat 1/6/18	Sat 1/27/18
33	Payload Prototyping	Sat 2/3/18	Sat 3/3/18
34	Testing and Refining	Sat 3/3/18	Sat 6/16/18



Appendix E – Budget

ROV Fair Market Value				
Item	**QTY**	**Price Each**	**Ext. Price**	**New/Used**
Vehicle Stability (Foam Bouyancy)	1	$77.52	$77.52	Re-used
Potting Compound (MG 832B)	1	$30.20	$30.20	Purchased
High Density Polyethylene (chassis)	1	$215.40	$215.40	Purchased
Tether(14 m)	1	$331.92	$331.92	Donated
Electronics Enclosure Penetrators	12	$5.28	$63.36	Purchased
Raspberry Pi 3	1	$50.28	$50.28	Re-used
Thrusters + ESCs	6	$185.80	$1,114.80	Re-used
1/4" Pneumatic Air Hose (14 m) + Connectors	1	$9.21	$9.21	Purchased
Electronics Enclosure	1	$1,168.22	$1,168.22	Re-used
DC/DC Converters (12 V, 5V) and PCBs	4	$82.11	$328.44	Re-used
Camera Tube Assembly	2	$100.34	$200.68	Purchased
Networking Equip (Switch, Fiber Conv., Etc)	1	$245.97	$245.97	Re-used
Power Distribution & Circuit Protection	1	$71.28	$71.28	Re-used
Pololu Maestro 24	1	$45.94	$45.94	Re-used
Rasberry Pi 3	1	$50.28	$50.28	Re-used
Wi-Fi USB Adapter	1	$13.37	$13.37	Purchased
Camera Module	2	$26.92	$53.84	Purchased
Electromagnet	1	$8.16	$8.16	Purchased
Ultrasonic Sensor	1	$1.30	$1.30	Purchased
PCB	1	$58.75	$58.75	Purchased
USB Extension Cables	1	$1.89	$1.89	Purchased
Stepper Motor	4	$15.00	$60.00	Purchased
Permanent Magnets	48	$0.28	$13.38	Purchased
Total			$4,214.18	

Topside Control Module Fair Market Value				
Item	**QTY**	**Price Each**	**Ext. Price**	**New/Used**
Dell Laptop	1	$974.99	$974.99	Purchased
Lexan (Control box)	1	$75.95	$75.95	Re-used
High Density Polyethylene (Control box)	1	$44.50	$44.50	Re-used
5 Port Switch with PoE + Fiber SFP	1	$66.50	$66.50	Re-used
Total			$1,161.94	