eastern Edge robotics

The Power of Innovation

Memorial University, St. John's, Newfoundland and Labrador, Canada
MATE International ROV Competition 2015, Explorer Class
Technical Report

Employees

Name	Position	Education	Career Aspiration
Kyle Doody	CEO	4th Year Mechanical Engineering	Engineering Managment
Kaitlin Quinlan	CTO – Electrical	5th Year Electrical Engineering	Instrumentation Engineer
Calvert Pratt	CTO – Software	3rd Year Computer Engineering	Computer Engineer
Nathan Ash	CTO – Mechanical	4th Year Mechanical Engineering	Mechanical Engineer
Thom Smith	CTO – Fabrication	3rd Year Bachelor of Technology	Underwater Vehicle Tech.
Anthony Randell	COO	4th Year Electrical Engineering	Electrical Engineer
Erin Matthews	CFO	2nd Year Naval Engineering	Marine Engineer
Petros Mathioudakis	Pilot/Payload Design	2nd Year ROV Technician	ROV Pilot/Technician
Christian Samson	Safety Officer	1st Year ROV Technician	AUV Technologist
Will Glatt	Structural Design	3rd Year Bachelor of Technology	Underwater Vehicle Tech.
Calvin Gregory	Structural Design	3rd Year Mechanical Engineering	Mechatronics Engineer
Nick Martin	Structural Design	4th Year Mechanical Engineering	Mechanical Engineer
Racheal Seymour	Electrical Design	3rd Year Electrical Engineering	Electrical Engineer
Jacob Parsons	Software Developer	5th Year Computer Engineering	Computer Engineer
Whymarrh Whitby	Software Developer	3rd Year Computer Science	Software Development
Connor Whalen	Software Developer	2nd Year Computer Engineering	Computer Engineer
Stephen Whiffen	Payload Design	2nd Year ROV Technician	ROV Technician
Jeremy Coleman	Payload Design	2nd Year ROV Technician	ROV Technician
Nicholas Wittering	Payload Design	2nd Year ROV Technician	ROV Technician
Alan Li	Payload Design	3rd Year Mechanical Engineering	Mechanical Engineer
Adam Tremblett	Payload Design	3rd Year Mechanical Engineering	Mechanical Engineer
Sarah White	Payload Design	1st Year Undeclared Engineering	Marine Engineer
Jennifer Roche	Payload Design	1st Year ROV Technician	ROV Technician
Coralie Brown	Payload Design	2nd Year ROV Technician	ROV Technician
Christina Hamyln	Graphic Design	3rd Year Bachelor of Visual Arts	Graphic Artist

Mentors

Paul Brett, B.Sc (Hons),B.Ed Post Secondary, M.Sc
Clar Button, B.Sc, B.Ed, M.Sc
Dwight Howse, M. Eng., M.B.A
Jai Ragunathan, B.Eng., B.Ed Post Secondary, M.Eng

OLD POLINA

Abstract

This technical document describes Old Polina, an explorer class remotely operated vehicle that has been constructed as a deliverable for the 2015 Marine Advanced Technology Education Center international remotely operated vehicle competition. This remotely operated vehicle was designed and manufactured by Eastern Edge Robotics, a company dedicated to developing robust solutions to perform work in harsh subsea environments. The purpose of Old Polina is to address the specific needs outlined by potential clients in the polar science and offshore oil and gas industries based in St. John's, Newfoundland & Labrador.

Old Polina's chassis is comprised of a polycarbonate frame designed around a clear acrylic canister which houses the onboard electronics. The remotely operated vehicle integrates six shrouded, brushless, direct-current thrusters, a pneumatic payload system, three standard-definition low light cameras, and two high-definition cameras. Old Polina utilizes interchangeable payload skids which house a customizable tool set specific to the target operating environment. The control system for the vehicle is implemented using Microsoft's .NET Framework and the programming language C#. A custom-designed tether connects onboard electronics to the topsides control module, a custom-designed computer system that interfaces with peripheral control devices. Throughout the development process, Company employees have learned essential technical skills and worked diligently to deliver a quality end product. The cost of materials to develop Old Polina for this contract is estimated at $ 20,500 USD.

Figure 1: Company Photo (Location: Marine Institute Flume Tank)

Back Row: A. Randell, T. Smith, J. Roul, N. Ash, N. Martin, J. Coleman, P. Mathioudakis, C. Gregory, C. Whalen, C. Samson

Front Row: N. Wittering, K. Doody, E. Matthews, K. Quinlan, J. Roche, S. White, C. Pratt, S. Whiffen, W. Glatt

Missing From Photo: R. Seymour, J. Parsons, W. Whitby, A. Li, A. Tremblett, C. Hamlyn, C. Brown, V. Hynes

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1 Step-by-Step Development

1.1 Safety

For Eastern Edge Robotics (EER) safety is the number one priority in all aspects of work and operation. The Company always takes a proactive approach to ensure members follow safety protocols and that they work safely in all environments. All employees are required to be familiar with standard lab and shop safety protocols including safety equipment locations, emergency exit routes, and dress requirements. Additional safety instruction specific to the use of power tools and other specialized equipment is provided where appropriate. Employees are advised on safety procedures specific to the pool environment before remotely operated vehicle (ROV) operations begin.

All EER products are designed and developed with a focus on proactive safety. Old Polina (OP) has a number of built-in safety features, including:

- Over-current protection
- Emergency stop switch
- Curved, smooth edges on the ROV
- Thruster shrouds
- ROV power isolated from topsides control module
- Warning labels on moving or exposed energized equipment
- Pneumatic pressure regulator and gauges on topsides end of tether
- Pneumatic pressure dump valve (onboard)
- Anderson SBS50BLU-BK power connectors

Figure 2: Employee demonstrating safe operation of power tools

Eastern Edge Robotics' safety culture extends beyond its products to include its practices. EER has developed a series of operational checklists (see Appendix A) which detail protocols for safe ROV operation. Pre-flight protocols include electronic and water ingress testing while post-flight protocols include the surface shutdown of all ROV systems. Launch and recovery is accomplished by a two-person team and takes advantage of handles on the ROV ensuring a safe transition to and from the water. While the ROV is in operation, members of the deck crew are required to wear closed-toe footwear, personal flotation devices, and safety glasses. All checklists indicate potential safety risks to operators. By diligently following safety practices, no serious or loss-of-time injuries have occurred in preparation for this contract.

With every new opportunity, EER strives to further its focus on safety. Examples of proactive safety measures taken by the Company include keeping a safety journal, completing Job Safety Analyses (JSAs), and reading Oceaneering®'s Health, Safety and Environment Employee Handbook. Together, these measures have helped contribute to increased safety awareness and identifying risks associated with performing work in both a fabrication and operational setting.

1.2 Project Management and Synergy

Eastern Edge Robotics operates under a tiered project management structure whereby project tasks are divided and assigned to employees based on discipline (i.e. mechanical, electrical, etc.). A discipline (team) lead is responsible for identifying all deliverables for contract work within their discipline. Another role of a team lead is the coordination of interdisciplinary projects. Discipline leads met to identify and plan interdisciplinary work, share deliverables, and create a work plan to identify the critical path. This, along with a milestone schedule developed early the project, allowed EER to ensure a smooth workflow was maintained and deadlines were met.

After team deliverables were addressed, team leads delegated work within their group according to experience. Due to the large size of the team this vertical structure was highly effective as it encouraged appropriate work assignment, accountability, and streamlined communication between employees. This allowed for tightly-controlled resource allocation and sharing between disciplines when necessary.

Once a work schedule was prepared, teams came together to plan their approach to the assigned tasks. EER emphasizes a process of divergent thinking and convergent development. In short, teams brainstormed potential solutions and individuals were assigned ownership of promising solutions. Once development was finished they consulted on their progress, evaluated the strengths and weaknesses of competing ideas, and worked on improving prototypes. This process was often applied several times depending on the difficulty of the work in order to achieve the best results.

The aforementioned work procedure has been found to be effective in recent years. Giving employees ownership of their work has proven to be a strong motivator. Pooling intellectual resources has consistently ensured quality in EER products and effective problem solving by leveraging the large and diverse workforce unique to the Company.

EER is able to produce high quality products as the Company has access to a wide variety of facilities - including but not limited to - a computer numerical control (CNC) router, 3-D printers, lathes, and fibre-optic termination equipment. As Company mentors have a strict hands-off policy, it is the responsibility of senior employees to educate new employees on the operational and safety protocols of shop equipment.

Each employee of EER can contribute to the project in a different way as they can provide unique knowledge, experience, and perspectives. While senior employees bring experience to the project, new employees offer fresh perspectives on company protocols and the design of the vehicle. A different perspective on current operations allowed the Company to reflect on the decisions made in the past and ultimately resulted in a higher quality product.

This year EER put a new focus on cross-functional development as it allowed for employees in any discipline to branch out and broaden their skills. By having employees work on cross-functional deliverables it helped to increase company synergy over the course of the project and will continue to in the years to come.

2 System Design and Rationale

2.1 Chassis and Propulsion

Eastern Edge Robotics' Old Polina features a new electronics enclosure around which the chassis was designed and constructed. OP's chassis consists of two principal components. The first is the main chassis, which provides structural framework for the pneumatic and electrical systems, in addition to buoyancy and propulsion. The second principal component are interchangeable payload skids, enabling a quick turnaround between demonstrations.

The ROV's chassis was manufactured by EER using one-half inch Lexan™ (polycarbonate) sheeting. Lexan™ was chosen over other materials such as High Density Polyethylene (HDPE), polyvinyl chloride (PVC), or metals due to its structural integrity, low density, and ease of fabrication. Lexan™ is also transparent, allowing for maximum visibility without compromising strength when compared to other materials. Another key design feature of OP's chassis is the use of a 20 mm grid-hole pattern (see Figure 3) on the entire chassis allowing for easy payload modification. These design features were re-incorporated from previous products as they have consistently proven successful in both development and production.

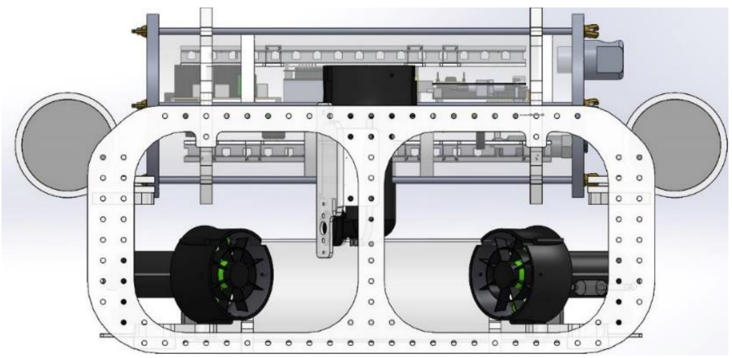


Figure 3: Chassis side profile showing grid-hole pattern

OP utilizes six SeaBotix® brushless direct-current (DC) thrusters for propulsion. These thrusters offer high thrust and excellent reliability in a compact package. Four of these thrusters are arranged in the horizontal plane with a 45° vectored layout. This layout allows high lateral manoeuvrability while retaining maximum thrust along the primary axis of the vehicle (forward-aft). Two thrusters are located in line with the center of gravity in the vertical plane; one each on the port and starboard sides of the electronics enclosure for efficient movement along the water column.

Figure 4: Seabotix® thruster

OP's buoyancy is minimalistic and modular in design, allowing for easy modification based on the density of the operational environment. This design was selected as last year's industry inspired floatation block proved to be cumbersome during operation and maintenance, while performing poorly. Modular designs had been successfully used in the past and the Company made the decision to revert to this approach. To optimize adaptability, OP was designed to be slightly positively buoyant with variable amounts of lead ballast on the payload skids to bring the ROV to neutral buoyancy. The buoyancy is located symmetrically on the upper corners of the chassis raising the center of buoyancy above the center of gravity, optimizing in-flight stability.

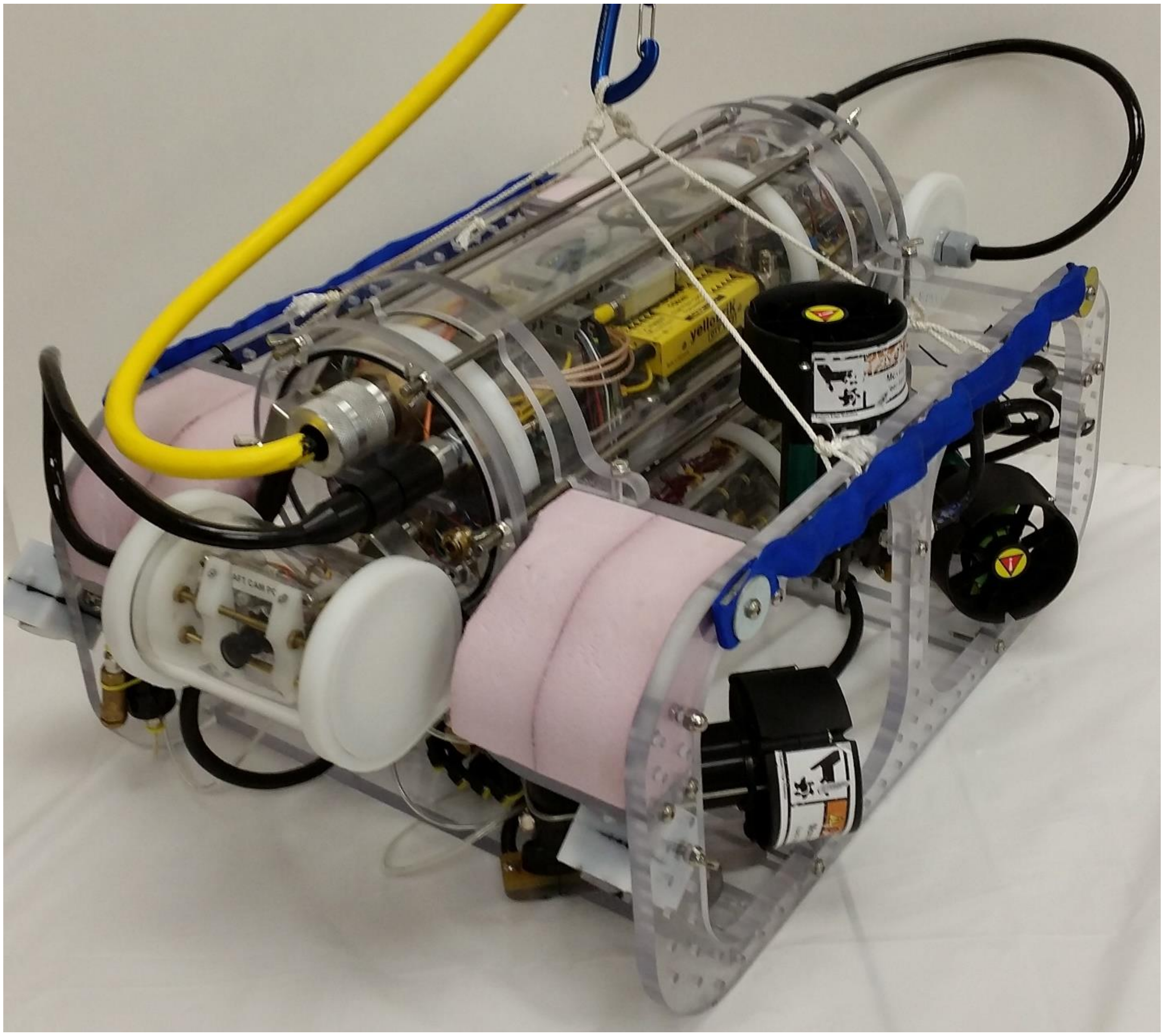


Figure 5: Old Polina

The primary chassis and propulsion system was modelled in Solidworks 3-D Computer Aided Design (CAD) software. This model allowed EER to verify that sufficient space was available for the routing of cables and components, as well as to verify alignment of the various external components. Secondarily, the production of this 3-D model allowed EER to perform flow simulations. These simulations permit the Company to ensure that drag forces induced from cross-flow currents were minimized as they are anticipated during contract demonstrations. Following simulations, EER CAD specialists converted the Solidworks models to MasterCam® tool paths, allowing the fabrication team to produce the components in-house on a CNC router. Uniform assembly hardware is used throughout all ROV systems allowing for ease of alteration while testing.

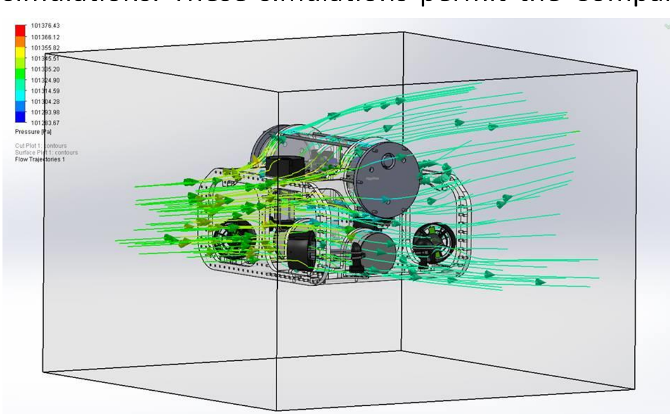


Figure 6: ROV flow simulation (Solidworks)

2.2 Pneumatics

Many of the tools used by OP require linear motion. Since electrical actuators can be expensive and complicated to waterproof, the Company decided to pursue a pneumatic control system for this contract. Depending on payload function, a single-acting spring-return or double-acting cylinder is used. Due to corrosion issues from a leak while testing with standard valves, the valves selected for the final product are stainless steel, specifically designed to be corrosion resistant.

Each of the eight valves are electronically controlled using a PIC® microcontroller. In order to keep the surface hardware simple, the pneumatic system is integrated into the topsides tether junction box. A standard industrial quick-connect fitting is used to connect the system to an air supply, allowing any standard supply to be used in operation.

Figure 7: Pneumatics control can

For safety reasons, one of the valves on the vehicle is connected directly to an exhaust port. By activating this valve, the stored pressure is released, rendering the system inert. The system was designed to be modular, allowing EER or its clients to expand and adapt the system for changing requirements. Pneumatic safety is a special priority since compressed air is the primary method of actuation for onboard payloads. Post regulator, all components are rated for 724 kPa but are only operated at 276 kPa (40 psi). At the surface, the junction box houses a regulator and multiple pressure gauges. The gauges show both supply and operating pressure, allowing operators to easily monitor system conditions.

2.3 Onboard Electronics

This year's contract saw a major redesign of the ROV's onboard electronics. Due to problems encountered in 2014 with overheating and space restrictions, the Company elected to resize and reconfigure the electronics enclosure. The improved design was composed targeting minimum size and maximum simplicity and reliability. Also of great concern was optimization for heat dissipation, electrical noise shielding, and location of bulkhead penetrators.

Figure 8: Electronics enclosure

The onboard electronics system is housed in a polycarbonate tube with two axial-compression end caps. This transparent tubing was chosen because it allows system status lights to be monitored during operation, and the circular shape evenly distributes pressure. This enclosure was designed, cut and assembled in-house. Within the enclosure are all of the major components required for both power distribution and communication onboard the ROV.

Power conversion and distribution is achieved using four DC/DC converters. These include a 48/28 V board for thrusters, two 48/12 V boards for payload power, control, and communication, and one 12/5 V board used for logic and instrumentation. Each of the DC/DC converters are protected by a high-side fuse matched to the current rating of that board. Each board is rated for input voltages at least 30% greater than nominal input.

The centerpiece of the communications system within the electronics enclosure is the remote-end unit of a Focal Technologies™ serial-/video-to-optical converter. It facilitates communication to and from the ROV using RS-485 and RS-232 communication and three standard definition (SD) video channels. EER built and programmed a custom thruster controller using a PIC® 18F1320 microcontroller, chosen for its ability to interface with both RS-232 and Inter-Integrated Circuit (I^2C) communication networks. To provide communication conversion, there is also an RS-232 to Transistor-Transistor Logic (TTL) converter, manufactured in-house by EER. TTL is used to communicate with a network of instrumentation and control devices.

Figure 9: Electronics enclosure showing layout and wiring

EER has chosen to use a TTL-based Pololu™ protocol communication network as it simplifies device expansion (up to 256 devices) and Pololu™ provides a wide range of instrumentation and control devices which suit the Company's purposes. Internal instrumentation is monitored by a Pololu™ Maestro. Sensors include temperature, pressure, and voltage for each of the DC/DC converters. These sensors help to ensure that Old Polina is operating correctly. The Maestro was chosen because it allows up to 12 (of 18 total) channels to be used as analog inputs, enabling sensor expansion. Further, it offers the ability to use any of the 18 channels for digital inputs, digital outputs or pulse width modulation (PWM). Payload motors are controlled by Pololu™ motor controllers.

Onboard the ROV are five cameras used for piloting and tool guidance. OP carries two 1080p high-definition (HD) cameras for piloting, chosen as they enable accurate distance measurement to be performed using pixel length ratios. Two interchangeable SD payload cameras are used. These may be mounted on the chassis using the grid-hole pattern (see Section 2.1 Chassis and Propulsion) as required for various payload configurations. Another rotating (SD) camera is located within the payload skid and can rotate from a forward facing view through downward to aft facing. This camera allows the pilot to get a comprehensive view of the entire payload skid and all tools while also allowing for an overhead view of the seafloor.

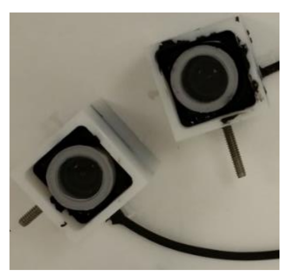


Figure 10: Interchangeable payload cameras

The HD cameras on the forward and aft of the ROV are able to rotate from a vertical up position through to a vertical down position enabling the pilot to get a full view of both the forward and aft of the vehicle including the tether.

A Keller America™ Preciseline pressure transducer is used to infer depth to a maximum depth of 20 metres. This transducer was donated to EER several years ago and has been used on several occasions as its 0.25% accuracy makes it extremely reliable.

Figure 11: Forward HD camera

2.4 Tether

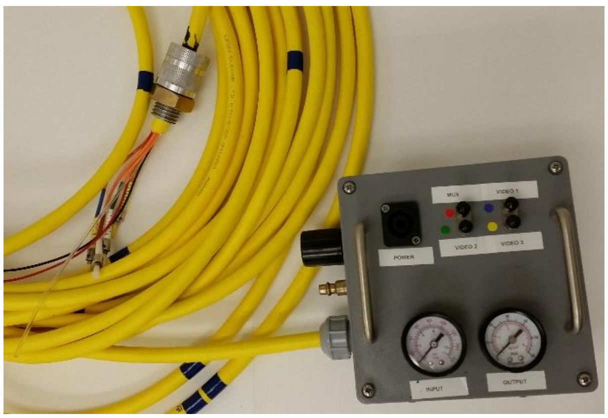


Figure 12: Tether with integrated junction box

In 2015, Eastern Edge Robotics acquired a new tether. It was provided by Leoni Elocab of Kitchener, Ontario, Canada. The tether contains eight optical fibres (only four are used), two copper conductors and an internal pneumatic hose. This tether is an improvement over its predecessor as the internal pneumatic hose reduces drag and improves tether flexibility compared to previous tethers which required an external hose. Further, the previous tether contained only two optical fibres. The increase to eight fibres enabled an increased number of HD cameras onboard without resorting to expensive optical multiplexing.

2.5 Topsides Electronics

The Topsides Control Module (TCM) is a customized Windows®-based computer, purpose built to interface with Eastern Edge's ROV and host the control software. A desktop computer with expansion cards has been used for several years due to the availability of both hardware and software, and ease of upgrading. Using a desktop computer also means that system peripherals (such as joysticks) can be changed with ease, making the system more modular. The hardware within the TCM acts to interface between the control software and devices onboard the ROV.

2.6 Software Control System

The control software for Old Polina was written by EER using the Microsoft .NET Framework and the C# programming language. This language was chosen as it allows fast and simple graphic user interface (GUI) development and has widespread support for external component libraries, such as Pololu™. The control software follows the Model-View-Controller (MVC) design pattern, allowing developers to update components of the system in isolation, allowing multiple members of the software development team to work on separate program components simultaneously. The system utilizes three tiers. The device tier allows seamless interaction with physical devices, the input control tier accepts input from the pilot, and the display tier provides feedback from the ROV. All communication between the tiers follow the publish-subscribe pattern, which decouples each of the tiers, making the system more robust.

The device tier consists of a set of classes representing the physical devices on the ROV. This allows software to be quickly developed without having to consider the hardware interactions. Each device class is developed independently of the control software allowing isolated testing.

The input control tier consists of input interface classes allowing interaction between the user and the control system. Each interface waits for a change in state and publishes an event that can be consumed by the controllers. This tier supports Phidgets input/output boards and generic gamepad devices, allowing for a wide variety of peripherals to be used to control the ROV.

The display tier is responsible for displaying the video feeds and telemetry data. It also enables the pilot to control thruster and tool power, as well as software tools. It consists of a multi-window GUI configured to meet the needs of the pilot and allows relevant information to be displayed. This enables the operators to easily monitor system information and video feeds.

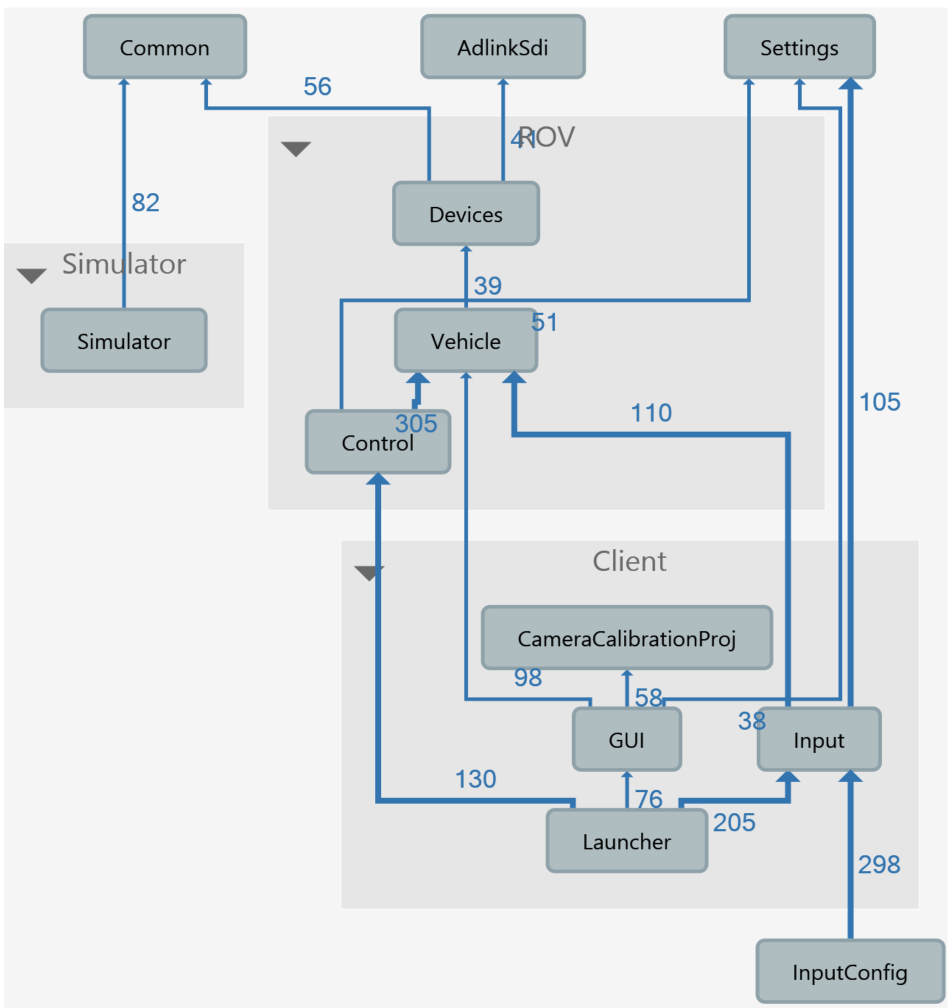
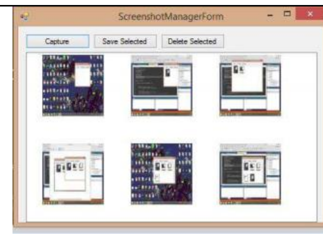
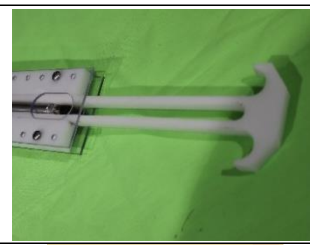
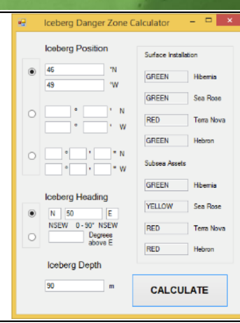
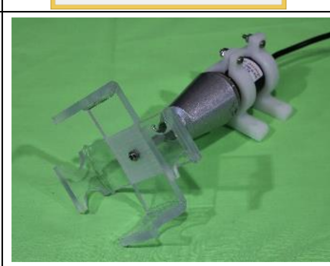
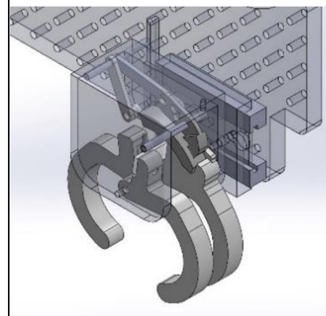
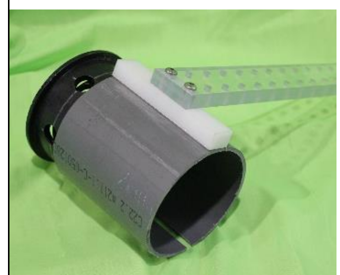
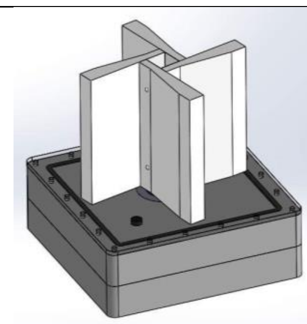
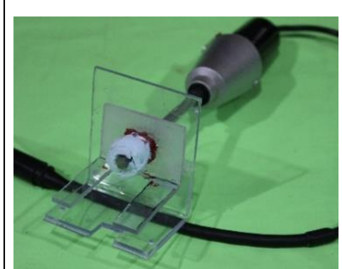
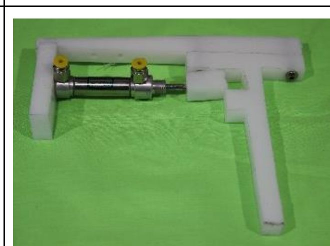


Figure 13: Software Flow Chart: Class Diagram (Generated by R#)

The image above depicts the flow of the software. The three notable entry points into the control software system are the launcher, the input configuration, and the simulator. The launcher component initiates the entire application process and each of its dependencies. The input configuration handles input from the ROV and the simulator is a component that can be used when testing the control software.

2.7 Payload

Tool	Function	Justification	
The Advanced Algae Attractor	A flexible plunger with elastic bands threaded through the top is used to collect algae samples.	This tool is advantageous as the rubber plunger can be used on both even and uneven surfaces.	
Zoidberg	This design is comprised of two curved fingers lined with screws which is controlled by a pneumatic piston and mechanical assembly. The claw is used for recovering urchins from the sea floor.	The screws lining the claw make this tool reliable in collecting the urchins due to the additional gripping points.	
Snappy Snippit Snatcher	A software tool that collects images throughout the mission and has the ability to distribute the images to other software components such as the measurement tool.	This tool facilitates fast controlled access to camera frames taken during operation to be analyzed for demonstration objectives.	
Cigar Cutter	A pneumatic actuator pulls a half round finger into a slot in order to grip a number of different diameter objects such as string or PVC.	The ease of use and adaptability of this multi-purpose tool allows it to be used for many tasks, lessening total payload requirements.	
Icebergs Ahoy!	A software tool which receives the iceberg's initial coordinates, heading, and draft as inputs and determines the surface and subsea threat levels for each of the four ocean installations.	Using a software tool for this task is advantageous as it yields a more accurate result compared to manual calculation and requires less time from the deck crew during operation.	
The WobblyPOP	A tool which consists of a polycarbonate claw attached to a DC motor. The claw is used to turn valves in various demonstrations.	The curved fingers of the claw allows the WobblyPOP to securely engage the valve handle without slippage. This is especially useful when operating in currents.	

Ratchet and Clamp	A tool which uses a pneumatically controlled clamp attached to a lift line at the surface. It is attached to the ROV with a removable pin. The clamp grasps the section of pipe and the lift line is pulled, removing the pin so the pipe can be extracted.	The ratcheting claw ensure that the pipe is firmly secured in the claw and the pull pin detached the claw from the ROV enabling retrieval without further ROV intervention.	
Flange Harness and Retrofit Positioning (FHRP) system	This system utilizes a slit piece of PVC pipe to retain two flanges on either side of the tool. As the flange is positioned on the high friction surface of the pipeline, the plastic flexes and releases the flange.	The double sided design reduces trips to the surface during the demonstration.	
Spinamajig	A pinwheel is attached to a waterproof box and is used to measure the current in the water. The wing of the pinwheel contains a magnet which is monitored by the circuit inside the box to count the number of rotations of the pinwheel from which current is extrapolated.	The pinwheel design allows for the current to be calculated from all directions, as it sits parallel to the surface of the water. The tool being external to the ROV allows accurate data to be collected while other tasks are being performed.	
Anchors Away!	A two tiered Lexan™ bracket grips the bolt in two locations while a foam insert is used to hold the bolts to the bracket using a friction fit. A motor allows it to be adjusted to any orientation.	The motor allows for bolting to occur at any orientation ensuring that flange placement does not affect task execution.	
Put a Ring on it	The design uses a T-shaped guide that is inserted into the pipe and holds the gasket in the proper position. The gasket is installed when the pneumatic piston is released.	This tool was specifically designed to ensure proper gasket installation in the presence of water currents.	

Hot Stabber	The hot stab is held inside this half section of PVC pipe, held down by a pneumatic piston. The tool is then aligned with the pipe and releases the hot stab by activating the piston.	The T-shape design uses the exterior of the pipe as a guide to ensure reliable insertion of the hot stab.	
Operation!	This tool utilizes a retractable magnet as a grounding point and two anode testing rings that wrap around the pipe. Each ring uses two metallic strips and simple LED to indicate whether the wellhead is grounded.	This tool allows for all anode to be tested in rapid succession without repositioning the ROV, decreasing time required to complete this task.	
Blastoise	This system is composed of a bilge pump and a cone. The cone mates with the pipeline system input and is lined with soft foam material to ensure a strong seal. The bilge pump is then used to circulate water through the system.	The robust cone design ensures mating is easily achievable and will have a strong seal ensuring optimal flow through the system.	

Figure 14: Payload Description Table

2.7.1 Payload Design Redundancies - Measurement

Underwater measurement is a complicated task requiring the development of many unique measuring solutions. During testing, Eastern Edge Robotics found that no single method was optimal for use in all situations. Therefore, three separate methods have been implemented.

The first method of measurement involves determining the ratio between distances in a digital photo and corresponding objects. This is done by locating objects of known length near the object being measured. These can be prop dimensions present in the demonstration or objects constructed by EER posed near the object being measured. Once the objects are in view, a screenshot is taken so that the ROV may continue operation while the measurement is being calculated. This method is the most useful for measuring the wellhead length and the length of the corroded pipeline. It is useful because it does not require a mounting point like The Handy Dandy Tape-O-Matic (see below). The disadvantage is that framing a large object in the camera's view can be difficult in tight quarters. The camera must also point normal to the axis being measured to minimize error. As a result, this method is not feasible for measuring the dimensions of the iceberg; it is large and there is no way to tell if the camera is in the normal plane. The height of the wellhead is also difficult to measure by this method due to the lack of a reference point on the base.

The second method of measurement involves tracking the pressure differential between two points in a column of water and using it to calculate the vertical distance. This method is limited in that it can only be used to measure depth. A simple software tool is used to save pressure values and handle all conversions between pressure and depth.

Figure 15: Handy Dandy Tape-O-Matic

The third method of measurement is a mechanical solution that uses a measuring tape with an HDPE ring attached to the end. This method was primarily developed for conducting measurements in scenarios with no known lengths. It is useful as it is much simpler and less error prone than the pixel-length ratio method. The main disadvantage is that it requires a mounting point for the ring. The increased accuracy comes at the cost of a more time-consuming measurement with a greater reliance on pilot skill.

3 Troubleshooting

3.1 Full Vehicle Integrated Testing

Eastern Edge Robotics has taken an integrated approach to systems testing for this contract. The majority of testing was performed with employees from both hardware and software backgrounds who co-operated to test new systems and troubleshoot existing issues.

The most effective method of troubleshooting was found to be a fully integrated systems test. This test method involved preparing the entire ROV as would be done for a flight and testing all systems at once. If problems arose, the approach was to isolate suspect components and test the remainder of the system. Once the issue was isolated, the component could be either removed for further testing or reconfigured and tested in-situ as required.

This method of testing enabled the Company to quickly and effectively determine sources of problems and greatly decreased the amount of time spent troubleshooting. This, in turn, meant that there was more time for practice and the implementation of new systems.

4 Challenges

4.1 Technical – HD Camera Latency

2014 was the first year that Eastern Edge Robotics used HD cameras. This new system has enabled precise measurement of objects using pixel-length ratios. Due to the high bandwidth of an uncompressed HD video signal, issues were encountered with latency introduced by components along the path from capture to viewing. This caused issues for operators as the occurring latency of up to one third of a second was found to hamper piloting ability.

In 2015, more HD cameras were added following the success of EER's optical measurement solutions. To address the problems encountered previously, EER assembled a team to troubleshoot the camera system. This team was tasked with determining the sources of the latency and minimizing their impact. It was discovered while testing various configurations of signal converters and monitors that the majority of the lag was being introduced by the HD capture card of the Topsides Control Module (TCM).

Several possible solutions were analyzed in order to determine the best method of mitigating lag. These included purchasing new capture cards for the TCM or converting from the native format to a compressed video format using low latency devices.

The solution chosen was to split the HD video signals at the TCM and have each go to two terminal devices: a high-definition multimedia interface (HDMI) converter for display on a dedicated monitor and the existing capture card on the TCM for manipulation in software. The HDMI converter was able to reduce the latency to approximately one tenth of a second. The capture cards are used for acquiring images for the purposes of software manipulation where latency is not an issue.

4.2 Non-Technical – Balancing Commitments

This year an issue encountered by most company employees was balancing time commitments. Every individual has a different way of prioritizing commitments such as school work, personal lives, as well as contributing to the Company. Often, members may take on too many commitments at one time, challenging their ability to balance commitments and complete assigned tasks.

To alleviate this issue Eastern Edge Robotics held a time management information session focusing on how to properly prioritize tasks, presented in a step-by-step guide. The highlights of this guide are as follows:

1. Create a list of all assigned tasks and create a schedule of activities for the week.

2. Highlight which commitments are urgent.

3. Identify the tasks that are personally important. These may include studying, family time or meeting company deadlines.

4. Label the remaining points as low priority.

5. After completing the list, reflect on how time is being spent. Question if time is being used effectively.

The time management information session proved to be effective. By writing down and planning tasks, the overall efficiency of the Company increased. This also allowed employees to better manage their schedules.

5 Lessons Learned

5.1 Technical - Simplicity

For the 2015 contract Eastern Edge Robotics has taken a more simplistic approach to design than in previous years. The systems on the ROV have become more complicated each year due to the need for additional components in order to complete the product demonstrations. The number of components and communication networks in the electronics enclosure caused challenges with sizing and system integration. In 2014, the Company encountered significant issues related to electronics complexity which hindered the ability to successfully perform mission tasks.

Considering past failures, it was decided that a minimalist approach would be taken during the electronics redesign in order to reduce complexity and ease troubleshooting. A lot of time was spent determining methods by which the system could be made simpler and easier to troubleshoot. Old Polina has fewer and smaller components wherever possible and has a much higher level of system integration thanks to a reduction in the number of communication channels used. This simplistic approach has successfully enabled the Company to increase the reliability and performance of the ROV while decreasing the amount of time spent troubleshooting. It has given the Company the ability to anticipate potential issues and design a reliable system.

5.2 Interpersonal – Motivation and Confidence

Eastern Edge employees learned a great deal about how personal motivation and confidence impacts productivity. With strict deadlines, time is a precious commodity. Therefore, it is important that the people to which tasks are delegated have the know-how, confidence and motivation to complete the assigned work. New company employees did not always display these qualities. Many experienced company employees avoided delegating responsibilities for different reasons such as losing ownership or having little confidence in the work of others. To improve interpersonal relationships, a mentorship program was introduced. This allowed experienced employees to become more comfortable in delegating tasks and helped build confidence and the technical skill sets of new employees. The Company realized that in order to successfully achieve results, it is pivotal to understand the importance of teaching, motivating, and taking pride in one's work.

6 Future Improvements – The Cal Case

The team identified the deployment and teardown phase as one of the least efficient steps in ROV operation. To mitigate this problem, a new deployment solution is required. Eastern Edge is planning on constructing a fully contained control unit for future contracts. Presently, the procedure is inefficient as all components of the TCM are separate and require individual integration at the launch site. Past measures to mitigate this problem have been largely unsuccessful and cumbersome to transport. The proposed solution will store all components essential for ROV flight including the TCM, power supplies, monitors, etc. in a pair of hard cases configured for quick deployment and teardown. The two cases will remove much of the hassle inherent in the current deployment procedure by reducing deployment to the following four simple steps:

1. Connect cases to each other
2. Connect cases to power
3. Connect vehicle to TCM
4. Launch vehicle

This solution has the added benefit of making transportation to and from operating locations safer for the equipment. The solution, dubbed "Project Cal Case", is currently in the design and development stage and is scheduled for completion by December 2015. Once completed, the Cal Case will greatly improve the Company's setup and teardown efficiency.

7 Reflections

7.1 Senior Refection – Kaitlin Quinlan

Figure 16: Racheal (left) and Kaitlin (right)

To say that being a member of Eastern Edge Robotics for the last four years has added to my education as an electrical engineer would be an understatement. While I have also competed in the MATE Competition during high school, the level of knowledge and innovation that exists on this team has elevated my engineering knowledge and ability significantly. In particular, the innovative problem solving methods have aided me in both my professional and school work when tackling problems. Through this team I have not only gained skills and knowledge related to my field, but I have also had exposure to mechanical and computer engineering in ways otherwise not possible. I have also honed my leadership, interpersonal, report writing, and presentation skills by working on all aspects of the MATE competition with Eastern Edge which have been invaluable in my professional career. The connections and friends I have made both within the team and from participating in the international competition will stay with me for the years to come. I can say with certainty that I will miss everyone but hope to participate in the competitions in different capacities in the future!

7.2 Junior Reflection – Racheal Seymour


Figure 17: Racheal installing a new topsides circuit breaker

I began my journey with Eastern Edge Robotics in October of 2014. As a third year Electrical Engineering student, I was ready to gather some hands on experience as well as pursue my interests in robotics and underwater ROVs. Several of my friends who had been a part of the team for many years had informed me that EER was what I had been looking for.

As a new team member, I had initially expected to be doing very basic and dull work. This was not the case; the electronics enclosure needed immediate repairs due to damage sustained from the previous year's competition. I was quickly immersed in the hands-on work I had been hoping for. While repairing various electronics boards, sensors, and cameras, I began to learn about the many processes and technologies that made up the vehicle's electronics systems.

This past year has given me an excellent opportunity to learn about ROVs, robotics, electronics, and the marine industry as a whole. I had not expected to meet so many people with similar interests as me or to be welcomed so wholeheartedly by an excellent group with a common goal. The skills and experience that I have obtained while working alongside my team members will directly impact my career as I go into the engineering profession. I hope that I have the opportunity to share my experience and skills with new team members in future competitions.

8 Finances

Early in the project, a budget was developed to determine the required cost to design and build the ROV and decide which vehicle improvements could be implemented for this contract. All potential costs were determined based on monies spent in previous years and used as a baseline for this year's project. By creating a detailed budget early in the development stages of the project the Company was able to identify major costs and allocate funds accordingly. This budget also helped to ensure that employees researched all materials prior to purchase. As a result, funds were used effectively and there was minimal waste. However, unforeseen circumstances always arise in any project so a contingency fund was established to ensure the project did not go over budget. As the completion is being held in St. John's, Newfoundland and Labrador, Eastern Edge did not have to travel, thus there are no travel costs associated with this year's competition. The developed budget can be seen in Figure 18 below. To see a detailed financial statement please review Appendix E.

Budget	Value	Description
Manufacturing Materials	$1,500.00	Materials for ROV fabrication
Electrical Components	$1,000.00	Electronics supplies and components
Tool and Component Prototyping	$ 500.00	Misc. materials used to develop payload design
Consumables	$1,000.00	Potting Compound, Fiber Melts, etc.
System Improvements	$3,500.00	HD Camera Components, SS Solenoid Valves
Travel	$ -	No cost of travel this year
Contingency	$1,500.00	
Total:	$9,000.00	*values are in Canadian Dollars

Figure 18: Budget

9 Acknowledgements

Atlantic Canada Opportunities Agency (financial assistance)
Broadata Communications (subsidization of Optic Video Converter)
ExxonMobil (financial assistance)
Focal Technologies (**Moog**) (donation of multiplexer for fibre-optics – 2006)
Hibernia (financial assistance)
Husky Energy (financial assistance)
Imprint Specialty Promotions (donation of polo shirts)
Keller America (donation of pressure transducer - 2005)
Leoni Elocab (donation of custom built tether – 2015)
Lynx Technik (subsidization of Optic Video Converters)
MATE Center (for providing the opportunity to compete)
Memorial University of Newfoundland (for financial assistance and use of facilities)
Faculty of Engineering and Applied Science
Faculty of Science
Marine Institute
National Science Foundation (MATE Supporter)
Province of Newfoundland and Labrador (financial assistance)
Statoil (financial assistance)
SubConn (donation of connectors – 2011, 2013, 2015)
Subsea 7 (financial assistance)

Also, a very special thank you to our mentors Clar Button, Dwight Howse, Paul Brett, and Jai Ragunathan for donating so much of their time and energy to this project.

10 References

A. Faghri, Y. Zhang, J. Howell, Advanced heat and mass transfer, Edition of book, Columbia: Global Digital Press, 2007, p. 794 - 868.

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HSE Employee Handbook, Oceaneering International, Houston, Texas, 2012

Appendix A – Safety Checklists

PRE FLIGHT SAFETY CHECKLIST

- ☐ ELECTRONICS ENCLOSURE IS SEALED
- ☐ NO ELECTRONIC WIRES ARE EXPOSED
- ☐ UNDERWATER CONNECTIONS ARE SEATED
- ☐ TETHER IS UNTANGLED AND SECURED
- ☐ PNEUMATICS CANISTER IS SEALED
- ☐ PNEUMATIC LINES ARE SECURED AND CONNECTED
- ☐ PNEUMATIC PRESSURE READING ARE WITHIN SAFE LIMITS
- ☐ NO LEAKS IN PNEUMATIC SYSTEM
- ☐ CONTROLS IN OFF OR NEUTRAL POSITION
- ☐ CHASSIS HARDWARE IS TIGHTENED
- ☐ PERSONNEL ARE CLEAR FROM ROV
- ☐ ALL ELECTRONICS HAVE POWER
- ☐ THRUSTER RESPOND TO CONTROLS
- ☐ PNEUMATIC CHANNELS ACTIVATE
- ☐ EMERGENCY STOP SYSTEM TESTED

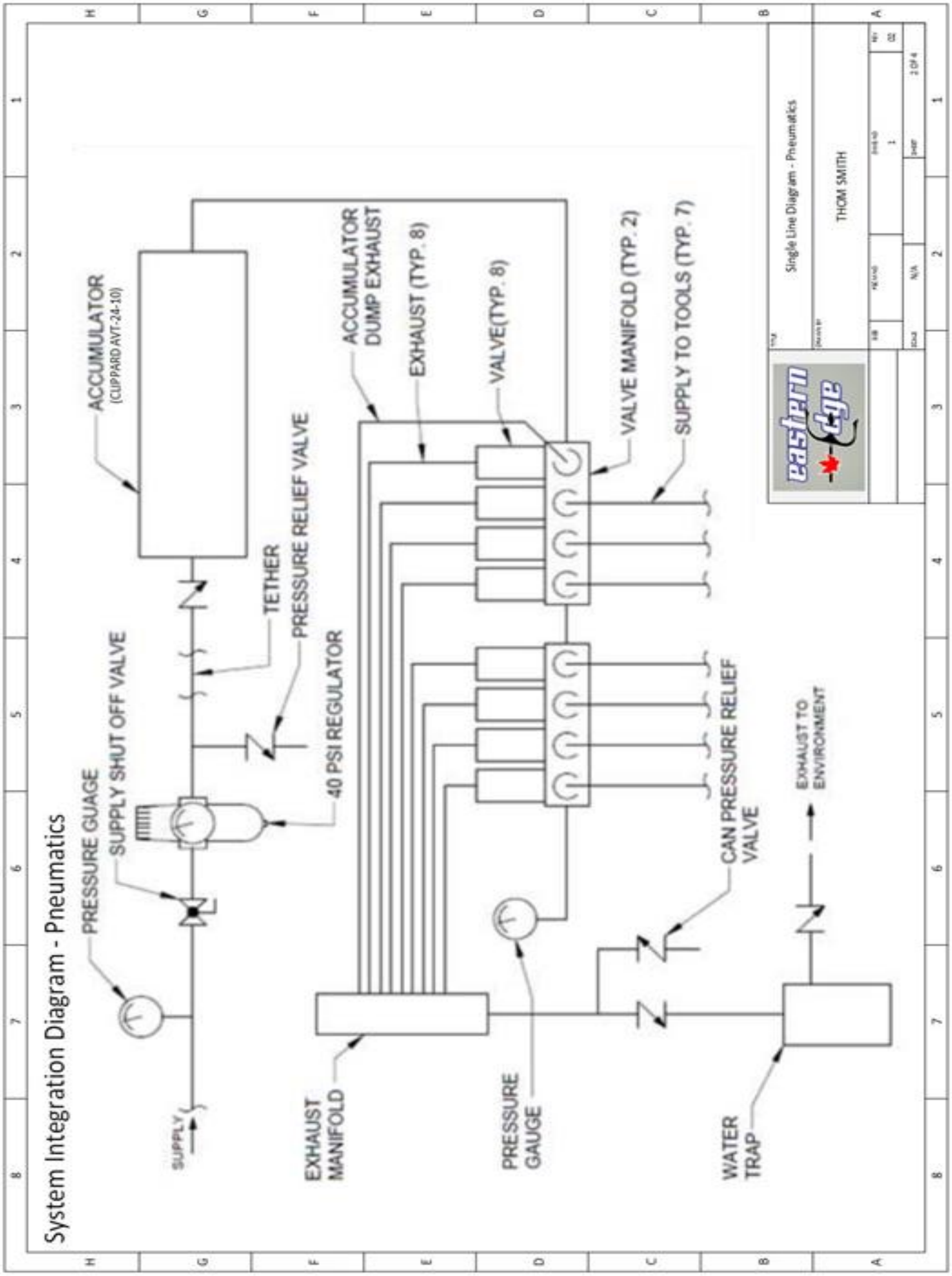
LAUNCH AND RECOVERY SAFETY CHECKLIST

- ☐ DECK CREW WEARING PFDS
- ☐ DECK CREW WEARING CLOSED TOE SHOES
- ☐ DECK CREW WEARING EYE PROTECTION WHEN REQUIRED
- ☐ TWO MEMBERS LAUNCH CREW READY
- ☐ LAUNCH ROV USING HANDLES
- ☐ LAUNCH TEAM CLEAR FROM ROV
- ☐ DECK CREW READY TO RECEIVE ROV
- ☐ ROV CONTROLS LOCKED ONCE IN RECOVERY AREA
- ☐ RECOVER ROV FROM WATER AND PLACE ON DECK

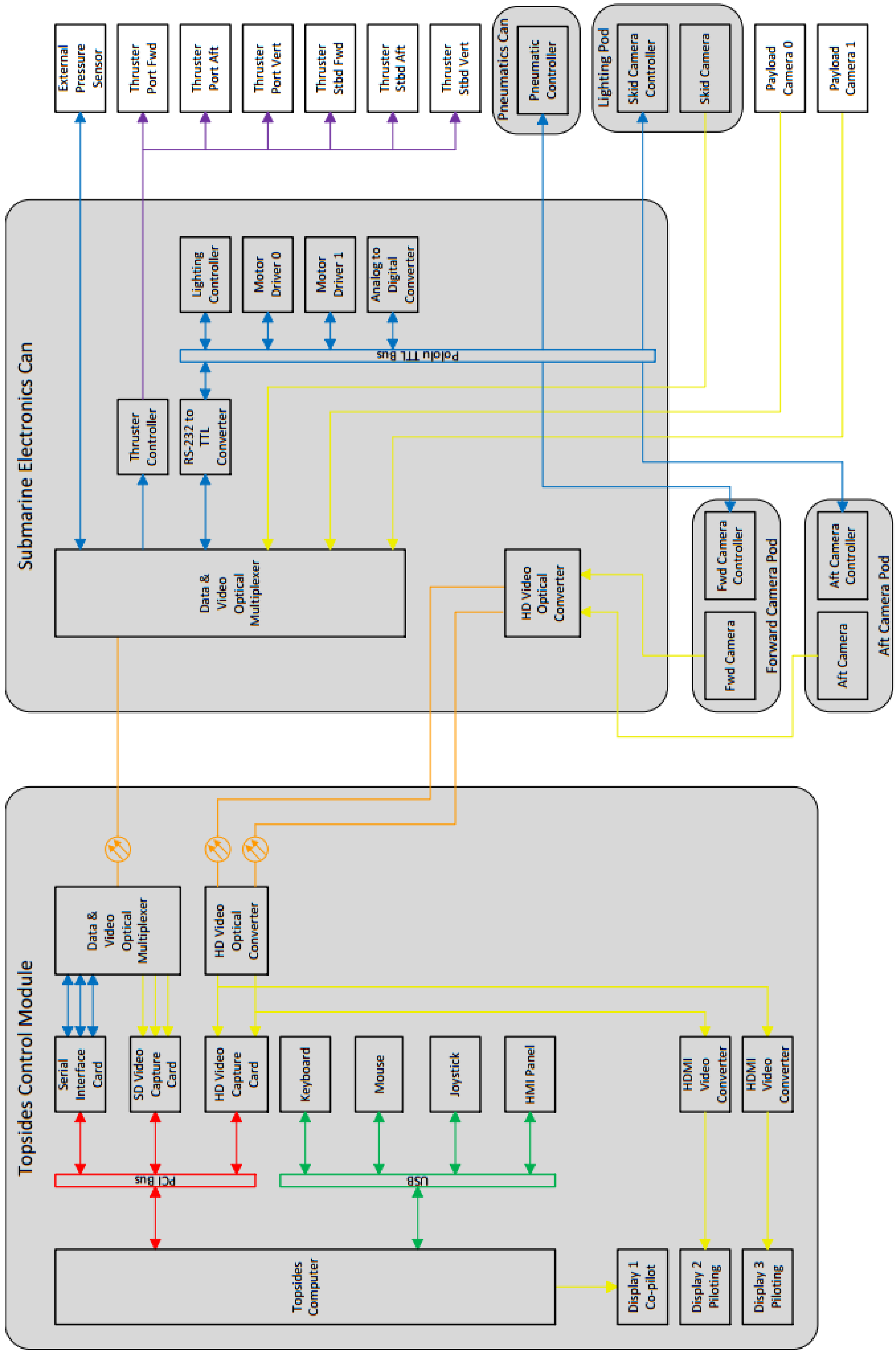
POST FLIGHT SAFETY CHECKLIST

- ☐ ROV POWERED OFF
- ☐ TETHER DISCONNECTED AND FLAKED
- ☐ PNEUMATIC POWER IS DISCONNECTED
- ☐ ALL SYSTEMS POWERED OFF

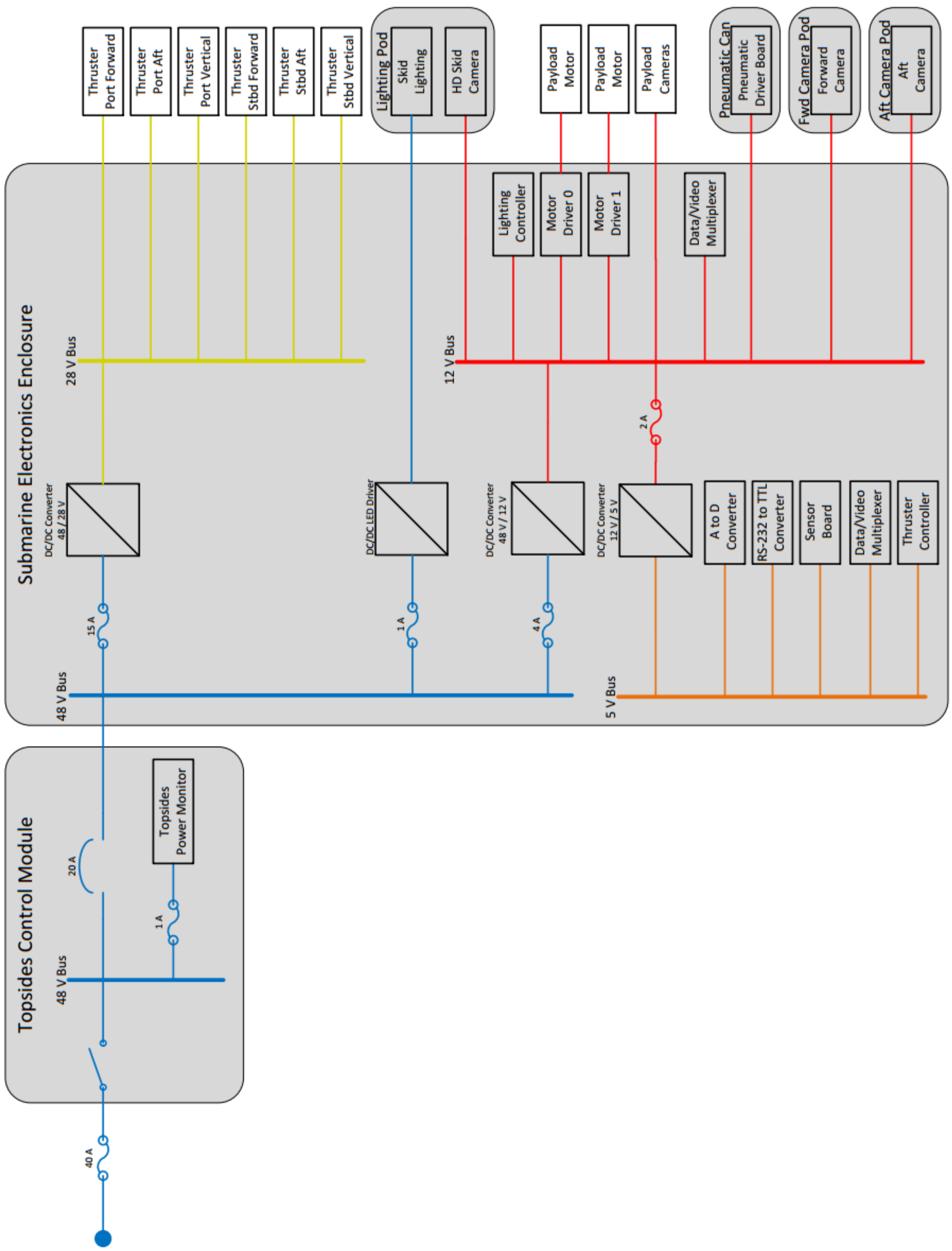
Appendix B – Pneumatic SID



Appendix C – Communications SID



Appendix D – Power SID



Appendix E – Financial Statement

Financial Statement

School Name:	Memorial University of Newfoundland	Reporting Period	From: 12/1/2014
Instructor/Sponsor:	Dwight Howse, Paul Brett, Clar Button, Jai Ragunathan		To: 5/28/2014

Funds

Type*	Discipline	Component(s)	Sources/Notes	Amount
Donation	General		Provided by Memorial University of Newfoundland - Marine Institute	$ 5,000.00
Donation	General		Provided by Memorial University of Newfoundland - Faculty of Engineering and Applied Science	$ 4,000.00
Donation	General		Provided by Memorial University of Newfoundland - Faculty of Science	$ 1,000.00
Re-used	Mechanical	**Thrusters**	Seabotix Brushless Thrusters - Thrusters were re-used as they do not require replacement	$ 6,000.00
Re-used	Mechanical	**Materials**	Manufacturing Materials and Mounting Hardware	$ 500.00
Re-used	Mechanical	**Pneumatics**	Pneumatics Control Can - Still functional and used as primary method of payload actuation	$ 1,100.00
Re-used	Electrical	**Communications**	Subconn Connectors, Maestro Boards, Motor Controller Boards, MUX, etc	$ 2,700.00
Re-used	Electrical	**Sensors/Instrumentation**	UM6, Pressure Transducer, SD Board Cameras, HD Board Camera, Servo Motors, Micro Controllers, etc	$ 1,500.00
Re-used	Electrical	**Power**	DC to DC Converters, Fuses, Power Connectors, Distribution Boards, etc	$ 500.00
Re-used	Software	**Topsides**	Control Computer, Joystick, Monitors, Payload Control Panel, Keyboard, Mouse, etc	$ 3,300.00
Donated	Electrical	**Tether**	Donated by LEONI Elocab Ltd. - Neautrally Buoyant, contains Eight Fiber, One Pneumatic, One Power and One Ground (30 ft used in this years Demo)	$ 5,000.00
Discounted	Electrical	**Fiber Optic Converter**	Lynx Technik - Provided discount YellowBrik SDI to Fiber Optic Converters and adapters	$ 1,155.70
Purchased**	Fabrication	**Material**	Polycarbonate, HDPE, Polycarbonate Tubing, Acrylic Tubing, Low Density Foam, Hex Stock, Aluminum - Used for fabrication of chassis and payload tools	$ 1,044.03
Purchased**	Manufacturing	**Manufacturing Supplies**	Router Bits, Drill Bits, Band Saw Blades, Edge Finder	$ 450.84
Purchased**	Mechanical	**Pneumatics Can Upgrade**	Solenoid Valves were replaced with Stainless Steel to mitigate corrosion issues	$ 669.19
Re-Used**	Manufacturing	**Payload Actuation**	Pneumatic Pistons, Servo Motors, Bilge Pumps - used for payload tooling actuation	$ 600.00
Purchased**	Electrical	**HD Cameras/Communication**	HD Cameras, SD Cameras, Misc Connectors, etc	$ 1,913.03
Purchased**	Electrical	**General Components**	C-Grid Connectors, Hand Tools, Wire, Circuit Components, Hydrometer, Switches, MOSFETS, Meastros, PIC Programer, etc	$ 1,022.42
Purchased**	Electrical	**Lighting**	LEDs, Tubing, Circuit Components, Drivers, etc	$ 96.82
Donated	Electrical	**Subconn Connectors**	Donated	$ 866.98
Purchased**	Mechanical	**Hardware**	Hardware used for mounting tooling and electrical components	$ 99.64
Purchased**	General	**Consumables**	Epoxy, Potting Compound, Fiber Melts	$ 352.97
Purchased**	Tooling	**Payload Tool Development**	Specialty Materials used for the development of Payload Tools (e.g. Pylons, Caribeaners, Dry Wall Hooks, etc.)	$ 54.93
Purchased**	General	**Misc.**	Whiteboard, dry erase markers, Team Registration Fee, Team Shirts	$ 953.18

Value of Re-Used Materials	$ 16,200.00
Total Funds/Materials Donated	$ 15,866.98
Total Expenditure (2015)	$ 8,679.73

***Items must fall into one of the following:**

Purchased - defined as items that are purchased new or services paid for.

Re-used - defined as items that were purchased in previous years. Amount listed as **estimated** current market value.

Donted - defined as equipment, materials, and time that were contributed to your company

Donation - defined as funds contributed to your company

Discounted - Provided to the team at a discounted rate

****Further breakdown of any of the above points can be provided upon request.**