TECHNICAL REPORT

Explorer Class

Opilio

Submitted by

Eastern Edge Robotics

Newfoundland and Labrador, Canada

To the Judges of

MATE/MTS International Robotics Competition 2006

Team Members

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Abstract

This Technical Report describes the remotely operated vehicle, *Opilio*, fabricated by the Eastern Edge Robotics Team of Newfoundland and Labrador, Canada.

Opilio was built to compete in the MATE/MTS International ROV Competition, hosted at the Johnson Space Center's Neutral Buoyancy Lab in Houston, Texas.

Opilio was designed to execute tasks related to Ocean Observing Systems, which is the theme of this year's competition.

These tasks are to be completed in 30 minutes and include the following:
(i) Completing the central node
(ii) Laying an instrument cable through assigned waypoints connecting the link to the central node.

This report also includes an introduction to our team, and documents the processes we used to develop our ROV. We also included lessons learned, troubleshooting techniques, future improvements, schematic diagrams and program flowcharts, as well as an essay on 'Ocean Observing Systems for Biological Studies', team photos, our budget and expense sheet and acknowledgements. For more information on this project please consult www.easternedgerobotics.com

Team Introduction

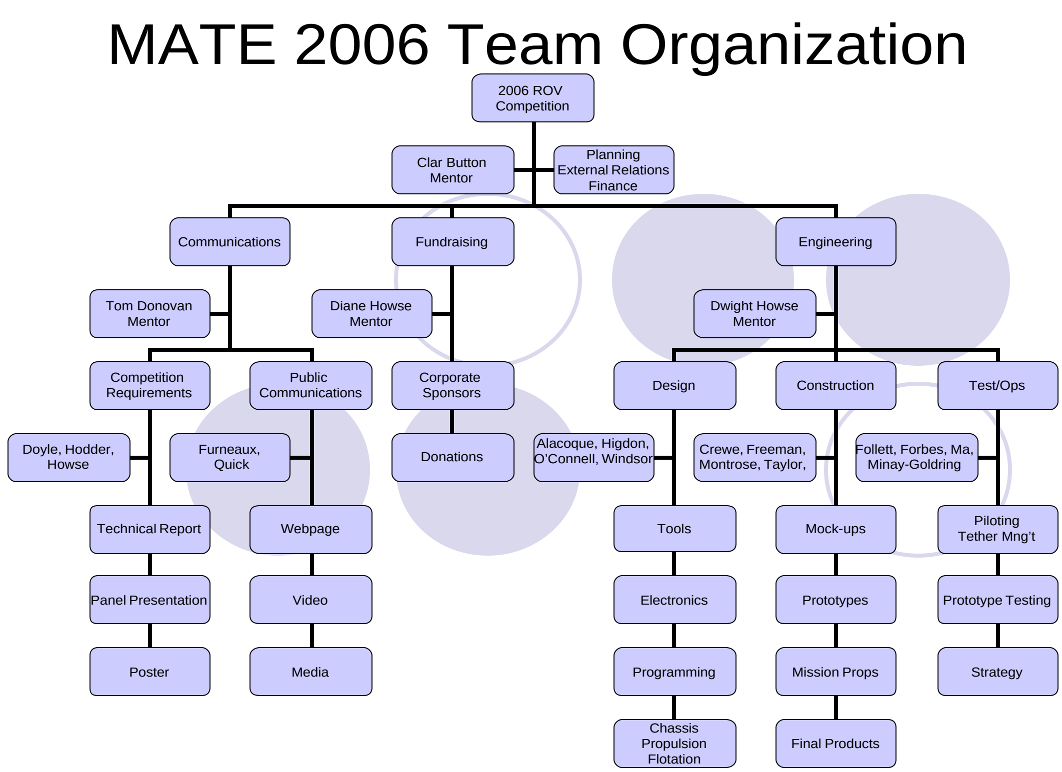
The 2006 Eastern Edge Robotics Team is comprised of 18 students from Newfoundland and Labrador, Canada. These students are studying diverse programs concentrating in Science, Technology and Engineering at The College of the North Atlantic (CNA), Memorial University (MU) and the Marine Institute (MI). The project began in early January, 2006 at O'Donel High School, in Mount Pearl, NL, with students meeting every Saturday from 10:00 AM – 4:00 PM.

This year the team named its ROV *Opilio*. It featured crab-like characteristics from its trapezoidal shape to its ability to achieve sway motion. The snow crab, also referred to as the queen crab, has the Latin name *Chionoecetes Opilio*. *Opilio* means 'shepherd' who, in a traditional sense, would watch over a flock. As this year's competition is about "Ocean Observing Systems," we decided that the name *"Opilio"* was well suited to the ROV.

Project Management

The key to success of any venture is organization. Team management helps ensure each team member has a job, thus maximizing productivity. We created a Team Organization Chart which divided the team into three smaller categories: Engineering, Communications, and Fundraising. Each group was supervised by a mentor, but it was ultimately the responsibility of team members in that group to ensure timely and quality completion of tasks. The largest group was engineering. This team designed, planned and built the ROV over a period of six months. Engineering was further divided into several subgroups that developed and fabricated the various components of the ROV. The Communications group was responsible for items including the preparation of the Technical Report, the organization of the Engineering Panel Presentation, the creation of the Poster Display, and the development of a team website. The fundraising group was completely comprised of mentors, who approached various persons and organizations in both the private and public sector to aid the team through the donation of funds and/or equipment. Each group documented their progress which proved beneficial when writing the Technical Report.

Eastern Edge Robotics Organizational Tree



Using Microsoft Project, we were able to create a Gantt organizational chart to set a schedule of various tasks to be executed and their expected date of completion. Availing of Microsoft Project's ability to designate Resources, specific people were delegated to each task ensuring that the construction of the ROV progressed efficiently. This saved time at each meeting since it was not necessary to allot time assigning people to tasks. The Gantt chart enabled a graphical depiction of the project. This allowed team members to not only view the progress made each week but also the time remaining for the completion of the project. Team members were able to see which areas of the project were progressing rapidly as well as the areas in which more assistance was required. The Gantt chart also helped give an overview of the entire project by illustrating how many small things were required for the completion of the larger picture. This image helped ensure continuous progress for the duration of the project. The following figure is a small sample of the Gantt chart created for the project, highlighting several tasks, their predecessors and the amount of time required for completion.

Sample of Eastern Edge Gantt Organizational Chart

ID	ℹ	Task Name	Duration	Start	Finish	Predecessors
3		**Fabrication**	**9 days**	**Sat 14/01/06**	**Sat 22/04/06**	
4	✓	**ROV**	**7 days**	**Sat 04/02/06**	**Sat 22/04/06**	**10**
5	✓	Chassis	7 days	Sat 04/02/06	Sat 22/04/06	
6	✓	**Tools**	**6 days**	**Sat 04/02/06**	**Sat 08/04/06**	
7	✓	Drop Off Electronics Module	6 days	Sat 04/02/06	Sat 08/04/06	
8	✓	Open Door	5 days	Sat 04/02/06	Sat 01/04/06	
9	✓	Pick Up/Drop Off Links	6 days	Sat 04/02/06	Sat 08/04/06	
10	✓	**Mock-Ups**	**2 days**	**Sat 14/01/06**	**Sat 04/02/06**	
11	✓	Electronics Module	2 days	Sat 14/01/06	Sat 04/02/06	
12	✓	Waypoints	2 days	Sat 14/01/06	Sat 04/02/06	
13	✓	Trawl-Resistant Frame	2 days	Sat 14/01/06	Sat 04/02/06	
14	✓	2 Links	2 days	Sat 14/01/06	Sat 04/02/06	
15		**Electronics/Programming**	**5 days**	**Sat 04/02/06**	**Sat 01/04/06**	**10**
16	✓	Waterproof Housing	5 days	Sat 04/02/06	Sat 01/04/06	
17	✓	Cameras	3 days	Sat 04/02/06	Sat 04/03/06	
18	✓	Control System	5 days	Sat 04/02/06	Sat 01/04/06	
19		Lighting	3 days	Sat 04/02/06	Sat 04/03/06	
20	✓	**Power Supply**	0 days	Sat 14/01/06	Sat 14/01/06	
21		**Testing**	**7 days**	**Sat 22/04/06**	**Sat 08/07/06**	**3**
22		ROV	5 days	Sat 22/04/06	Sat 17/06/06	4
23	✓	Tools	5 days	Sat 22/04/06	Sat 17/06/06	
24		Electronics	7 days	Sat 22/04/06	Sat 08/07/06	
25		Video Systems	3 days	Sat 22/04/06	Sat 27/05/06	
26		**Communications**	**10 days**	**Sat 14/01/06**	**Sat 29/04/06**	
27		**Technical Report**	**10 days**	**Sat 14/01/06**	**Sat 29/04/06**	
28	✓	Research Paper	3 days	Sat 14/01/06	Sat 11/02/06	
29		Photos	4 days	Sat 14/01/06	Sat 25/02/06	
30		Schematics	3 days	Sat 01/04/06	Sat 29/04/06	15

Design Specifications and Rationale

(1) Chassis

The chassis is constructed of 5mm polycarbonate which was cut, scored, and bent into a trapezoidal shape. Four thrusters are configured at 30° to the vertical axis and fastened to the underside of the chassis. Two additional thrusters are attached horizontally on each side of the outer chassis. The electronics can is mounted on the top of the chassis and held in place using straps. This configuration gives the ROV four degrees of freedom: heave, surge, sway, and yaw. This gives the ROV excellent control that makes it ideal for the complex underwater movement required. Polycarbonate is used for the frame because it is transparent, durable, easily worked, and very difficult to damage.

(2) Cameras

The ROV uses three high quality, low-light board cameras from Super Circuits (PC169XS.) One is stationary inside the electronics can, facing upward, and the other two are mounted on the chassis, one facing frontward and the other backward. The cameras operate on 12 volts DC at 110 mA. They have 460-line resolution with a low 1.0 lux rating and together provide a 360° field of view in the vertical plane. This is achieved by having tilt control on the two chassis-mounted cameras. The tilt is controlled by a servo motor inside the camera housing. The cameras connect to the electronics though 4 -pin waterproof connectors. The cameras are housed in clear 5cm O.D. polycarbonate tube with 3mm walls. Ensuring a 360° view of the ROV's surroundings iss imperative in the design of the robot as it is required to operate in environments which are not easily navigated. The camera that faces upwards in the electronics can ensures that the pilot has vision upward to see the tether and to navigate back to base. By constructing our own cameras from clear tube, board cameras, and servos, we achieved video with high resolution and an ability to function in low-light environments, which is ideal.

(3) Tether

The tether was custom built to our specifications and donated by Leoni Elocab of Kitchener, Ont. It contains three 12-gauge copper wires for power and six multi-mode fiber optic strands, which transport video signals, an RS-485 signal, and USB control signals. Our system multiplexes the three video lines and one RS-485 channel onto one fiber strand using a Focal model 907 optical multiplexer.

Two additional strands are used for the fiber-optic USB extension that was donated by OptiCIS. This configuration means that the tether has three redundant fibres that are easily swapped in if other strands are damaged. The tether is neutrally buoyant in fresh water making it ideal for use in a fresh water pool, such as the competition scenario.

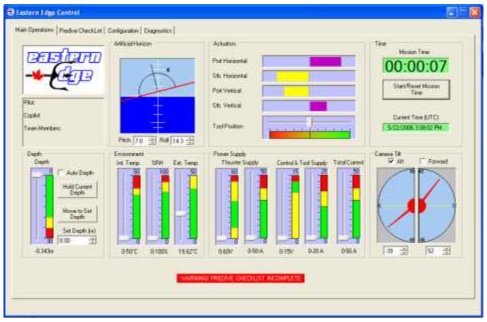
(4) Thrusters

The ROV uses six 90W thrusters, donated by Inuktun Services Ltd of Nanaimo, B.C. They have a depth rating of 300m and are very reliable. Two independently controlled thrusters are mounted in the center of the ROV's chassis and provide surge and yaw motion. Four are mounted at 30º to the vertical axis, (two port and two starboard). The port and starboard pairs are independently controlled thereby enabling both heave and sway motion. This is ideal for the complex underwater movement required of the ROV. These particular thrusters were selected because they were donated, were the correct voltage for the ROV, and were very high quality.

(5) Control System

The control system for the ROV is a notebook PC running a program developed using the C# Express language. It reads user inputs from a keyboard, a mouse, and a USB joystick using DirectX. These inputs are monitored and appropriate output responses are calculated. The output voltages to control thruster and tool motors are communicated using standard servo signals interfaced through Phidgets servo interface boards. These boards also control the tilt of the cameras. All relevant information is displayed on one of four tabbed windows: Main Operations, Pre-dive Checklist, Configuration, and Diagnostics respectively.

(i) Main Operations



The Main Operations tab displays relevant data essential for the proper operation of the ROV. This includes a mission timer, visual representation of the camera tilt position, thruster power, tool position, power supply condition, and environmental parameters such as humidity in the electronics can and temperature. An artificial horizon has been incorporated to display pitch and roll although they are not controlled degrees of freedom.

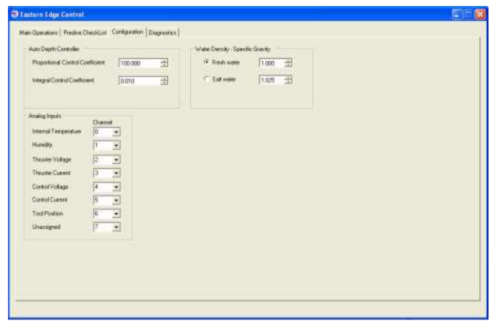
The ROV is controlled mainly from the joystick which provides the user interface for surge, heave, yaw, and sway. The joystick is also used to control camera tilt and selection. The joystick also includes a switch to automatically center the tilt of the cameras.

The control system incorporates an auto-depth feature that is able to be selected to maintain the current depth or to move to a pre-selected depth.

(ii) Pre-dive Checklist

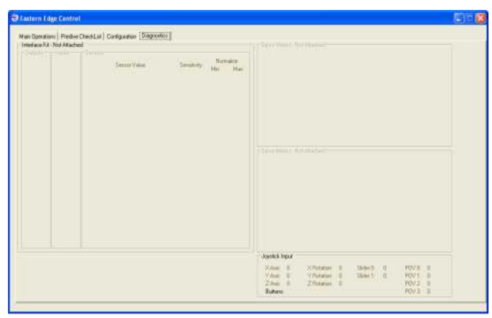
This checklist ensures that all safety and runtime checks are completed before launching the ROV. On this screen, the ambient air pressure is also measured to be used as an offset for the depth sensor. When all elements of the checklist are addressed, a warning flag on the Main Operations page is turned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

(iii) Configuration



On this page the proportional and integral coefficients for the auto depth values are set, water density is selected to ensure proper depth readings and the analog sensor channels are configured.

(iv) Diagnostics



The Diagnostics page provides raw values from sensors including the joystick and analog sensor as well as providing a direct interface to the servo controls for camera tilt, thruster power, and tool power.

(6) Electronics

(i) Surface Unit

The surface unit contains a Focal 907 fiber optic multiplexer which exchanges data and video with the ROV. This information is sent and received over a single multimode fiber optic strand. A Keller USB to RS485 converter is also used to allow connectivity to the RS485 output on the multiplexer, which is connected to the depth sensor allowing us to receive information when using our auto depth feature. A USB to fiber converter allows USB signal to be transmitted over two fiber optic strands. This overcomes the inherent 5m limitation on USB cable length. A USB hub allows us to interface to the various control and human interface devices, including the joystick. A relay-based video switch is configured for three inputs and two outputs. In addition, a manual video switch has been incorporated to override the relays in case of failure. A 12VDC to 5DC converter has also been used to power the Focal 907 so that less heat is generated and less power is used than if a regulator were used. We decided to use a fiber optic system because of the possible future expansion of the ROV as well as advantages such as EMI immunity, small size and weight, and relatively low signal loss when compared with copper. In addition, fiber optics allowed us to overcome the length restrictions on USB cable while enabling the use of commercial off the shelf USB control devices.

(ii) Submersible Unit (Electronics Can)
The submersible electronics unit contains many of the same devices as the surface unit such as a Focal 907 MUX, a USB to fiber converter, and a 12VDC to 5VDC converter. It also contains two Phidgets 4-servo controllers that control the thrusters, tool, and camera tilt. Pulse Width Modulators from IFI Robotics have been used to control the thrusters and the tools giving proportional control over these devices. The electronics can also contains a Phidgets 8/8/8 interface kit which allows us to read various analog sensors such as temperature, humidity, and power supply condition. A camera has also been incorporated allowing us to see upwards from the inside the transparent can.

(iii) Joystick
The joystick being used has 12 switches, an 8 position hat switch, and four analog potentiometer inputs. It has a twistable, rapid-fire handle that is used to control surge, sway, and yaw while a slider is used to control heave.

This particular joystick was selected due to the number of control elements as well as the fact that it is an inexpensive commercial off the shelf unit that is easily replaced in case of damage.

(iv) Depth Sensor
A Keller Preciseline pressure transducer is used to measure water depth. It is configured with a full range of 300 lPa. It is referenced to a vacuum and therefore provides a measure of up to about 20m of depth. This device communicates over an RS-485 output and is specified to have ± 0.1% accuracy using its 32 bit data.

This transducer was donated to the team by Keller America and provides the accuracy required to incorporate an auto-depth feature. An added benefit is that the unit incorporates a thermometer that is used to give an indication of the water temperature in the environment.

(v) 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.

(vi) 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.

(vii) Accelerometer
The ROV uses a dual axis accelerometer that can measure ± 5 gravities (± 49.0 m/s^2) of change per axis. It measures dynamic (vibration) and static (gravity/tilt) accelerations. The sensor used is an Analog Devices 'ADXL320', which has a position update rate of approximately 30 Hz and consumes 100mA from the USB. It is incorporated into our ROV to display pitch and roll.

(viii) Electronics Housing
The electronics housing was purchased from Prevco Inc. Its measures 12cm x 15cm x 20cm and is constructed of clear polycarbonate. It is injection molded to have a single removable end where all connections are added. With an o-ring seal, it is rated for use to a depth of 75 m.

This housing was selected as most appropriate for our application. Previously, the team made their own housing from large PVC pipe and an end cap, but had problems with leaking and the electronics inside getting wet. Using a commercial product, though costly, ensures that the delicate and valuable electronics are kept safe and dry.

(7) Tool

A single tool was designed to complete all tasks. It is made of clear polycarbonate and 10-32 threaded stainless steel rods. The tool uses a proportional controller to drive a 12V bilge pump motor to control the tool. The motor turns a threaded rod that opens and closes a gripper constructed of polycarbonate. The polycarbonate is covered with sandpaper to increase its grip on objects being held. As the gripper opens and closes, a pin is also inserted into or retracted from a U-shaped bracket that holds or releases the control module.

This design was used because the team decided to only use one multi-tasking tool to complete all tasks. This allows the ROV to be more compact and uses less materials and controls than having multiple tools. Polycarbonate was used for its durability and strength. The team decided to use proportional controllers to ensure that the tool works optimally and to reduce the amount of error.

Challenges

This year, the team elected to develop its own control system using off the shelf components and a control program that was developed by the team members. Three team members volunteered to design the control program and spent every Saturday from January-May working on it. The team, consisting of first and second year engineering students at Memorial University, decided to treat all sensors separately, splitting them into different units. The program reads the joystick, keyboard, and mouse controls and responds to these inputs to control thrusters, cameras, and the tool. The program is written using a Visual C# Express environment that enabled them to produce a program that is very intuitive and provides a significant degree of control and feedback to the operator. The development of the control system proved to be a challenge since neither of the team members had previously programmed using C# although they had some experience with C++ and JAVA programming. In addition, neither member had previously written a program that was required to interact with the environment in real time. An additional challenge when residing on an island is the significant lead time required to receive shipments of supplies. Once materials were selected there was a considerable amount of time spent waiting for their arrival. This posed a significant challenge, requiring the ream to manage their time effectively, so that the arrival of these parts did not interfere with the completion of the ROV. It was important that we kept all tasks in mind so that if the completion of one aspect depended on the arrival of a part another aspect of the project was worked on in the meantime. One particular situation faced, was in waiting for the tether to arrive. The lead time for this product was extended to occur several more weeks than was originally anticipated. This challenge was overcome by creating a tether system that simply required the use of underwater connectors thus allowing the ROV to be tested with an older tether and fiber optic cable that could easily be interchanged with the new tether upon its arrival.

Lessons Learned/Skills Gained

When building the control system, it was required that the team members learn the more complex elements of programming. The choice of C# as the programming language meant students were required to learn a new syntax rather than the syntax of JAVA and C++ with which they were familiar. Students had not previously programmed with this level of sophistication in terms of inputs and output control. Much research was required to write code which enabled communication with the joystick, and programming of the sensors, servos, cameras and thrusters. The complexities of how the servos control thrusters with a pulse-width modulator, was also something students had not been familiar with previously. A second set of skills gained resulted from the rendering the ROV's design in AUTOCAD. While team members had some experience with 2-dimensional modeling using AutoCAD, the move to 3-dimensional drawing presented a learning challenge. Students benefited from the tutelage of one team member who had some 3-dimentional experience, thus the students were able to render a very detailed image of the ROV in 3d. This was the first time that the team had incorporated fiber optics in their design so the competition provided an opportunity for the team to learn some of the benefits and challenges of fiber optics as well as the equipment and devices associated with fiber optics.

Troubleshooting Techniques

There were many obstacles which presented themselves in the construction of this year's ROV. The task is very challenging and required much thought and research to generate workable ideas. While all team members are pursuing study in the areas of science and technology, the specific fields are extremely diversified and the students are in different stages of their education. This was both an asset and a hindrance as many students wanted to work on their own area of expertise but were not quite versed enough in their program to complete necessary tasks. These challenges were dealt with by having team members collaborate on all areas of the ROV. This ensured the entire team had a working knowledge of all components of the ROV but could still focus on their area of interest. It also allowed the more advanced students to share their knowledge with the other students, and brush up on their own skills in the process. This process of 'assisted building' was the best troubleshooting technique that the team used, as it allowed them to build and learn at the same time.

Future Improvements

Identifying future refinements is an integral part of any design process. There are numerous improvements which would optimize Opilio's performance. The addition of an automatic heading mechanism would enable the ROV to maintain a specific course in the horizontal direction. This would be achieved through the use of an electronic compass. When used in conjunction with the depth sensor currently in use, the pilot would be able to set both the depth and heading allowing for better concentration on tasks. To improve the pilot console, the incorporation of a "heads up display," has been considered. This display would overlap different views from various cameras as well as overlay the time allocated for the mission on the vision screen. It is very difficult to determine where items are in relation to the ROV when underwater due to a lack of depth perception when using only one camera. To assist in this area, research has already commenced on a viewing mechanism involving stereo vision enabling the pilot to essentially become a part of the surroundings. Another device that we believe would be beneficial would be a range finder. We also intend to add a data logging feature to our control program so that we can replay and analyze the mission parameters that are recorded such as thruster levels, joystick inputs and sensor values.

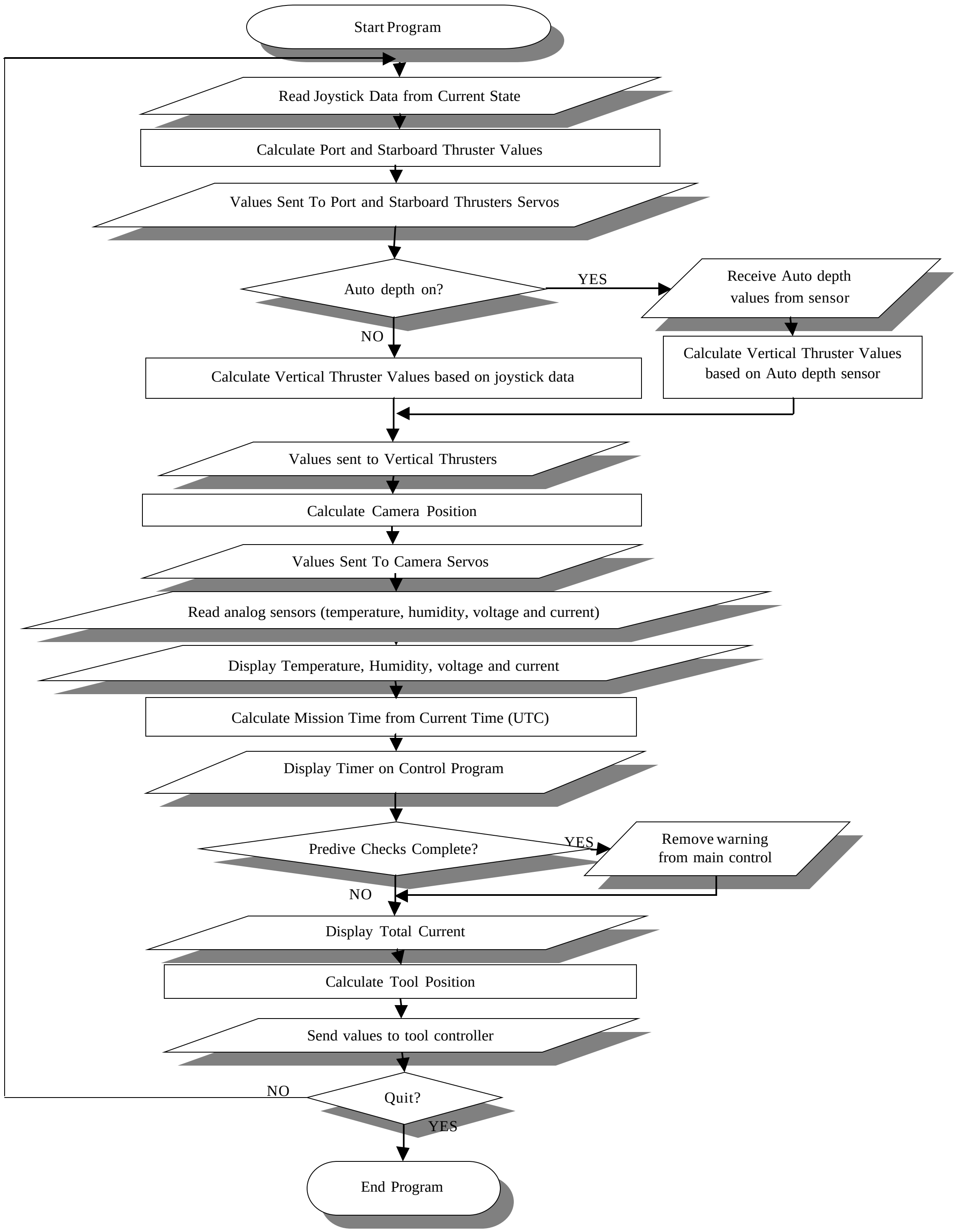
Using Ocean Observing Systems for Biological Studies

The province of Newfoundland and Labrador has a long-standing history in marine science. The Ocean Observing Systems found in Placentia Bay and Bonne Bay, NL, are examples of this. In early 2004, Memorial University partnered with Satlantic Inc., of Halifax, N.S., to establish the Bonne Bay Observatory (B_20) in the northern region of Gros Morne National Park, a UNESCO World Heritage Site. Bonne Bay is set in a sub-arctic fjord, and the observatory system was built to study the impact of the physical environment on marine ecosystems. The actual observatory is located on a sill in the shallow water between the basin of the fjord and the Gulf of St. Lawrence. The observatory has a continuous, real-time stream of data for the diverse array of scientists using it. Some of the instruments being used include sensors for temperature, salinity, chlorophyll fluorescence, carbon dioxide, oxygen, inorganic nutrient concentrations and spectral irradiance, acoustic sensors to determine currents, bubble distribution and plankton abundance and video to determine plankton and benthos species abundance. The system is autonomous and the data recorded underwater is sent to the surface through an electro-optic cable.

A program called SmartBay has recently been established in Placentia Bay, NL. This is an area of significant ecological diversity and is also host to fishing and oil tanker traffic. SmartBay proposes to promote sustainable development in the area by developing management strategies. It has established a system of 'integrated management,' whereby information is taken from multiple sources, allowing managers to make better decisions, manage stocks and direct research. Much of the required information for this project has already been recorded by other sources. They will be using data from spaceborne and airborne sensors, along with seabed characterization and bathymetric data. National organizations are currently resurveying Placentia Bay using multibeam sonar. In addition, buoys have been set up to record meteorological, oceanographic and water quality information. Users can then analyze the data using online GIS and data visualization tools. There have been many projects proposed using this information, two of which have already been established. The first involves determining snow crab habitat, which is financially and ecologically important, and the second involves using the oceanographic and meteorological buoys to allow mariners to stream data onto electronic charts.

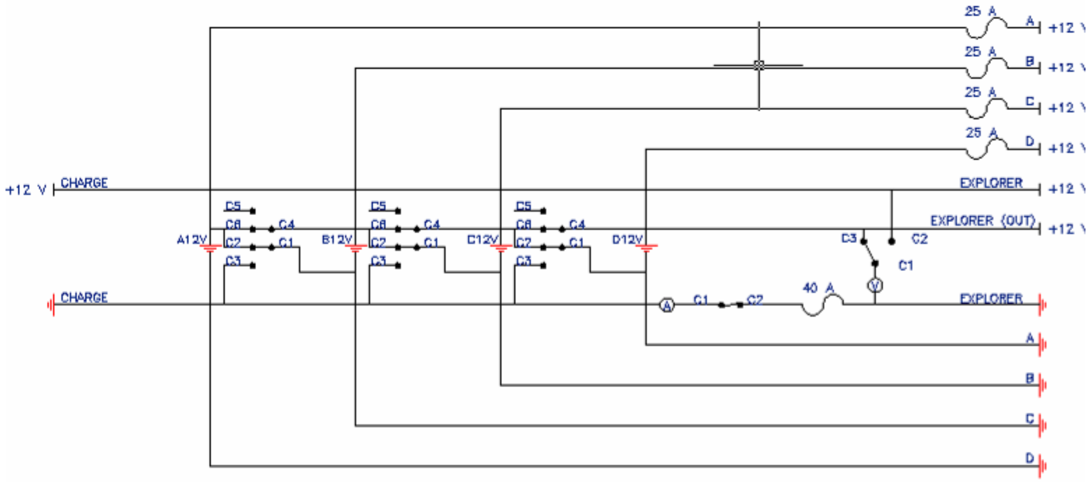
Both of these systems are important to the ecological environment of Newfoundland and Labrador. They help scientists promote sustainable development in the rich marine habitats off the coast of this island province. This is important because of the dwindling numbers of some species and the previously difficult task of managing populations and quotas. For economic, ecological, and cultural reasons, these systems are vital to the future of the east coast of North America.

Program Flow Chart

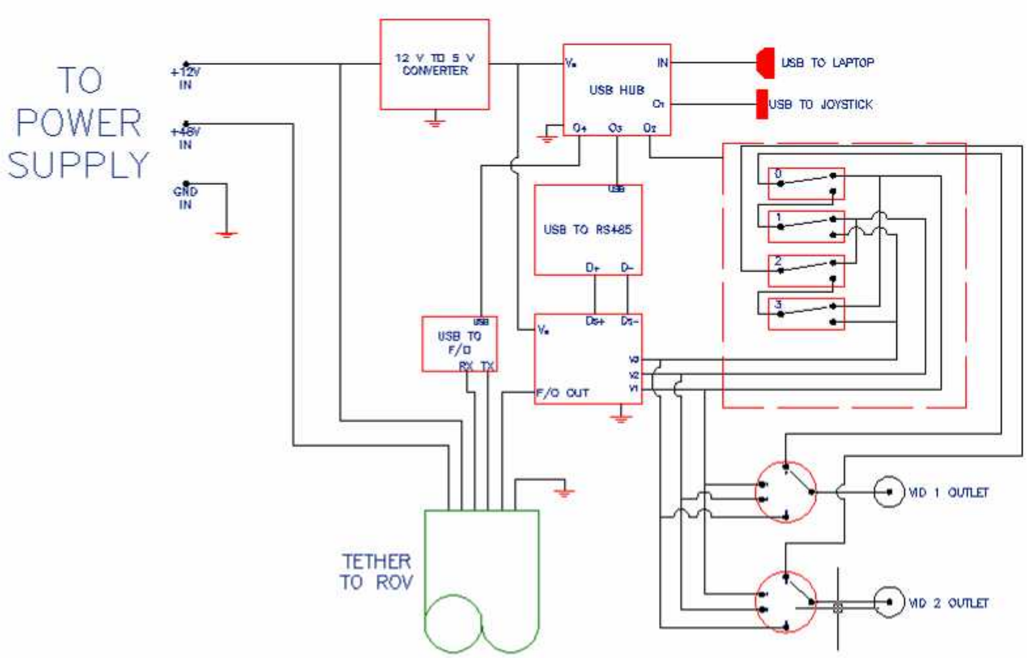


Schematics

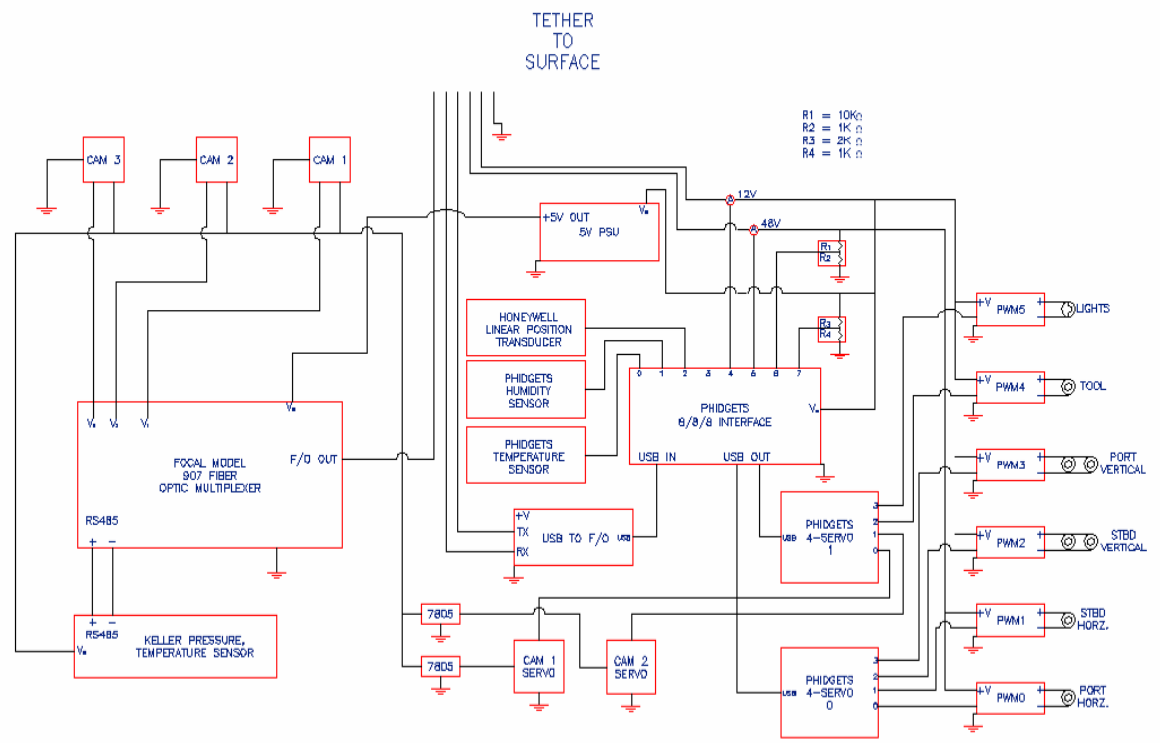
POWER SUPPLY



SURFACE UNIT

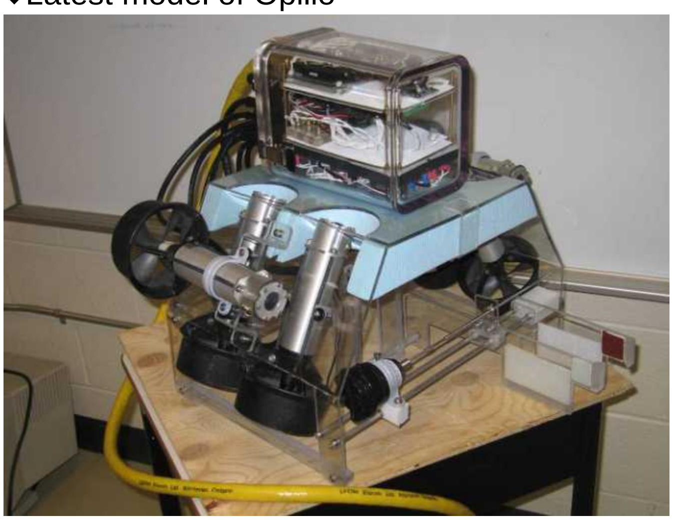


ELECTRONIC CAN CIRCUITRY



Our ROV Opilio

↓Latest model of Opilio



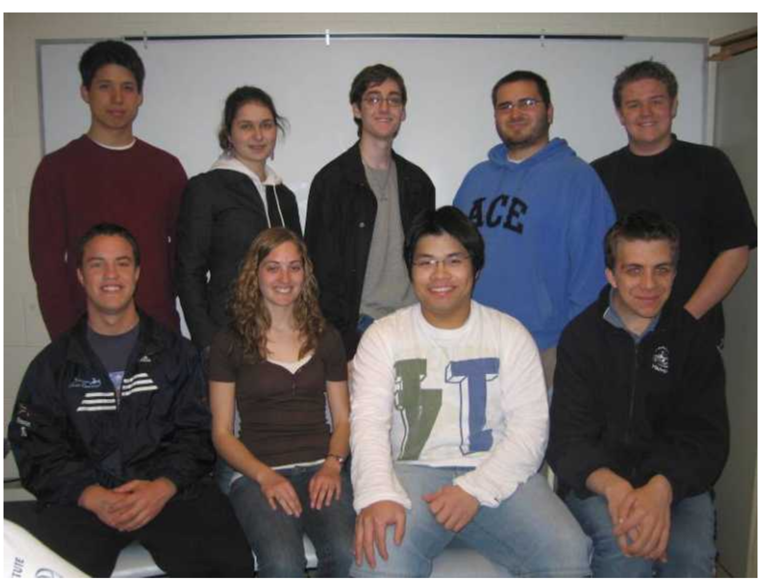
↓Surface unit of electronics

eastern edge robotics

Team Photo Album

↑Programming team working on console ↑ Teammates working on electronics

↑ Teammates considering thruster configuration ↑ Tool construction



← Team Members
B.R. Matt Minay-Goldring, Marianne Alacoque, Scott Follett, Austin Taylor, Justin Higdon.
F.R. Mikhail Freeman, Sarah Howse, Peter Ma, Andrew Furneaux.
Missing: Stephen Crewe, Gina Doyle, Jason Forbes, Renée Hodder, Patricia Howse, Marcel Montrose, Tamara O'Connell, Renée Quick, Stephen Windsor

Budget and Financial Statement

Expenses

ITEM	**COST ($CDN)**
AIRFARE	
14 students @ $716.44 (tax inc.)	$10030.16
4 mentors @ $716.44(tax inc.)	$2865.76
ACCOMODATIONS	
7 rooms/7 nights @ $ 80 CA per night	$3920.00
MEALS	
18 people x 8 days @ $25 US/day	$3600.00
VAN RENTAL	
2 vans/8 days @ $75 CA/day	$1200.00
BUILDING COSTS	
Polycarbonate	$350.00
Cameras and electronics	$950.00
Waterproof electronics housing (Prevco)	$320.00
Hardware (fasteners, drill bits, etc.)	$150.00
Commercial pressure transducer	$575.00
Six 48 V thrusters @ $ 1000.00	$ 12000.00
Fiber-optic interface board	$3500.00
Custom built tether	$1200.00
TOTAL	**$40460.92**

Donations/Revenues

ITEM (COMPANY)	**VALUE ($CDN)**
Commercial pressure transducer (Keller America)	$575.00
Fiber Optic USB Extension (OptiCIS)	$200.00
Six 48 V thrusters (Inuktun)	$12000.00
Fiber-optic interface board (Moog)	$3500.00
Custom built tether (Leoni Elocab Ltd.)	$1200.00
Faculty of Engineering, Memorial University	$7000.00
The Marine Institute	$5000.00
14 students @ $ 798.99	$11185.92
TOTAL	**$ 40660.92**

Acknowledgements

The members of Eastern Edge Robotics would like to extend their gratitude to the following sponsors:

Marine Institute of Memorial University

Faculty of Engineering at Memorial University

Inuktun Services Ltd.

Moog

Leoni Elocab

Keller America

Honeywell Canada

OptiCIS

SubConn

Ultragraphics

Our parents (for their understanding and loving support)

Our mentors, Clarence Button, Thomas Donovan, Diane Howse, and Dwight Howse, whose energy and generosity never fail to astound us.

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Roberts, Emma. *Bonne Bay: Observing a Highly Dynamic Environment.* Marine Scientist. 6:10;2004

Appendix A: Team Members

Name		Expected Graduation Date
Alacoque, Marianne	Faculty of Engineering, MU	May 2010
Crewe, Stephen	Engineering Technology, CNA	May 2010
Doyle, Gina	Faculty of Biology, MU	May 2008
Follett, Scott	Faculty of Engineering, MU	May 2010
Forbes, Jason	Pre-Engineering, MU	May 2011
Freeman, Mikhail	Marine Engineering, MI	May 2008
Furneaux, Andrew	Computer Support, CNA	June 2007
Higdon, Justin	Pre-Engineering, MU	May 2011
Hodder, Renee	Faculty of Engineering, MU	May 2010
Howse, Patricia	Faculty of Biochemistry MU	May 2009
Howse, Sarah	Faculty of Engineering, MU	May 2010
Ma, Peter	Faculty of Engineering, MU	May 2010
Minay-Goldring, Matthew	Faculty of Engineering, MU	May 2010
Montrose, Marcel	Marine Systems, MI	April 2007
O'Connell, Tamara	Faculty of Engineering, MU	May 2009
Quick, Renee	Faculty of Kinesiology, MU	May 2011
Taylor, Austin	Marine Systems, MI	May 2007
Winsor, Stephen	Naval Architecture, MI	May 2007