# TECHNICAL REPORT

**Eastern Edge Robotics Team**
The Marine Institute of Memorial University

**MATE/MTS International Robotics Competition 2007**
Explorer Class

**<u>ROV *Bartlett*</u>**


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**APPENDICES**

# 1. ABSTRACT

This report describes the development of the ROV *Bartlett*, designed and fabricated by the Eastern Edge Robotics Team, Newfoundland & Labrador, Canada. *Bartlett* was purpose-built for use in the 2007 MATE/MTS International ROV Competition, to perform three missions, based on the 2007 International Polar Year (IPY) theme.

*Bartlett* has a structural frame of 12.5mm thick Lexan™, six (6) orthogonally positioned thrusters providing motion in six degrees of freedom, three (3) tilting, hi-resolution cameras, four (4) variable intensity LED cluster lamps, a waterproof Lexan™ electronics housing and low-compressibility (690 kPa), H-100, "High-load" structural Styrofoam™ encased in fiberglass forming the flotation. Fiber-optic signal transmission is used in propulsion and tool control, sensor input and video systems. Custom programming using C# incorporates data visualization tools from Dundas Gauge and DirectX. Custom tether is neutrally buoyant in the competition environment.

Task-specific tools of original design or application have been fabricated for each mission task. The priority in design was simplicity, low drag, low weight, high-efficiency, reliability, and robust materials.

The Eastern Edge Robotics Team is a diverse group, comprising 17 students from three academic institutions: Memorial University, the Marine Institute, and the College of the North Atlantic. The polar theme of the 2007 MATE/MTS ROV Competition inspired the team to name their ROV *Bartlett* after Captain Robert Bartlett, an eminent polar explorer born in the British colony of Newfoundland.

# 2. BUDGET AND FINANCIAL STATEMENT

## 2.1 Expenses

| ITEM | COST ($CAD) |
|---|---|
| Polycarbonate (Lexan™) | 350.00 |
| High Load Styrofoam™ | 43.00 |
| Fiberglass | 70.00 |
| Cameras (3 @ $120) | 360.00 |
| Analog input board | 150.00 |
| Servo controller (2 @ $50) | 100.00 |
| Fiber-optic interface board | 3500.00 |
| Pulse width modulator (8 @ $250) | 1500.00 |
| Misc. electronics | 2375.00 |
| Pressure Sensor | 575.00 |
| Waterproof electronics housing | 250.00 |
| Hardware (fasteners, drill bits, etc.) | 150.00 |
| Digital Compass | 500.00 |
| Thrusters (6 @ $ 2000) | 12000.00 |
| Custom built tether | 1200.00 |
| Data Visualization Software | 600.00 |
| **TOTAL** | **$23,723.00**<br>**(approx $21,350.70 USD** |

## 2.2 Donations/Revenues

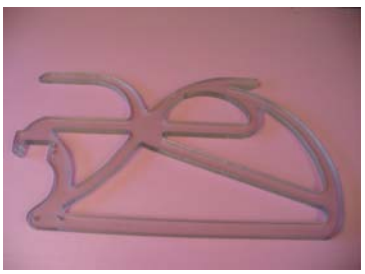
| ITEM (COMPANY) | VALUE ($CAD) |
|---|---|
| Commercial pressure transducer (Keller America) | 575.00 |
| Six 90W thrusters (Inuktun) | 12000.00 |
| Fiber-optic interface board (Moog) | 3500.00 |
| Custom built tether (Leoni Elocab Ltd.) | 1200.00 |
| Dundas Gauge | 600.00 |
| The Marine Institute | 5000.00 |
| Imprint Specialty Promotions | 150.00 |
| Ultragraphics | 100.00 |
| **TOTAL** | **$23,125.00** |
| | **(approx $20,812.50 USD)** |

# 3. DESIGN RATIONALE

## 3.1 Structural Frame

The structural frame has two components that provide structural integrity to ROV *Bartlett***:**

- a machined, 12.52 mm thick polycarbonate plastic (Lexan™) frame, and;
- a contoured foam flotation constructed from low-compression foam coated with a glass-reinforced epoxy resin.



The structural frame was designed using the SolidWorks 3-D CAD program, which produced a template for milling this unit. It is designed to minimize drag, especially for conducting Mission 1 in a water current of 0.5 m/s.

Flotation was constructed by laminating four (4) pieces of 50 mm thick H-100, low compression Dow Styrofoam Highload extruded polystyrene foam into a mass 200 mm deep, using an epoxy glue. This foam is ideal for the shallow depths of the competition as it is designed for use under extreme loads. It has a 692 kPa (100 psi) compression tolerance. The maximum competition depth is 4m with a pressure of 40 kPa (6 psi). Given the challenge of operating in a water current, we performed a dynamic fluid analysis to validate the shape of this flotation. See Appendix C for a graphic representation of the fluid analysis. The final shape was designed in Solidworks 3-D CAD. See Appendix D for SolidWorks CAD renderings.

## 3.2 Propulsion

The ROV uses six (6) 90W Inuktun thrusters with a depth rating of 300m. The thrusters have standard EO connectors and are liquid filled with “Enviro-Rite™“ fluid for pressure compensation. They are placed within the Lexan /structural foam frame as follows:

- Four (4) thrusters are placed horizontally at a 45 degree angle to the surge axis; the forward pair being placed higher than the aft pair to eliminate turbulent interference and to provide pitch control.
- Two (2) additional thrusters are placed vertically, one each on the port and starboard sides. With independent control of each thruster, this configuration enables six degrees of freedom: surge, sway, heave, yaw, pitch and roll. These particular thrusters were used, chiefly as they were donated, delivered high performance and met the design specifications for the competition.

## 3.3 Video Camera

*Bartlett* uses three (3) high quality, low-light PC board cameras purchased from Super Circuits (PC169XS,) housed in clear 5cm O.D. polycarbonate tube with 3mm wall thickness. These color cameras have a 1/3" CCD with 460-line resolution and a 1.0 lux rating. They operate on 12 volts DC with low current rating of 110 mA. A 2.5 mm lens provides a $90^{o}$ field of view in water. The cameras can be tilted (rotated $90^{o}$ vertically either up or down from horizontal plane) by a small servo-motor inside the polycarbonate tube. SubConn 4-pin waterproof bulkhead wet-mateable connectors join the cameras to the onboard electronics can. The cameras are positioned as follows:

- One forward-facing camera located on the front of the ROV with a full view of all mission task operations.
- One forward-facing navigation camera located at the aft of the ROV which will provide supplemental views of the missions.
- One upward-facing camera which will assist in the under-ice sampling task and navigating the ROV through the ice at the end of Mission 2.

## 3.4 Tether

Leoni Elocab, Inc donated a team-designed, custom-built tether. It has six (6) multi-mode fiber optic strands for control and video signal transmission and three (3) 12-gauge copper wires for DC power. The tether has five (5) redundant fibers in case of damage to others. The tether is covered with a slick, low-drag, high-visibility yellow polyurethane coating and is neutrally buoyant in fresh water, making it ideal for use in the competition environment.

# 4. CONTROL SYSTEM

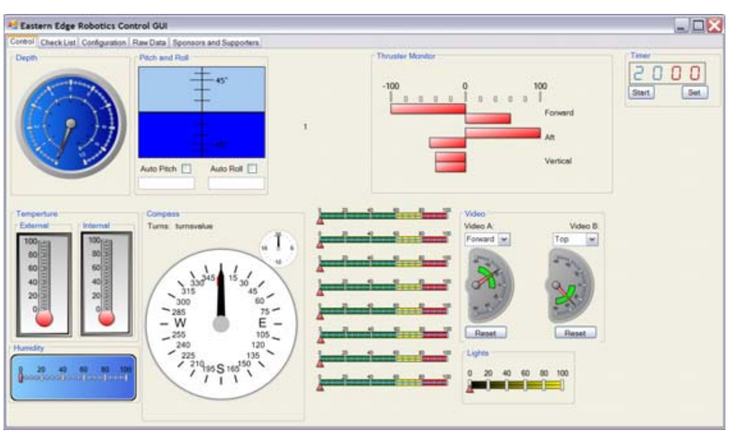
ROV *Bartlett* has a control system that was programmed using the C# language. The program is run on a notebook PC and uses DirectX to read user inputs. Inputs from a keyboard, mouse and USB joystick are monitored and appropriate output responses are calculated. The C# programming is designed with five threads (or integrated segments) which sample data continuously. (Programming logic flow chart may be viewed in Appendix A)

The threads are:

- Analog/digital converter signal processing thread for all sensors and power supply monitoring.
- Joystick / propulsion control thread which determines thruster control signals for each of the six thrusters in manual or auto modes.
- Accelerometer thread which reads and displays values for pitch, roll and heading, as well as temperature inside the water proof 'can' onboard the ROV.
- GUI thread which produces values for display on the laptop monitor and video overlay.
- Report thread that acts like a black box to record all the data inputs, outputs for each dive. This allows post-dive analysis of missions and is a precursor to providing autonomous control of the ROV for repetitive dives and tool operations.

Thread design increases speed of processing with dual-core processors in our computer by 1.7 times. The programming uses a series of display windows to represent relevant information: Operations, Pre-dive Checklist, Configuration, and Raw Sensor data. Team designed displays are supplemented by analog gauges from Dundas Data Visualization.

## 4.1 Operations




The Operations tab presents all data required for the ROV to operate. Some of the functions included are: a timer, camera tilt position, thruster power, tool position, power supply monitoring, humidity and temperature in the electronics can. An artificial horizon displays pitch and roll and provides a mechanism for auto-pitch and roll setting. A digital compass shows heading and monitors the number of turns in the ROV tether.

The control system incorporates auto-depth, auto-pitch and auto-roll features which can be used to maintain the current depth, pitch or roll, or to move to a pre-selected depth, pitch or roll.

## 4.2 Pre-dive Checklist

This checklist ensures that all safety and runtime checks are completed before launching the ROV. On this screen, the ambient air pressure is also measured to be used as an offset for the depth sensor. When all elements of the checklist are addressed, a warning flag on the Main Operations page is turned off. Some configuration features are also included on the pre-dive checklist, including zeroing the auto depth, pitch and roll.

## 4.3 Configuration

The configuration page provides a mechanism to tune the operation of the ROV. The function for each of the servo controls is selected and min-max limits are set. For depth control, the operator can select the water density to calibrate the sensor. Depth, pitch, roll and heading all can be configured to be automatically controlled. The configuration page establishes coefficients for proportional and integral control of parameters.

## 4.4 Raw Data

The Raw Data page provides values from sensors including the joystick and analog sensors. It also displays the settings for each of the sixteen servos. This page functions in debugging and troubleshooting and acts as a fail safe for the joy stick.

# 5. ELECTRONICS

The electronics system is divided into two components: the electronics can, which is onboard the ROV, and the topside electronics. Refer to Appendix B for Electrical Schematics.

## 5.1 Topside Electronics

### 5.1.1 Joystick

The pilot controls the ROV using a Logitech USB joystick, which controls the camera selection, and provides the user interface for control of surge, sway, heave, and yaw, as well as the onboard tools. The joystick has twelve switches plus an eight (8) position 'tophat' switch. The tophat switch and four button switches are used to control camera functions. With the trigger pressed, the six side buttons control tools. The trigger acts as a "*dead man*" switch to ensure that tools are not activated accidentally. With the thumb switch activated, the six side buttons control the auto depth, heading, pitch, and roll functions.

### 5.1.2 Topside Control Unit

The topside control unit provides the power interconnections, monitoring, and protection, the interface to the PC through USB ports, the video overlay, and the communication with the ROV over a fiber-optic tether.

Power is supplied for the control electronics at +12V and to the thrusters at a switch-selectable +12, 24, 36, or 48V level on the battery box. This allows full power at high voltage when required and fine motion at low voltage when desirable. Voltages and currents are monitored and displayed as is the internal temperature of the control unit using a Phidgets 8/8/8 interface with 8 channels of 0-5V A/D conversion.

Control of the ROV is handled through the USB ports on a PC. To connect to the PC, one USB port is used for the joystick and a second for the remaining electronics control.

The electronics control USB signal is directed to a Quatech Technologies 8-port RS-232/422/485 device. Each port on this device is individually configurable as either RS-232, 422, or 485. *Bartlett* is configured with six RS-232 control channels and two RS 485 channels.

One of the RS-232 lines is used to control a video overlay board to display real-time information such as depth and heading on the video display monitor. Of the remainder, four (4) RS-232 channels and two RS-485 channels are interfaced to the ROV through the console unit of a Model 907 video/data multiplexer from

Focal Technologies. This unit also provides communications of the three (3) video channels from the ROV all on a single fiber strand.

## 5.2 Onboard Electronics

### 5.2.1 Submarine Electronics Can

The electronics are housed in a rectangular polycarbonate box from “Prevco”. The housing has a 75m depth rating and measures 9.35 x 12.06 x 19.99 cm.

The tether connects to the waterproof electronics can onboard *Bartlett* using multiple-plug, segmented bulkhead connectors from SeaCon-Brantner.

Inside the waterproof electronics can, the remote unit of a Model 907 video/data multiplexer from Focal Technologies conveys and converts optical signals from the tether to the video and data electronic signals useable by the onboard electronics. One of two Polulu 8-channel servo controllers in the can, receives RS-232 signals from the topside control box to activate individual IFI Robotics Victor HV pulse width modulators to provide independent proportional control to each of the six (6) thrusters and to control one tool and the lighting. The second Pololu servo controller controls camera tilt on each of the three cameras and also controls some of the tools.

An 11-channel analog-to-digital converter from B&B Electronics monitors the various analog sensors onboard *Bartlett*. It has 12-bit resolution over a 0-5V range and is connected by an RS-232 bus. Onboard sensors sample relative humidity inside the can as a leak alert, monitor internal temperature in the can and also monitor the power line voltages.

An Ocean Server OS-1000 digital compass that measures heading relative to magnetic North is contained in the electronics can. An integrated two-axis accelerometer measures pitch and roll that are displayed as an artificial horizon on the computer monitor topside display. These sensors provide the feedback signals for auto-heading, auto-pitch, and auto-roll as well as an additional temperature sensor. The digital compass communicates over an RS-232 bus.

### 5.2.2 Depth Sensor

Connected to the electronics can is a Preciseline™ pressure transducer, used to determine water depth, and donated by Keller America. It has 16-bit internal digital error correction and a floating isolated piezo-resistive sensor giving ± 0.1%

accuracy in depth. It is configured with a full range of 300kPa. It is referenced to a vacuum and therefore provides a measure of up to about 20m of water depth. The ±0.1% accuracy allowed the programming team to include the auto-depth feature in the Configuration menu of the control system. It communicates over an RS-485 bus and also provides the ability to measure water temperature.

### 5.2.3 Temperature Sensor

Temperature inside the electronics can is measured using a “Microchip” TC1047A sensor that covers a range of -40 to +125 degrees C. It is read as an analog input and provides the operator with a warning in case devices inside the can are overheating.

### 5.2.4 Humidity Sensor

Humidity inside the can is measured using a “Humirel” HTM1735 sensor that covers a range of 10%-95% rH. This gives an indication of condensation or water incursion in the can. It is read as an analog input.

### 5.2.5 Cameras

Three single board cameras were mounted on servos in watertight housings to provide a 360 degree view around the ROV in the vertical plane. Each camera uses a 2.5mm lens to provide a 90 degree horizontal field of view in water. Cameras are model PC169XS models from Supercircuits and provide a low 1.0lux rating with a high resolution of 460 lines.

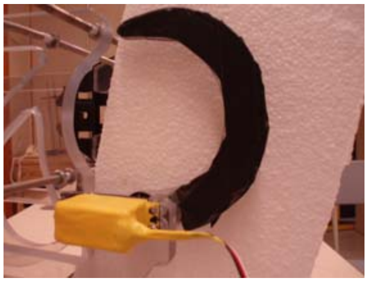
# 6. TOOLS

## 6.1 Mission 1: Flume Tank

The tool for Mission 1 is an “off the shelf” mooring retriever modified to fit our ROV. A tool designed for this specific purpose is called the “*Happy Hooker*”. It is a PVC I beam bent into a “U”-shape with a diameter of 15 cm. The opening of the “U” is blocked by a plastic bar, which is hinged on both ends. The “Happy Hooker” allows a line to pass through and return through the ballasted U-bolt. This tool can be fully detached from the ROV.

## 6.2 Mission 2: Ice Tank

### 6.2.1 Collecting benthic jellyfish



A multi-purpose "talon gripper" designed and fabricated for collecting the 'O'-ball, is located on the front of the ROV at its base. The "talon gripper" is fabricated using the 12.5 mm thick Lexan™ frame of the ROV as the fixed part of the claw and a 100 mm diameter curved arc of 6 mm thick Lexan™ forming the talon part of the claw. These parts intersect in a vertical plane. The talon part of the gripper moves in a downward arc to capture the 'O'-ball, actuated by a waterproofed servomotor (HiTec HS-422, 180$^{o}$ rotation, 4.8-6.0 VDC, 4.1 kg stall torque).

### 6.2.2 Collecting a sample of algae

To collect a sample of algae, the ROV uses a bilge pump motor fixed at the end of 50mm Polycarbonate tube. When the ROV approaches the balls, the pilot turns on the bilge pump motor, creating a vacuum force, which sucks the balls into the tube. The balls are held in the tube by a ring of Velcro tape covering the inside of the tube.

### 6.2.3 Deploying a passive acoustic sensor

To deploy a passive acoustic sensor, the ROV uses the two multi-purpose grippers (exactly the same as those used to collect the benthic jellyfish). The grippers close around the weighted base unit, allowing the buoyant instrument and cable to float freely in the water. This ensures that when the grippers open to release the base, the buoyancy of the instrument will help it stay upright in the water. See photo above.

## 6.3 Mission 3: Tow Tank

### 6.3.1 Install a gasket in the wellhead and inject corrosion inhibitor into wellhead's protective cover

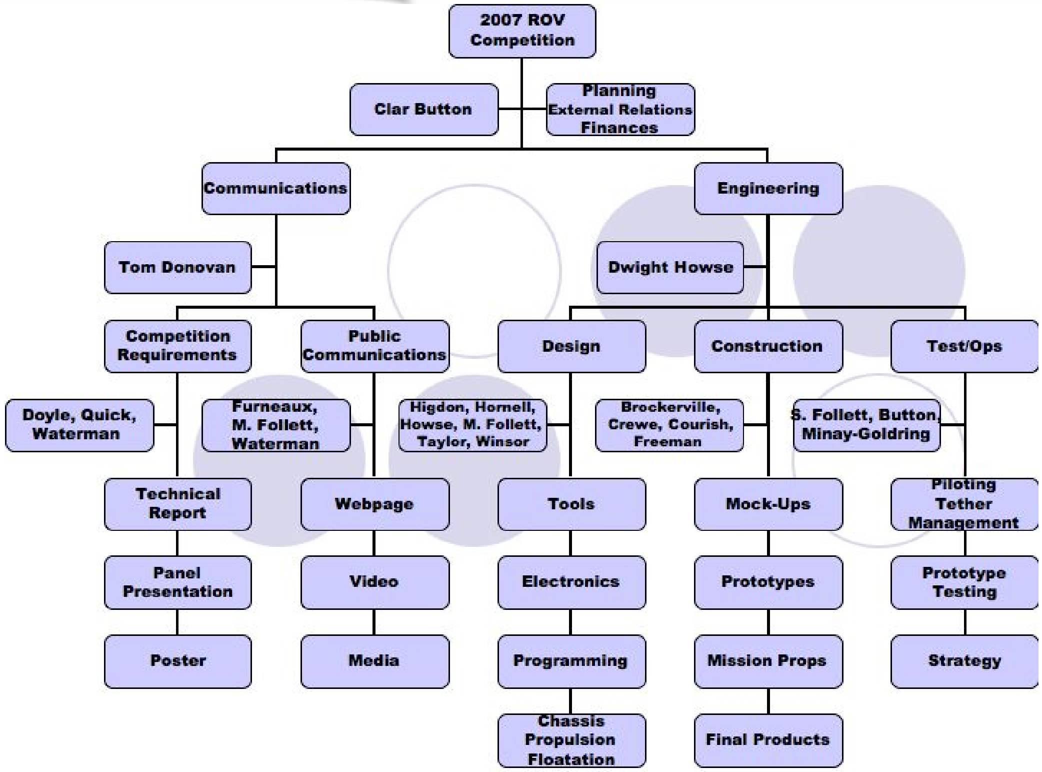
The tool used to remove the wellhead cap and install a gasket will be the same tool used to collect the jellyfish sample and deploying the passive acoustic sensor ("talon gripper"). This tool has proved to be truly multi-purpose. See photo above

The tool used to inject the corrosion inhibitor is made from 6.0 mm thick Lexan™ and uses a waterproofed servomotor winch directly connected to a spool to retract the line connected to the hot-stab. The hot-stab is inserted, the line is released and the ROV backs away from the wellhead. The hot-stab is retrieved when the injection is complete.

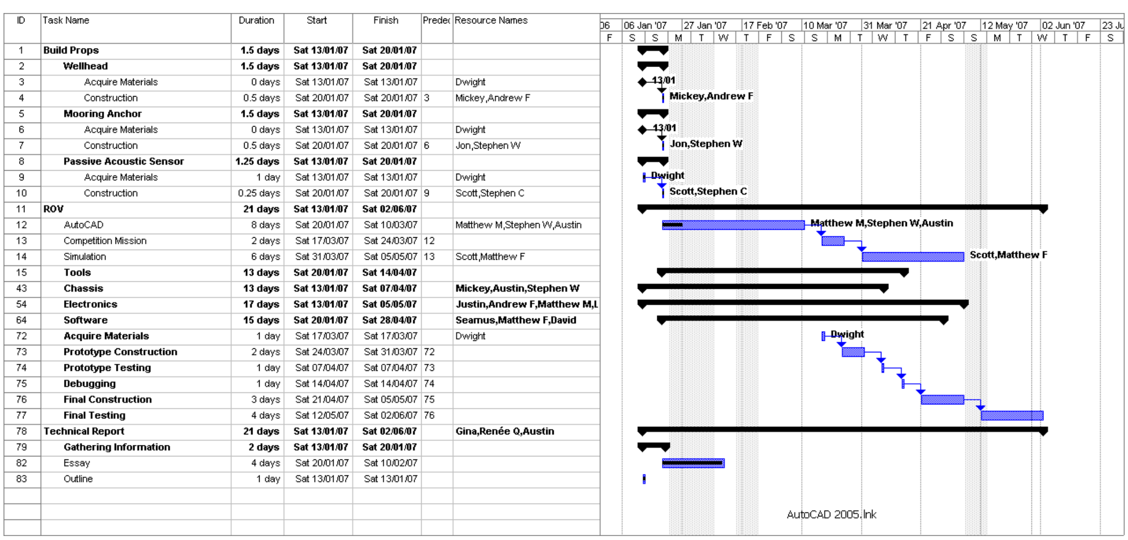
## 7. CHALLENGES

Engineering any novel mechanism is always a challenging process. Our team is comprised of students from three different post secondary institutions, all of which run on different schedules. Combine that with student work terms and it was quickly discovered that project management was the biggest issue for our team. To maximize productivity we first created a Team Organization Chart, (see below) which divided the team into two categories: Engineering and Communications. Mentors supervised each student group, but it was the responsibility of team members in each design group to ensure timely and quality completion of tasks.

Each group documented their progress and reported on a weekly basis. A reporting and planning session started each meeting and was the mechanism that enabled all team members to stay abreast of developments as well as contribute their ideas for improvements. The team has long recognized that our success is a function of the quality of knowledge and skills of its members. With junior members emerging from the high school system each year, veteran team members take responsibility for mentoring and training new members throughout the design and fabrication process.




Another major challenge was scheduling and monitoring the progress in all aspects of the competition.. This was achieved by creating a detailed project plan in Microsoft Project. A Gantt chart (sample below) scheduled materials and components arrival and work progress. This chart allowed the team to view progress for the entire project and direct resources to critical activities.



| ID | Task Name | Duration | Start | Finish | Predec | Resource Names |
|---|---|---|---|---|---|---|
| 1 | **Build Props** | **1.5 days** | **Sat 13/01/07** | **Sat 20/01/07** | | |
| 2 | **Wellhead** | **1.5 days** | **Sat 13/01/07** | **Sat 20/01/07** | | |
| 3 | Acquire Materials | 0 days | Sat 13/01/07 | Sat 13/01/07 | | Dwight |
| 4 | Construction | 0.5 days | Sat 20/01/07 | Sat 20/01/07 | 3 | Mickey,Andrew F |
| 5 | **Mooring Anchor** | **1.5 days** | **Sat 13/01/07** | **Sat 20/01/07** | | |
| 6 | Acquire Materials | 0 days | Sat 13/01/07 | Sat 13/01/07 | | Dwight |
| 7 | Construction | 0.5 days | Sat 20/01/07 | Sat 20/01/07 | 6 | Jon,Stephen W |
| 8 | **Passive Acoustic Sensor** | **1.25 days** | **Sat 13/01/07** | **Sat 20/01/07** | | |
| 9 | Acquire Materials | 1 day | Sat 13/01/07 | Sat 13/01/07 | | Dwight |
| 10 | Construction | 0.25 days | Sat 20/01/07 | Sat 20/01/07 | 9 | Scott,Stephen C |
| 11 | **ROV** | **21 days** | **Sat 13/01/07** | **Sat 02/06/07** | | |
| 12 | AutoCAD | 8 days | Sat 20/01/07 | Sat 10/03/07 | | Matthew M,Stephen W,Austin |
| 13 | Competition Mission | 2 days | Sat 17/03/07 | Sat 24/03/07 | 12 | |
| 14 | Simulation | 6 days | Sat 31/03/07 | Sat 05/05/07 | 13 | Scott,Matthew F |
| 15 | **Tools** | **13 days** | **Sat 20/01/07** | **Sat 14/04/07** | | |
| 43 | **Chassis** | **13 days** | **Sat 13/01/07** | **Sat 07/04/07** | | **Mickey,Austin,Stephen W** |
| 54 | **Electronics** | **17 days** | **Sat 13/01/07** | **Sat 05/05/07** | | **Justin,Andrew F,Matthew M,L** |
| 64 | **Software** | **15 days** | **Sat 20/01/07** | **Sat 28/04/07** | | **Seamus,Matthew F,David** |
| 72 | **Acquire Materials** | 1 day | Sat 17/03/07 | Sat 17/03/07 | | Dwight |
| 73 | **Prototype Construction** | 2 days | Sat 24/03/07 | Sat 31/03/07 | 72 | |
| 74 | **Prototype Testing** | 1 day | Sat 07/04/07 | Sat 07/04/07 | 73 | |
| 75 | **Debugging** | 1 day | Sat 14/04/07 | Sat 14/04/07 | 74 | |
| 76 | **Final Construction** | 3 days | Sat 21/04/07 | Sat 05/05/07 | 75 | |
| 77 | **Final Testing** | 4 days | Sat 12/05/07 | Sat 02/06/07 | 76 | |
| 78 | **Technical Report** | **21 days** | **Sat 13/01/07** | **Sat 02/06/07** | | **Gina,Renée Q,Austin** |
| 79 | **Gathering Information** | **2 days** | **Sat 13/01/07** | **Sat 20/01/07** | | |
| 82 | Essay | 4 days | Sat 20/01/07 | Sat 10/02/07 | | |
| 83 | Outline | 1 day | Sat 13/01/07 | Sat 13/01/07 | | |

# 8. TROUBLESHOOTING TECHNIQUES

Problems in ROV design and fabrication typically occur in two areas:

- Electronics, communications and control programming, and;
- Tools designed to perform the mission tasks

## 8.1 Electronics and signal processing troubleshooting

Ease of electronics trouble-shooting was designed into our system by the use of modularized sub-systems that have independent communications channels. Each subsystem's function was tested before final assembly to preclude system-wide malfunctions. The following subsystems were tested:

- A/D converter
- Digital compass
- Video-overlay PCB
- Depth and temperature sensor
- Servo controllers
- Sensors voltage, current and relative humidity sensor inside can
- Propulsion (all six thrusters)
- Video cameras

Furthermore these tests are built into the pre-dive checklist addressed before every mission as a preventative trouble-shooting method. The control programming requires that this rigorous protocol must be completed before the ROV can be used in the water. This procedure assures the team that *Bartlett* is perfectly functional before commencing each mission. Furthermore it eliminates the need for whole system testing, in case of a malfunction in one subsystem. In the rare case when electronic subsystems fail, the modular design enables rapid identification and repair of the problem.

## 8.2 Mechanical troubleshooting

Mechanical troubleshooting occurs during and after performance tests of the ROV vehicle or any of the tools devised for the 2007 missions. ROV performance is evaluated in relation to the design specifications originally drafted in the early stages of design. ROV movement and maneuverability are assessed in a larger tank through inspection portholes at various depths. Our routine test tank is a 4 m cube. ROV trim, attitude, and movement are tested against these design specifications using observers with check lists, stationed at the portholes.

These first-hand observations are supplemented with recorded video from underwater cameras attached to poles that are inserted in the tank. We find this technique invaluable to identifying performance concerns.

Trouble shooting the performance of tools is similarly conducted by visual and video observation, in the same tank. As the tool designs are refined, we will move the ROV into a larger tank which is 22m long, 8 m wide and 4 m deep, which has a complete wall of 12 cm thick clear glass. The observations and video recording made through the glass at the bottom of this tank are ideal for discovering inefficiencies in the design and for suggesting improvements.

## 9. FUTURE IMPROVEMENTS

Each year, the Eastern Edge Robotics team looks for ways to stretch our knowledge and the capabilities of our ROV. It is a constant process of improvement and increased capacity, approaching commercial ROV systems. Our improvements make the previous year's ROV obsolete. While not giving away specific plans, we are hoping to make advances next year in the following areas:

i. Tether: reduction in the number of power wires, and consequently weight, diameter, cost and drag.
ii. "Uni-body" construction: reduction in the number of structural members by enhancing the structural integrity of the flotation material
iii. Video output: achieving functional, depth perception.
iv. Autonomous operations: increasing the efficiency of repetitive task performance to reduce bottom time and costs. Our advances in data acquisition built into this year's programming will greatly help to achieve this objective.
v. Autonomous and assisted movement: plotting course and depth change profiles to minimize time spent in travel to the mission sites.

From discussions with industry, we believe that, rather than following current technology in commercial ROVs, several of the above advances will lead industry design and technological enhancement.

## 10. LESSONS LEARNED/SKILLS GAINED

Each year, Eastern Edge Robotics pushes the envelope in using more sophisticated techniques and equipment. Some of the new technical skills developed by team members this year include:

- Use of SolidWorks for 3-D CAD drawings of the ROV;

- Redesigning the programming with thread compartmentalization;
- More advanced use of C# as a programming language for interfacing
- Manual and CNC machining for structural frame and contouring flotation;
- Using servo motors to actuate tools and tilt onboard cameras;
- The intricate methods for waterproofing servo motors for use underwater;
- Our first requirement for refurbishing our thrusters with new seals and pressure compensation fluid;
- Milling our own waterproof bulkhead penetrators for the waterproof can;
- Design and use of more advanced data visualization tools;
- New sensor use on the ROV, such as artificial horizon accelerometers;
- Fluid dynamic analysis to design low-drag ROV structure and flotation.

Soft skills developed by team members this year include:

- A new system for mentoring junior team members by matching with veteran members;
- Team-building exercises to integrate new and veteran team members;
- New enrichment programs for intermediate and high schools to recruit and train new, knowledgeable, team members;
- Program for this year was exceptional for the team in terms of new skills.

New members and several veterans expanded their areas of expertise by collaborating with experienced members to learn new concepts in different areas. In electronics, for example, new team members learned about voltage dividers, pulse width modulators, speed controllers, fibre-optics, cameras and sealing electronics. Some people who had previously focused on electronics and programming decided to focus on chassis and prop development, and learned more about designing with SolidWorks, prototyping and testing new designs.

## 11. REFLECTIONS ON THE EXPERIENCE (from Matthew Follett, Team member)

Being a Computer Scientist, working as a programmer, on a team of mostly engineers, is an interesting experience. Working with different groups of people, getting the chance to work with people who all have a specialty in different areas and trying to get to a final goal is always a good thing. Explaining your ideas and goals can be hard at times, but, with perseverance and a good analogy or two, the ideas soon begin to stream between two groups.

Coming from a program where majority of the work is done solo and group projects are a rare occurrence, it's always nice and sometimes frustrating working with other people. When we consider working with people in different fields, it's always exciting to exchange ideas with other teammates, no matter their expertise, but frustrating, as you wait for that one key component to continue your work.

Playing with circuits and getting the computer and the circuit board to talk back and forth is a new experience; it's frustrating trying to figure out why the message isn't being read properly, but worth the trouble when it all starts to work. This isn't something we experience in the classroom; the components we talk to are internal to the system and are always in working order and explained clearly.

One of the more exciting ideas I got to work with was using multiple-threads, where we had multiple programs running at once, all working towards a singular goal. Dealing with data hazards, as multiple threads try to use and update the same variable, had to be dealt with, as well as dividing everything into two groups.

Working with the Eastern Edge Robotics team has been a fantastic experience. While there are times when you get sick of working on the same project week after week, it's always a great feeling seeing progress being made by the other groups and it makes you feel like the items you are working on truly do make a difference. - *Matthew Follett*

## 12. DESCRIPTION OF CULTURAL, HISTORICAL AND SOCIETAL ASPECT OF HUMAN LIFE AT THE POLES.

### "Everything a hero should be" – Polar Explorations of Capt. Bob Bartlett

With 2007 being declared an International Polar Year, people around the world are focusing on science, ocean observing, and industry operations in polar areas. Being from a province with close ties to polar regions, the Eastern Edge Robotics Team has a particular interest in polar exploration, especially since one of the most famous polar explorers of the 20$^{th}$ century, Captain Robert (Bob) Bartlett, was born and raised in Newfoundland.

When Robert Peary completed the first successful expedition to the geographic North Pole on April 9, 1909, it was Captain Bob Bartlett who commanded the *Roosevelt* from New York City to within 209 km of the North Pole. Peary's team of 23 men shrunk to 5 as they neared the Pole, but those brave men will be remembered forever as the crew who defied all odds and won the race to the Pole.[1, 2]

Captain Bob Bartlett was born in Brigus, Newfoundland on August 15, 1875. He attended a Methodist college for two years, due to his mother's insistence that he become a minister. He left before finishing to go sealing with his father off the coast of Labrador.[3] A distinguished sailor by the age of 17, he made a record 40 visits to the arctic and sailed over 300,000 km around the arctic. He received the Hubbard Gold Medal from the National Geographic Society for his contribution to polar exploration. He captained the *Karluk* in its ill-fated 1913-1914 expedition to the north, despite his arguments that the ship and expedition leader, Vilhjalmur Stefansson, were unfit to go. When Stefansson abandoned the ship and its crew after a disastrous trip north, Bartlett took responsibility for the remaining crew of 22 men. With a single Inuit guide, he hiked over 1100 km to Siberia and back to the Bering Straight to find a ship to rescue his men off from the ice. He was credited with saving 16 lives and won the Royal Geographical Society award for outstanding heroism. A survivor, William Laird McKinlay, said of the expedition: "…there was for me only one real hero, Bob Bartlett, honest, fearless, reliable, loyal, everything a hero should be." [4]

His adventures were many and varied. He captained American transport ships during the First World War, commanded an expedition to the Aleutian Islands in 1928, and used his own schooner, the *Effie M. Morrissey*, to later explore Labrador and the Arctic.[5]

Captain Bob never married and had no children. He died of pneumonia in New York City on April 28th, 1946. His contribution to polar exploration was outstanding and matched by few others. His home in Newfoundland, *Hawthorne Cottage*, has been designated a Canadian National Historic Site and stands as a tribute to his achievements.[3,6] - *Gina Doyle*

## 13. ACKNOWLEDGEMENTS

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Keller America
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Marine Institute, Memorial University
MATE Centre
Moog
SubConn
Ultragraphics

Our mentors, Tom, Dwight, Clar and Diane

## 14. RESEARCH SOURCES

Image of Capt. Robert Bartlett courtesy of the Historic Sites Association of Newfoundland and Labrador. (http://www.historicsites.ca/hawthorne.html)


1: Library and Archives, Government of Canada. CANADIAN HEROES IN FACT AND FICTION: Captain Bob Bartlett. http://www.collectionscanada.ca/2/6/h6-206-e.html

2: PBS. 1999. Robert Peary: To the Top of the World. http://www.pbs.org/wgbh/ amex/ice/sfeature/peary.html

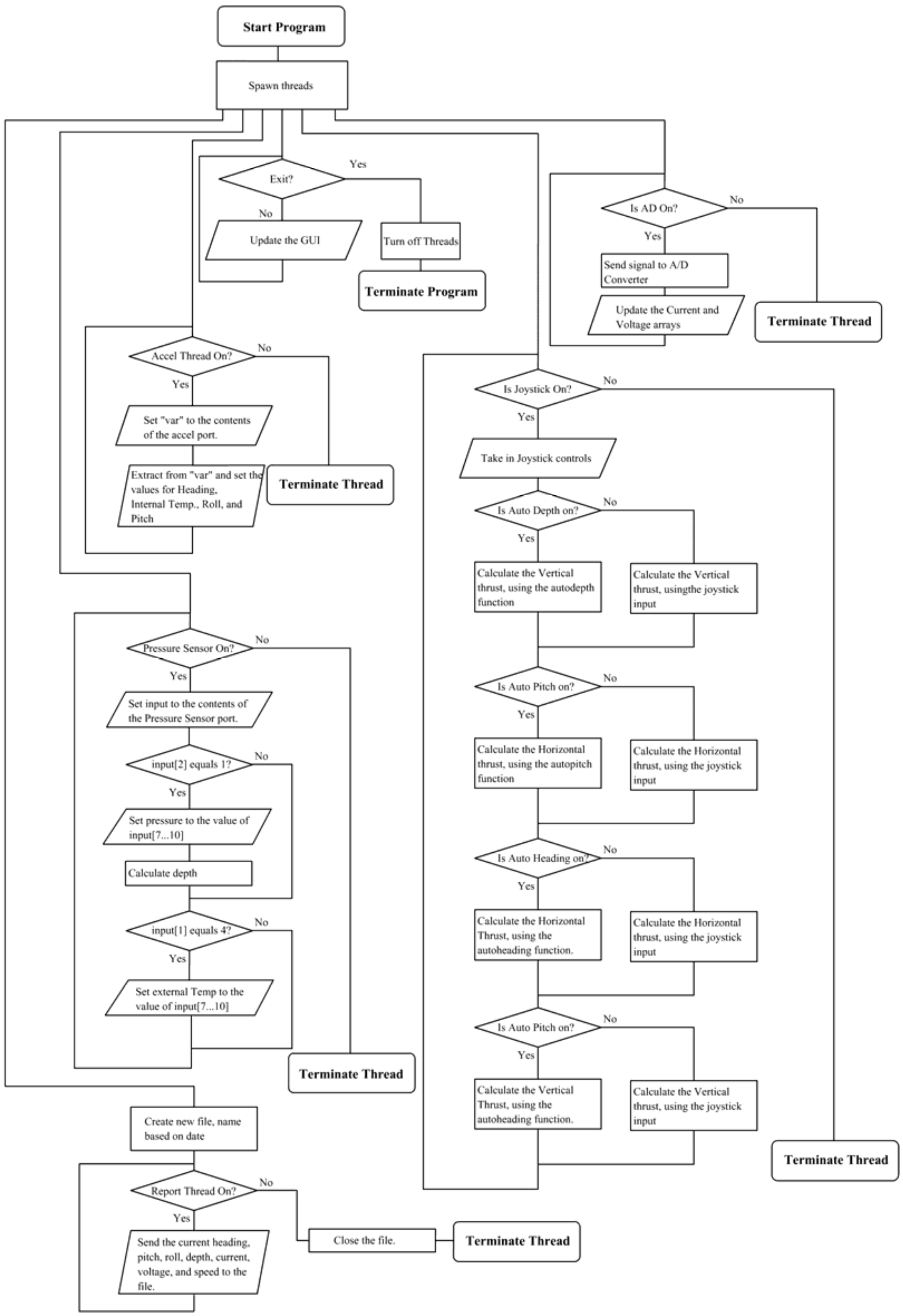
3: The Schooner Ernestina. The Story of Robert Abram Bartlett, Arctic Explorer (1875-1946). http://www.ernestina.org/history/Bartlett/RobertAbramBartlett.html

4: Myerson, RM. 2005. The Canadian 'Karluk' expedition: Bartlett was a hero, Stefansson was not. http://www.cookpolar.org/karluk.htm.

5: Appleton, TE. Canadian Coast Guard - USQUE AD MARE - A History of the Canadian Coast Guard and Marine Services: Bob Bartlett. http://www.ccg-gcc.gc.ca/usque-ad-mare/chapter10-07_e.htm

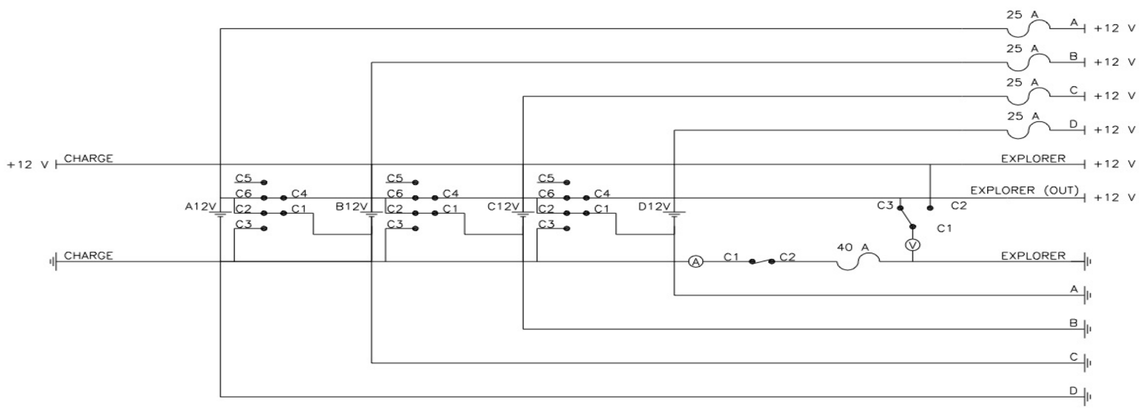
6: Historic Sites Association of Newfoundland and Labrador. Hawthorne Cottage: Historic Home of Captain Bob Bartlett. http://www.historicsites.ca/hawthorne.html

# APPENDIX A – PROGRAMMING FLOW CHART

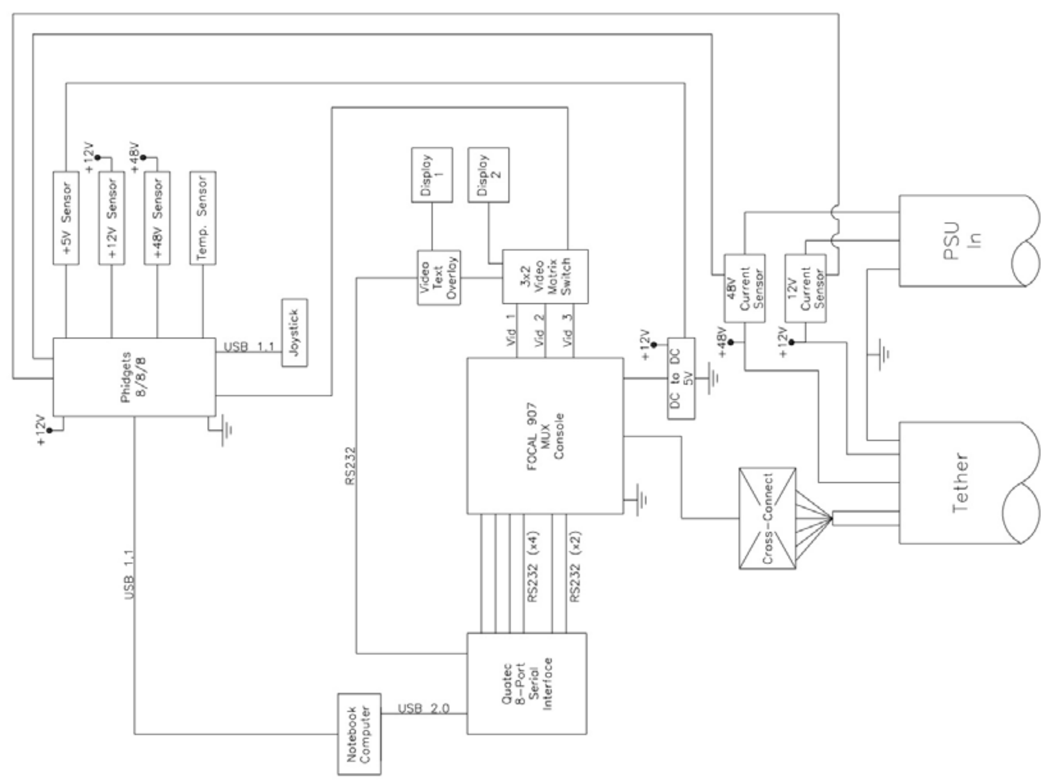


# APPENDIX B - ELECTRICAL SCHEMATICS

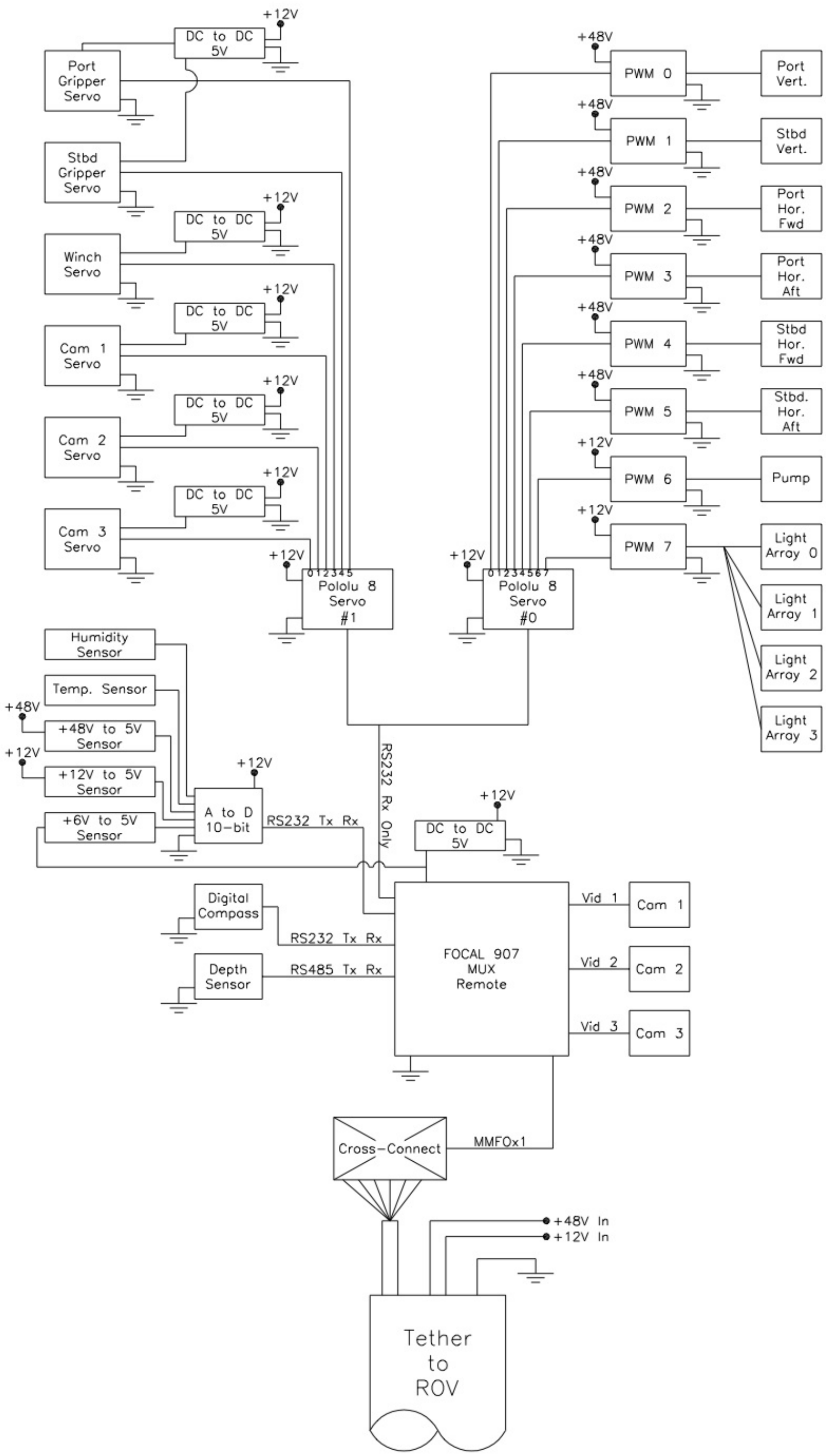
POWER SUPPLY



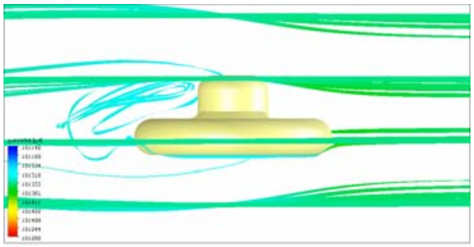

TOPSIDE ELECTRONICS MODULE

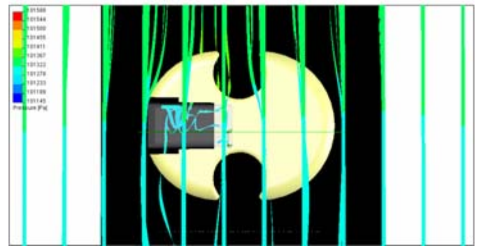


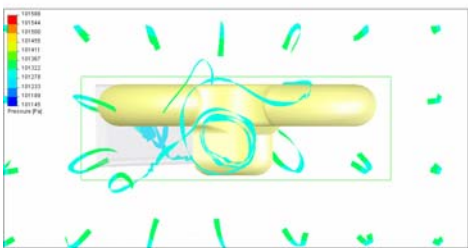
# SUBMARINE ELECTRONICS MODULE

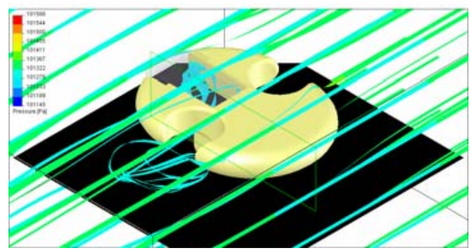


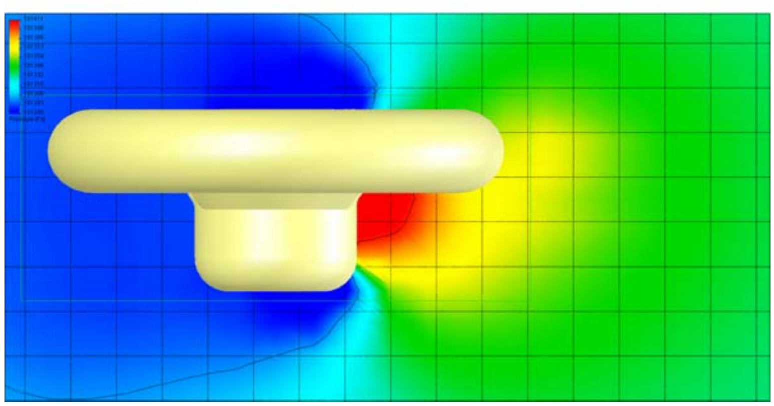
## APPENDIX C - FLUID DYNAMIC ANALYSIS











## APPENDIX D – SOLIDWORKS RENDERINGS