REPORT

DALHOUSIE UNIVERSITY ROV PROJECT

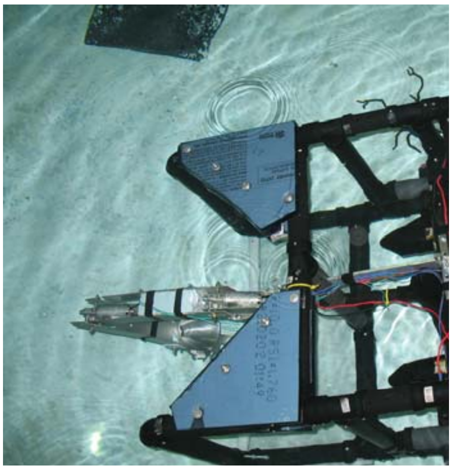
“Liquid Death”

Final Project Report

Electronic Copy

PREPARED BY :
PETER PEARL
CHRIS LANE
DAINIS NAMS
TIMOTHY POHAJDAK
JOESEPH DUCHESNE
MATT GALE

MENTOR :
GEORGE JARJOURA



June 5, 2008

Jill Zande
Marine Advanced Technology Center
Monterey Peninsula College
980 Fremont Street, Monterey
California, United States of America
93940

Attention: ROV Project Director

Dear Jill Zande,

RE: ROV Project Submission
June 2008

As requested, we are very pleased to provide one (1) electronic copy of our project report to you as formal submission for this year's MATE ROV project. If you have any questions please contact me at ch816772@dal.ca.

Yours truly,

Christopher Lane
Dalhousie ROV Project Team

Cc, Dr. Leon, Dalhousie Dean of Engineering; George Jarjoura, Project Mentor; Peter Pearl, Project Lead

TABLE OF CONTENTS

Appendices:

1.0 PHOTOGRAPHS OF COMPLETED ROV

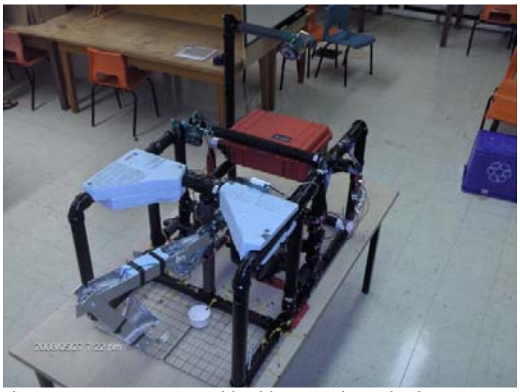


Figure 1.1: Port-Forward looking Starboard-Aft

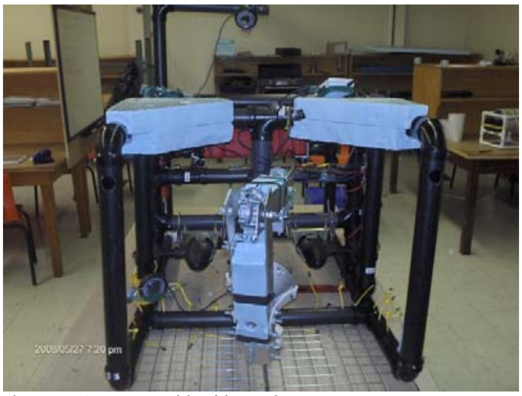


Figure 1.2: Forward looking Aft


Figure 1.3: Starboard looking Aft

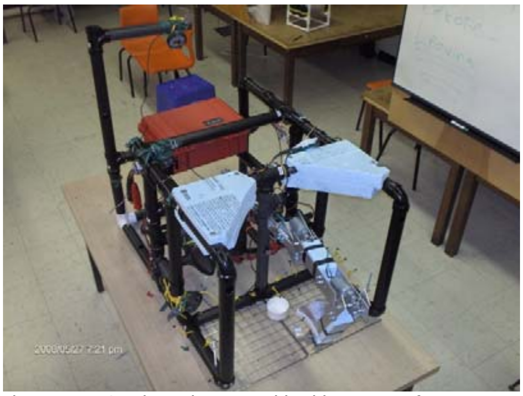


Figure 1.4: Starboard-Forward looking Port-Aft

2.0 PROJECT BUDGET

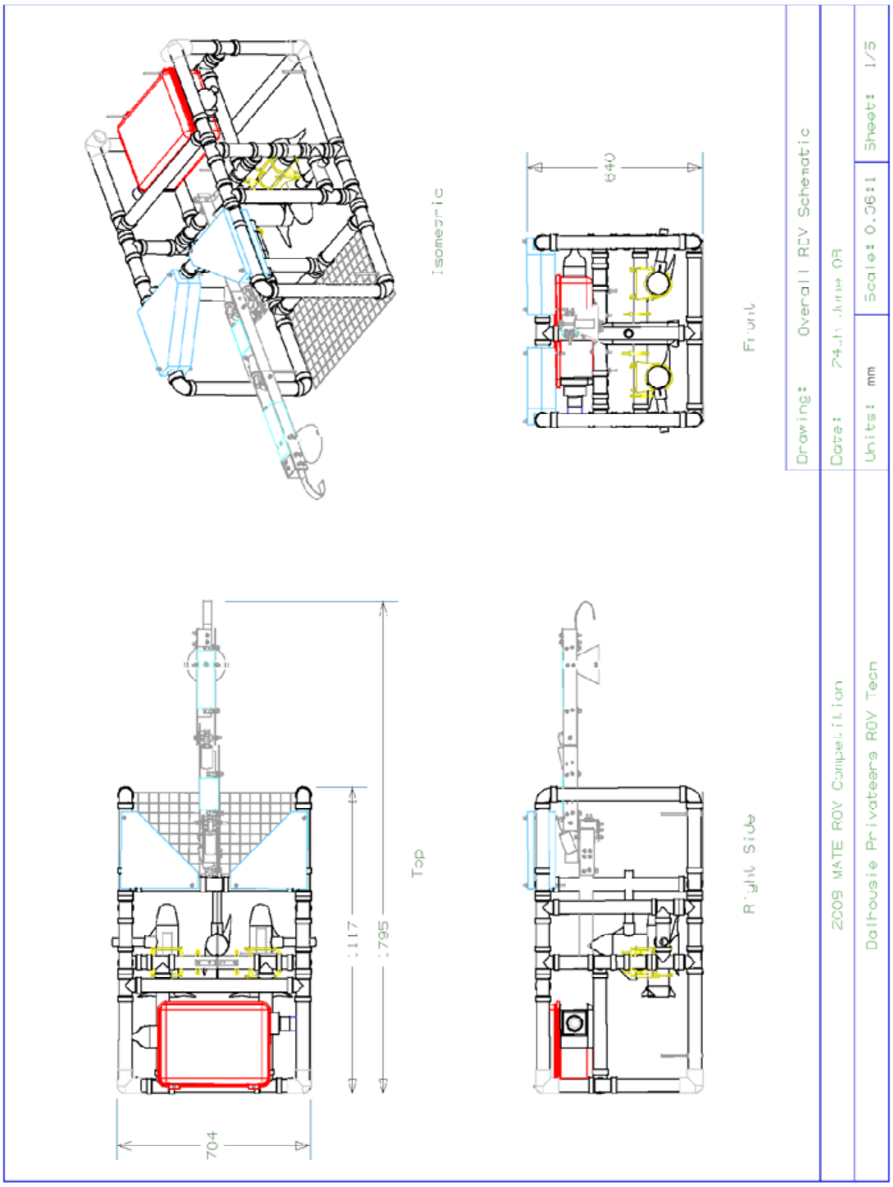
FUNDING	
Shell Canada	$ 5000.00
Dalhousie University	$ 4763.78
Subtotal	$ 9763.78
EXPENSES	
Build Cost*	$ 2759.48
Airfare	$ 5431.65
Lodging	$ 1225.00
Shipping	$ 347.65
Subtotal	*$ 9763.78*
Total	$ 0.00

Build Cost*

Part	Units	Source	Cost Per Unit	Total ($)
Artigo Computer	1	Minipc.ca	363.24	363.24
12V Relays	12	Digikey	14.67	176.04
Ardunio	1	Digikey	42.54	42.54
DC to DC Converter	3	Digikey	94.35	283.05
Trolling Motor	4	Canadian Tire	159.99	639.96
Cameras	3	Future Shop	19.99	59.97
12V Batteries	4	MDE	54.82	219.28
ABS/PVC Tubing	20m	Local Hardware	N/A	65.32
Wiper Motors	3	Local Hardware	24.99	74.97
Aluminium Stock	10m	Local Hardware	N/A	61.98
Electrical Wire	1	Local Hardware	104.56	104.56
Electronics Box	1	Local Hardware	158.21	158.21
Styrofoam	N/A	Local Hardware	N/A	26.32
Sealant	N/A	Local Hardware	N/A	178.79
Misc Electronics	N/A	N/A	N/A	157.60
Misc Stock	N/A	N/A	N/A	147.65
Subtotal				*$ 2759.48*

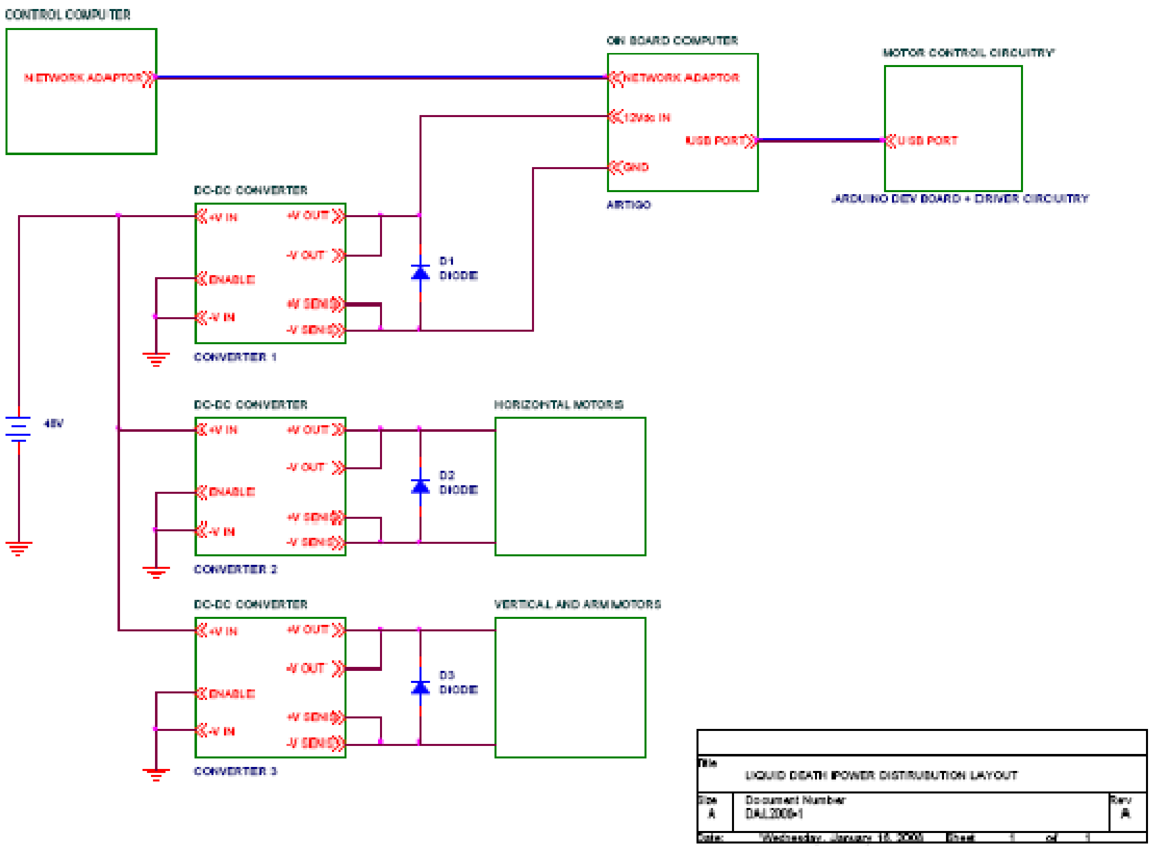
3.0 MECHANICAL SCHEMATIC

The following diagram illustrates the overall structure of the ROV. See Appendix for arm, motor, and assembly drawings.



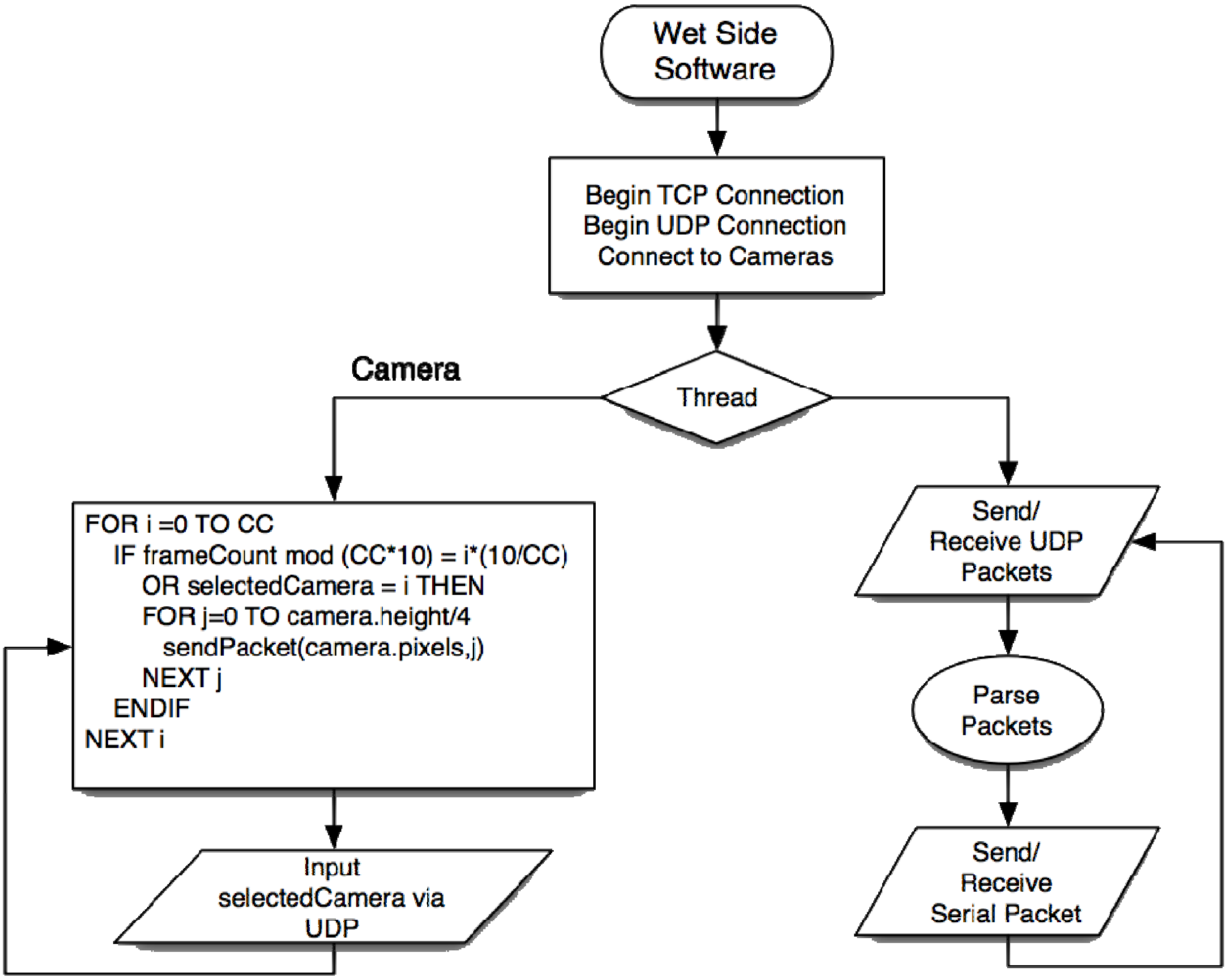
4.0 ELECTRICAL SCHEMATIC

The following diagram illustrates the schematic for power distribution of the ROV. See Appendix for schematic of motor control and sensor layout.



5.0 SOFTWARE DIAGRAM

The following logic diagram illustrates the wet side software of the ROV. See Appendix for complete system software logic diagrams.



Variables Used
CC = camera count, the number of cameras
frameCount = a frame counter that increments every frame
selectedCamera = the current main camera

6.0 DESIGN RATIONAL

6.1 FRAME AND TETHER

A combination of Polyvinyl Chloride (PVC) and Acrylonitrile Butadiene Styrene (ABS) piping was used to construct the frame. Frame material had to be rigid to avoid unwanted flexing and therefore be easier to control underwater. Also, the material had to be easy to work with and cost effective to meet our budget and facility limitations.

The structure was developed to avoid bending moments large enough to flex the ABS piping. The design had to accommodate three propulsion motors, an electronics box, payload, cameras, and articulating arm. These were then encased by skeletal frame, using the least amount of piping, while satisfying the above conditions. The mount for the arm is a piece of aluminum that runs horizontally through a vertical piece of thickened ABS pipe. It is anchored to a perpendicular and horizontal pipe further aft. This structural load is unique, and had to be compensated for because the arm is a precision instrument and must therefore have a rigid mounting.

The PVC joints and ABS structural members were connected with screws. This allows the frame to be adjusted or taken apart easily and quickly while still providing a secure connection. Many small holes and a few large holes were drilled into the frame allowing water to enter and exit quickly. The large holes allow for bulk water transport, and were placed on low load members to avoid compromising the frames structural integrity. Small holes were spread out over the frame to ensure 100% of the void space in the piping would be flooded.

The tether consists of a positive wire, negative wire, data cable, and safety wires that are bound together with Styrofoam blocks to provide buoyancy. The power lines are 8 gauge wires to minimize resistance and power loss over long distances. The data cable is a standard Ethernet cable to provide simple hardware to interface software with.

6.2 TOOLS

The arm is made from Aluminum. The material had to be lightweight because of the lifting moments developed during joint rotation. The aluminum was positioned so that a maximum amount of mass was placed away from the center of gravity. This increases the moment of inertia and provides a more rigid structure. Due to the nature of the arms task, precision is important, and thus the members must be rigid. Bolts were used for connection to avoid shear stress failure from lifting loads. Three windshield wiper motors were used for the joints. This provides high torque for lifting and three degrees of freedom making the arm very dexterous. The claw is a hook with teeth. This provides a good structure for collection of the OBS and sandbags. A funnel is incorporated at the base of the claw. This will direct the flow from the vent to our temperature sensor allowing direct measurement of only the vent water temperature and not ambient water temperature.

6.3 SOFTWARE AND ELECTRONICS

Power from the surface was run into three DC to DC converters. These were used to regulate the current sent to the relays and computer. The wet side computer is the Artigo, the small size allows for easy storage; however it also has to support four USB cameras, interfacing board, and temperature sensor. So computation power cannot be compromised for size. The interface board is the Aduino NG which converts digital signals sent from the surface to electronic signals for our relay control board. The relay control board was designed, printed, and hand populated by our team. The relay banks were configured in an H-bridge setup to prevent power loss associated with mechanical switches. Although advanced mechanical switches are available that could accomplish this we chose the H-bridge solution for its cost effectiveness and ease of implementation.

The software package designed for the communication to the ROV was developed mostly in Java. This provided our code with stability and our programmers with access to high level code libraries. We determined that computation speed would not be an issue when choosing Java over the other options such as C++. The software is broken down into two standalone programs the networking and the control software. This allows us to remotely reboot our control software should we have a critical failure.

7.0 COMMISSIONING

7.1 RESOLVED ISSUES

Finding a suitable mechanism to join the members of the arm was difficult. We constrained our design by having the motors mounted at the point of rotation. We needed a connector for each joint that would fit into the hex cuff of the motor and also to the aluminum of the arm. Also the connection had to be very tight so there was no give that could make the arm hard to control. Summarized are two mechanisms we designed and one that we employed.

First, a hex bolt through the motors hex cuff, and then through a precision punched a hex hole in the aluminum and a reinforced steel hex plate. Spot welds on the steel plate to hold the hex bolt in place and rivets to bind the aluminum to the steel would keep the apparatus static.

Second, the method we used, was to run the hex bolt through the motors hex cuff then through a round drilled hole in the aluminum. The hex bar has threads machined into it. A nut on the interior prevents the aluminum from being squeezed. On the outside a lock washer and two nuts prevent slipping during rotation.

7.2 TROUBLE SHOOTING TECHNIQUES

The resolution to our joint issue came from collaboration. Mechanical design was initially the responsibility of two of our team members however we incorporated the ideas of many others into this design. To remedy this problem our designers were encouraged to develop as many plausible solutions as possible. Designs ranged from standard solutions to imaginative and irregular designs. We also consulted with numerous outside sources to expand our design creativity. The product of our collaboration was our final design which we believe is the best possible solution in this scenario. By getting input for many sources we were able to resolve this issue quickly and effectively. However this is a slower process and should be reserved for significant problems.

7.3 LESSONS LEARNED

Proper planning must go into the project before it begins. Our initial planning helped us avoid major conflicts and provided a general timeline. However, a more in depth plan could have helped us work more efficiently and allowed us to spend more of our time in a redesign phase. As this was the first year for this project our initial estimated of required hours per task was not accurate. Without accurate task times the sequencing and task scheduling became uninformative. Next year we can use this information to develop a more accurate estimate of our work schedule which will help us work more time effectively. With a good work forecast we will be able to also better manage our resources and possibly reduce costs or at the least be able to avoid losing build/testing time because of waiting for space or equipment. Although we were not able to use this year’s schedule for these purposes it has provided us with the means of creating an accurate one next year.

A schedule should not be abandoned after it has been created. Tracking the progress of our tasks will give a good picture of where we are behind and where we are ahead. By comparing our updated schedules to the project baseline our progress will be easy to track and control.

The new schedule should be produced in the following manner:

1. Defining all tasks associated with the project
2. Sequencing the tasks by providing relationships between them
3. Providing each task with an accurate estimated duration
4. Providing each task with an accurate estimated resource loading
5. Scheduling the tasks based on the above properties
6. Controlling the produced schedule by updating and comparing it to a baseline

8.0 SUGGESTED DESIGN IMPROVEMENTS

Next year we would like to upgrade three major areas of our ROV; the cameras, software, and frame. As this was the first year of the project at Dalhousie University we focused our design around functionality without sacrificing operational abilities. However we believe that when this is redesigned we can increase our budget because the project will have less inherent risk and therefore we can upgrade these areas of our design.

Currently we are using web cameras for observation. As previously discussed these work well however we require four to give our pilot sufficient visibility. A camera with the ability to rotate would eliminate the need for multiple viewpoints, and could replace the current setup. It would also be desirable to have a camera that could capture at higher resolution while maintaining at least 30 frames per second.

Our frame is built with material that we chose based on cost and ease of use. These materials have no significant drawbacks, however if we constructed our frame from aluminum or steel it could increase the durability of the frame providing various significant benefits. With a more durable frame we would see a decrease in repair expenses and frame rehabilitation expenses; as well we would reduce the risk of structure failure from accidental impacts.

Finally, our software package was generated in-house specific to this project. This package will always benefit from code additions and will continue to evolve for its useful lifetime. We will be adding new features and functions to it in the future.

9.0 EARLY RESEARCH OF MID-ATLANTIC RIDGES

In the early 1980's Dalhousie University, in partnership with the Bedford Institute of Oceanography, launched numerous expeditions to recover and analyze basalts of the mid-Atlantic ridge. Most of the drilling occurred near Mount Glooscap, named after a mythical first nation's character from Atlantic Canada. During this time exploration of mid-oceanic ridges was a topic of great interest.

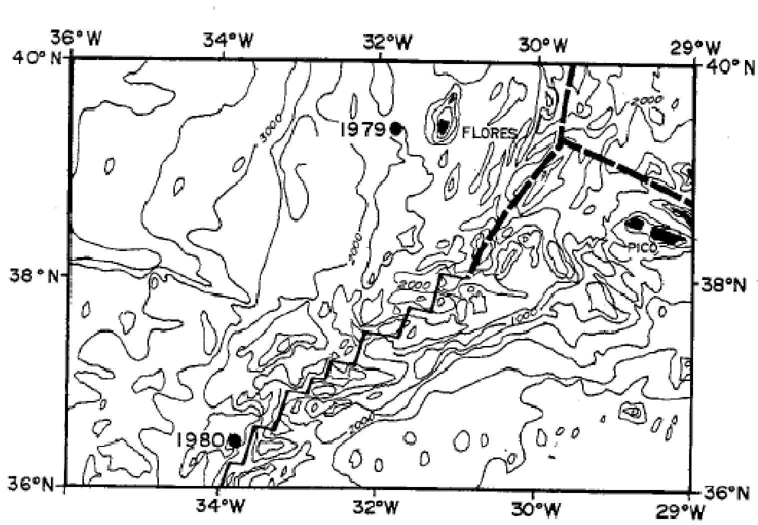


Figure 8.1: Location of Mid Atlantic Ridge Test Sites

These recovery missions made use of early ROV technology. The drilling apparatus referred to as the "Brooke Drill" after its designer John Brook, was used to collect core samples from the bottom of the ocean. This apparatus had all of the trademark traits of a modern ROV. Depth, pitch, and roll were computed from the surface by the use of SONAR equipment. A "Pinger" attached to the tether sent sound waves through the water bouncing them off the drilling apparatus. Sound would further rebound off the ocean floor allowing the transducer on the surface to determine the distance from the ROV to the ocean bottom and from the "Pinger" to the ROV. The distance to the ROV was especially useful because this told the "pilot" if there was slack in the tether or not, and therefore if it had landed on bottom. Slack also meant that no weight was being supported by the tether. The drilling apparatus had its full weight on the supporting tripod legs because the resulting force from drilling into hard seafloor was large. For this reason lead weights were added to the rig to bring its total dry weight to more than two metric tons. The tether to the bottom was five kilometres long and operated at approximately 4800V; however 48V was lost over the length of the cable. During operation this would mean 6 Amps of current to power the drill motors. This would also later power a video feed to the surface as well as two 25 kilowatt light sources.

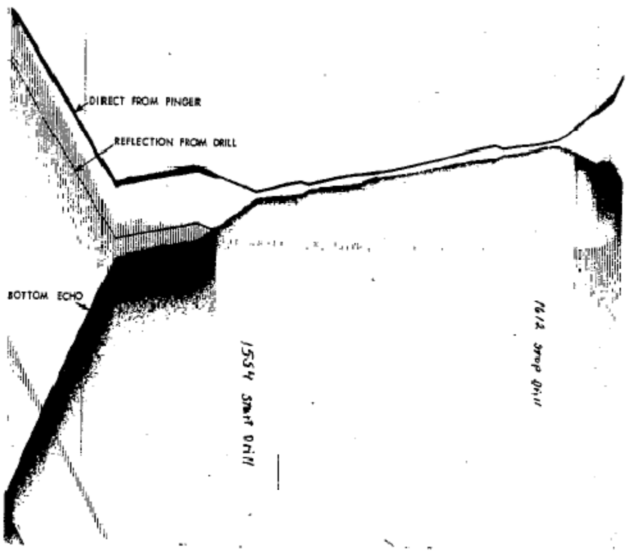
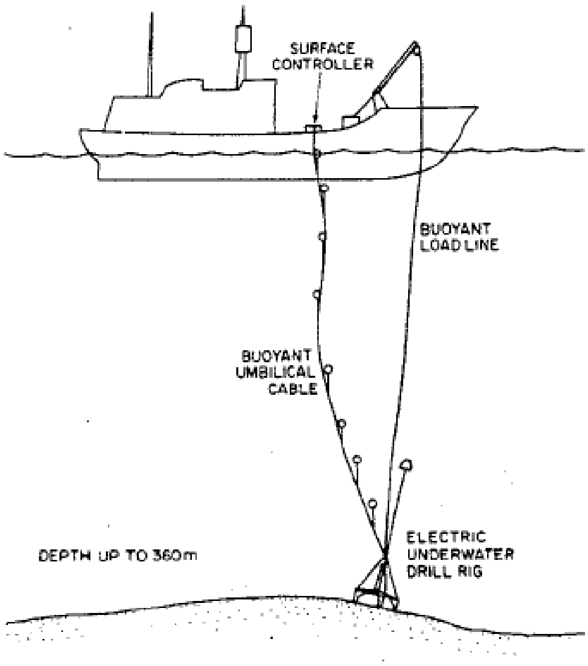


Figure 8.2: Echo Sounder Record Showing Pinger-Bottom and Pinger-Drill Separation.

Eventually the project would slow down as basalt core samples became hard to retrieve because of the brittle nature of the rock. The drill would either jam from irregular shaped specimens or would crush them if enough power was supplied. This was accompanied by a shift in government policy and spending. During Brian Mulroney's time as Prime Minister, federal government grants were awarded to more economically feasible projects. At this time deep sea exploration was not considered a profitable venture and so the drill was used for other projects. Accompanying this the ship time offered by the Bedford Institute of Technology became expensive. The ship used for these experiments is still used today as the primary research vessel however is has undergone significant refitting.



10.0 Comments

10.1 Dainis Nams

The most impressive aspect of the project was the level of creativity and innovation demonstrated by the Dalhousie team. Except for two members, everyone on the team is new to ROV design; the entire team is composed of second year students. Despite our inexperience we not only built a functioning ROV, but built one from the ground up. The entire design - including the frame, waterproof control box, electronics, and programming - was hand-made by team members and incorporates no industrial ROV components. Such an undertaking was only possible because of the inventive nature of the Dalhousie team.

10.2 Matt Gale

This project was big for everyone involved. It was a chance to put the theory that we spend so much time learning about in school into practice and build something as cool as a robot! It was lots of work, but how many people can say that they've built anything of this complexity? We are all only in second year and we were able to make an underwater vehicle from scratch. Who knows what we'll come up with another year of school under our belts?

10.3 Timothy Pohajdak

I've really enjoyed working on this project. I've learned a lot about the importance of working together as a team effectively and communicating with others to coordinate work effectively. We made a few mistakes along the way, but in each case we learned from those mistakes. Problem-solving and creating design ideas were some of the most interesting parts of the project. Overall, this project was really interesting and educational.

10.4 Christopher Lane

The ability to follow through with our designs because of the support from the university and Shell Canada made this project unique. Most work I have done while at university is either theoretical or through a much smaller budget. In comparison, seeing our design take shape was a very exiting change. Knowing the quality of our designs would impact our performance, I think, made everyone strive to produce their best work. I am happy to say my teammates have produced work of surprisingly high quality and have represented Dalhousie University well.

10.5 Peter Pearl

After attending the mate 2007 competition at Memorial University as part of Nova Scotia Community College I was left with a new found respect for opportunities in the marine sciences field. After enrolling at Dalhousie University's Bachelor of Electrical Engineering I wanted my peers to have the same opportunities to share in my experiences at MATE ROV competition. Through the year my expectations have been thoroughly exceeded by my fellow team members, I am pleased with our first offering to the competition.

10.6 JOSEPH DUCHESNE

I am very happy with everyone's efforts. Working together with these individuals has been a pleasure and I have learned a surprising amount from my peers. Although I was overwhelmed by the amount of work to be done at the beginning, this team has shown that with diligent work we can accomplish great feats.

11.0 REFERENCES

Ryall, Patrick J.C. (1990), An Electric Drill for Deep-Sea Coring. In McMurray, Gregory, Gorda Ridge A Seafloor Spreading Center in the United States Exclusive Economic Zone, (pp. 201-210). New York: Springer-Verlag.

Ryall, Patrick J.C. (1987), Remote Drilling Technology. Marine Mining, 6, 149-160

Ryall, Patrick J.C. Interview. 2 May 2008.

12.0 ACKNOWLEDGMENTS

We would like to thank Shell Canada for their generous funding and support of this project. Without this help our project could not have reached its full potential. We are very lucky to have them take such interest in our education and hope to continue a mutually beneficial relationship in the future.

George Jarjoura gave his time and expertise to make our team possible. We have benefitted as his students and now he has enabled us to apply this knowledge to practical applications. For this we are indebted.

Dalhousie University, who we are here representing, has given us all direction and inspiration. Specifically we would like to thank Dr. Cirus, Associate Dean of Engineering, and Dr. Leon, Dean of Engineering. They saw the value of this project and have supported us the entire way.

We would like to extend our thanks to the MATE center for providing students from around the world a venue to develop and share ideas in.

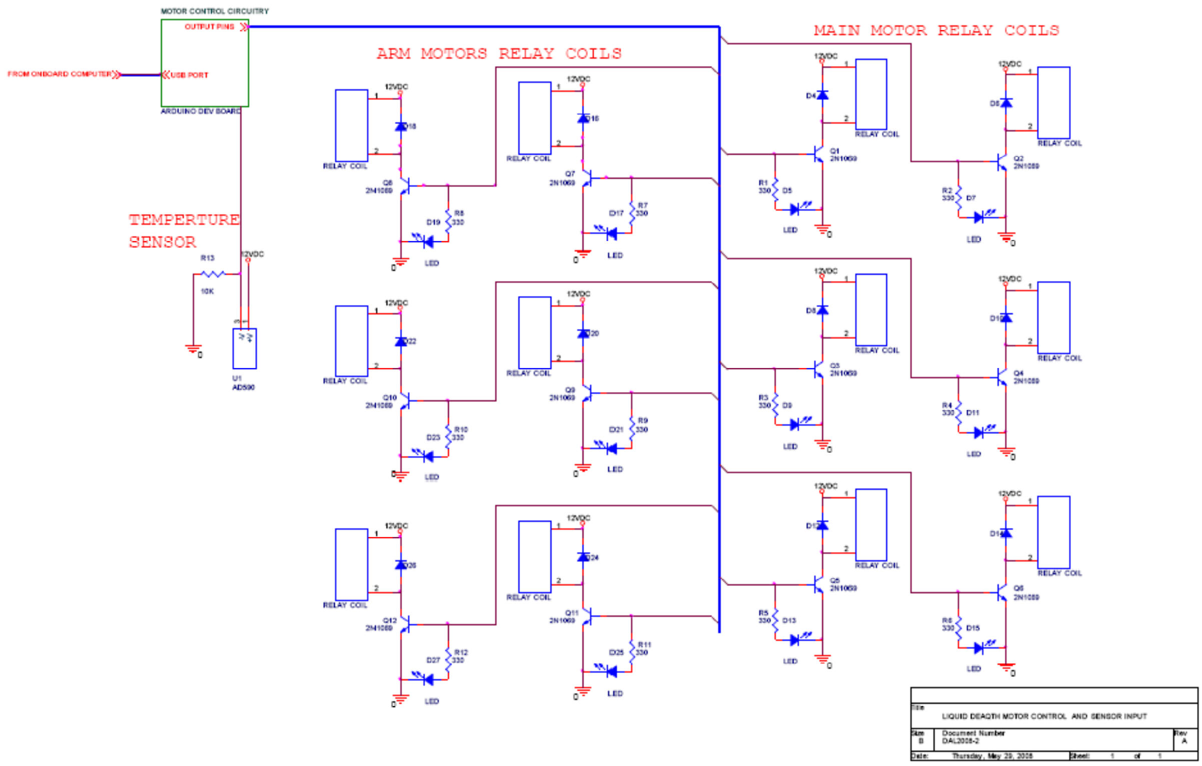
Some people who provided valuable insight and invested time in this project could not be at the Scripps's Institute of Technology to see what their help accomplished. We would like to extend our thanks to Blair Mason, Tom Connal, Tim Little, Linda Conrad, and many more in the Dalhousie Engineering department.

For all of those who supported us we sincerely thank you. Without your acts of encouragement our goal would have never been realized.

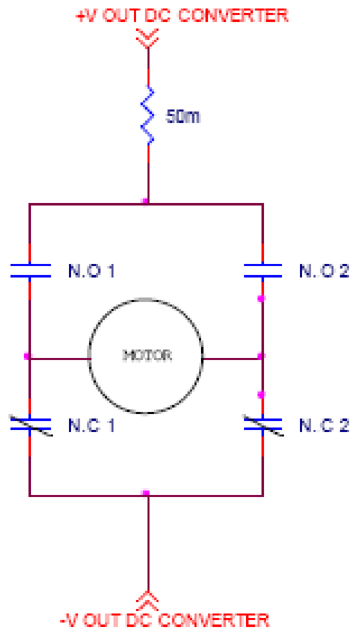
APPENDICES

Appendix A
Electrical Schematics

Motor Control and Sensor Input



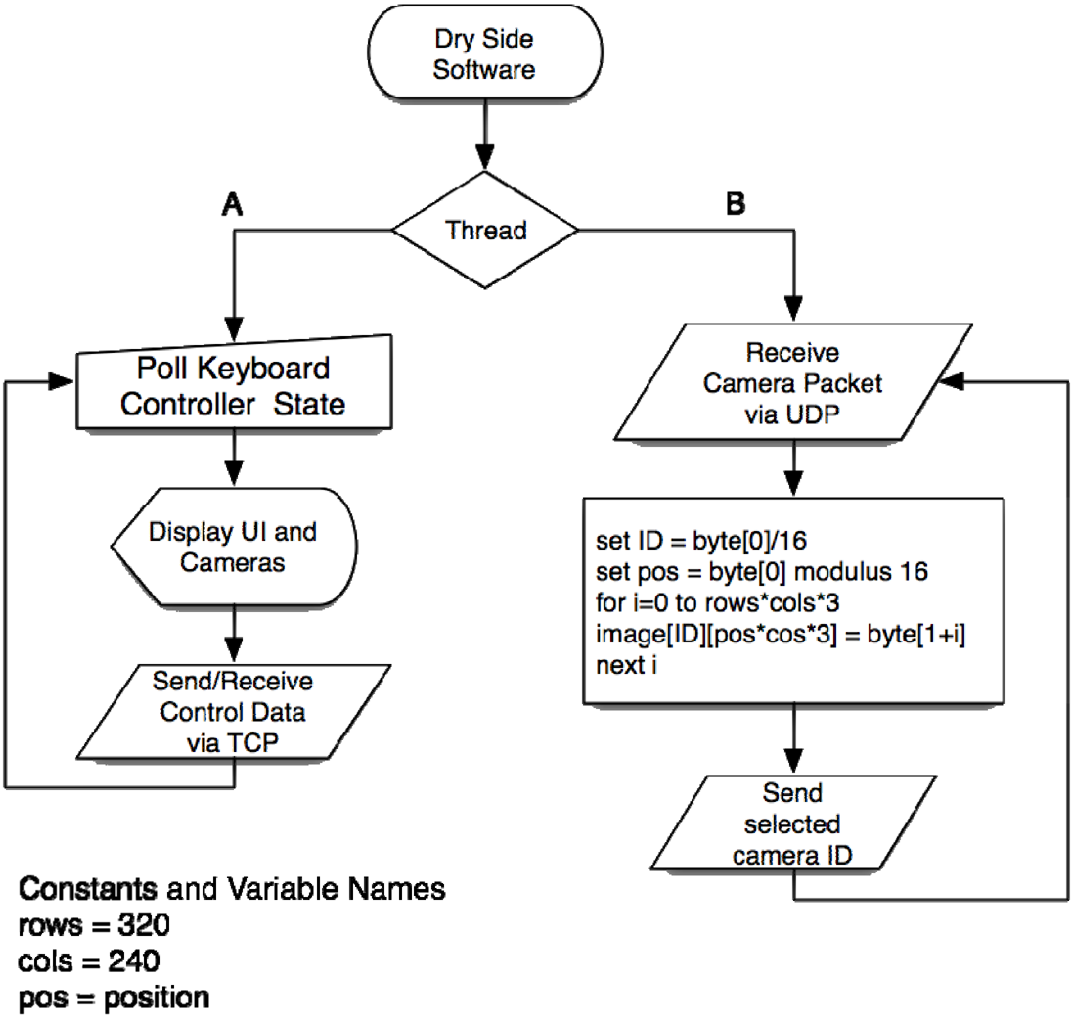
H-Bridge Arrangement



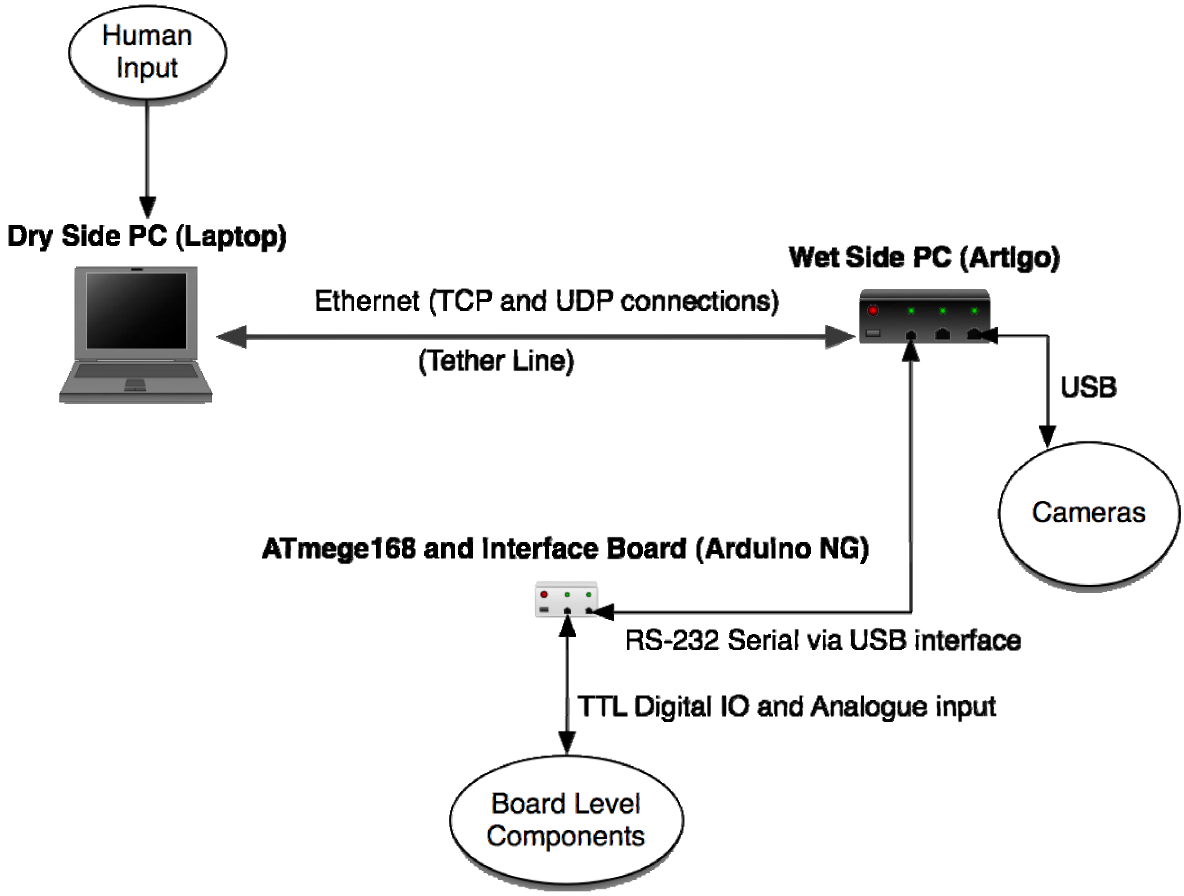
Title	LIQUID DEATH H BRIDGE ARRANGEMENT	
Size A	Document Number DAL2008-3	Rev A
Date:	Thursday, May 29, 2008	Sheet 1 of 1

Appendix B
Software Diagrams

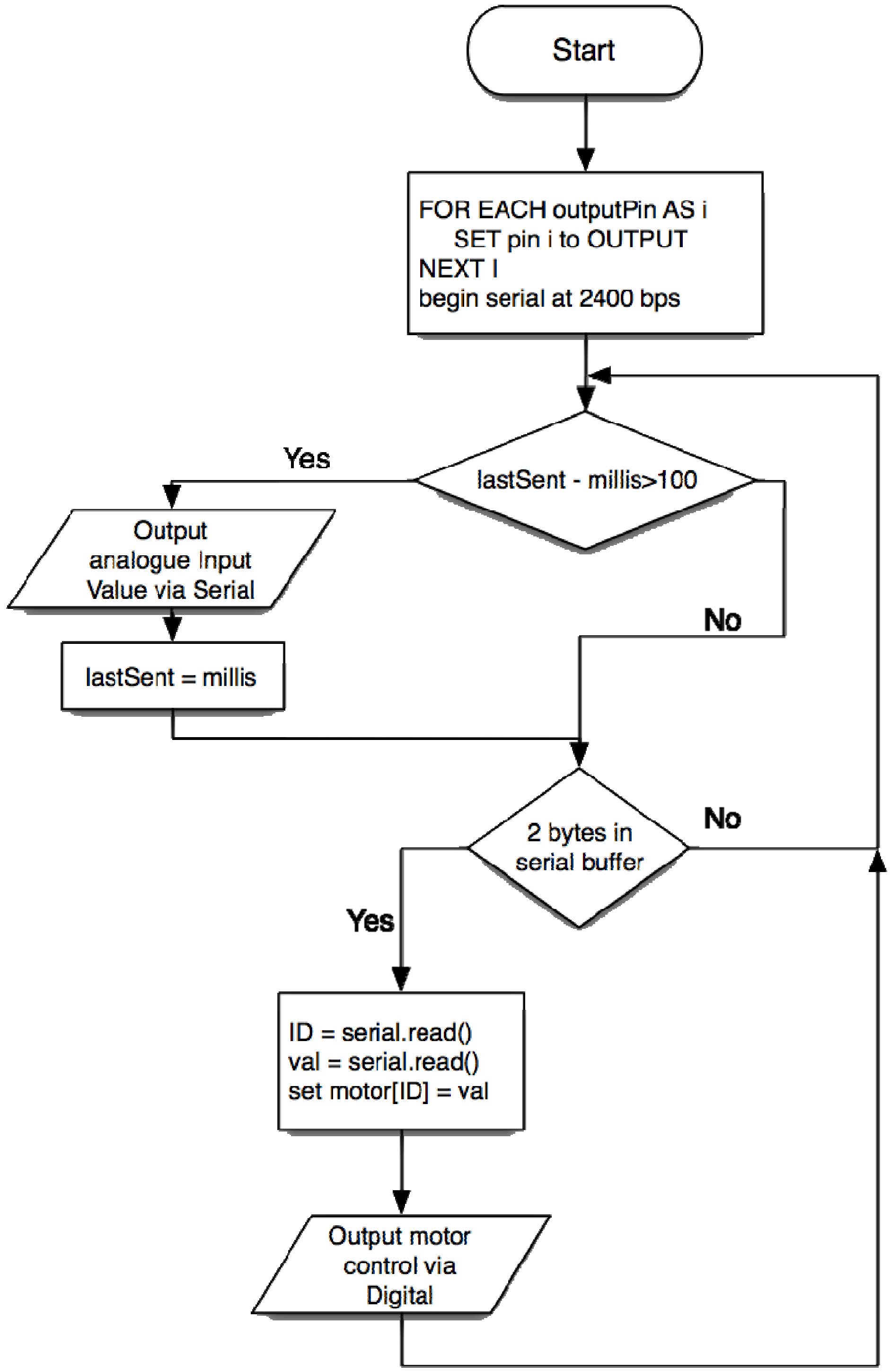
Dry Side Software



Network Layout

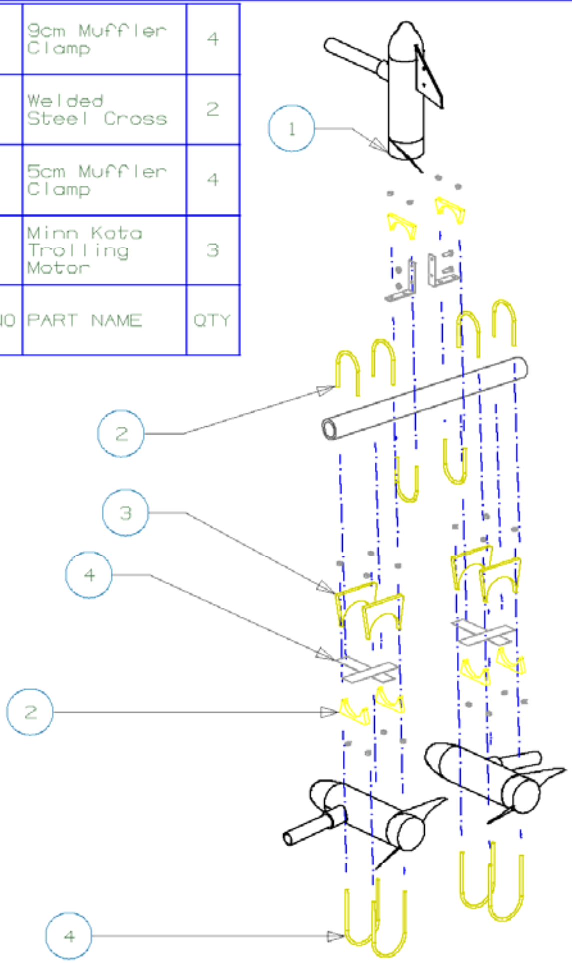


Board Level Software (ATmega168/Arduino)

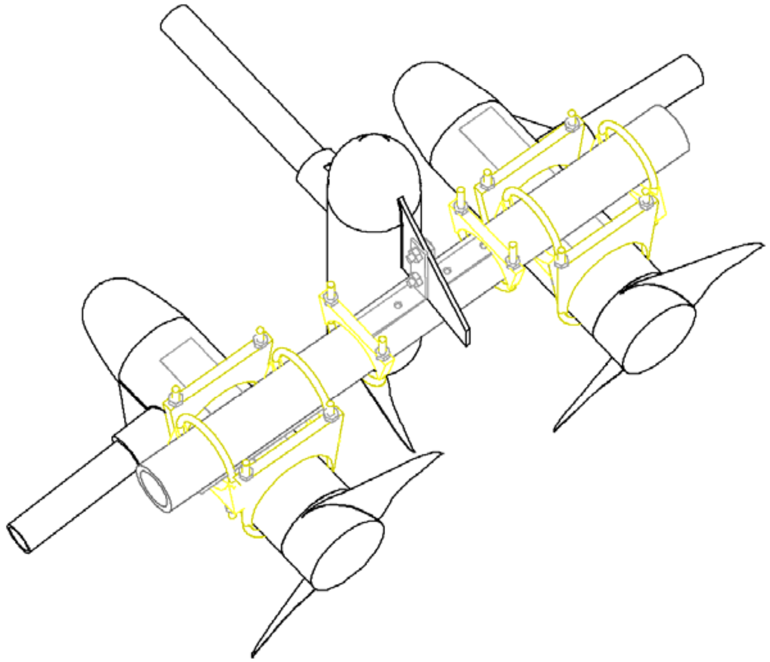


Appendix C
Mechanical Drawings

4	9cm Muffler Clamp	4
3	Welded Steel Cross	2
2	5cm Muffler Clamp	4
1	Minn Kota Trolling Motor	3
PC NO	PART NAME	QTY

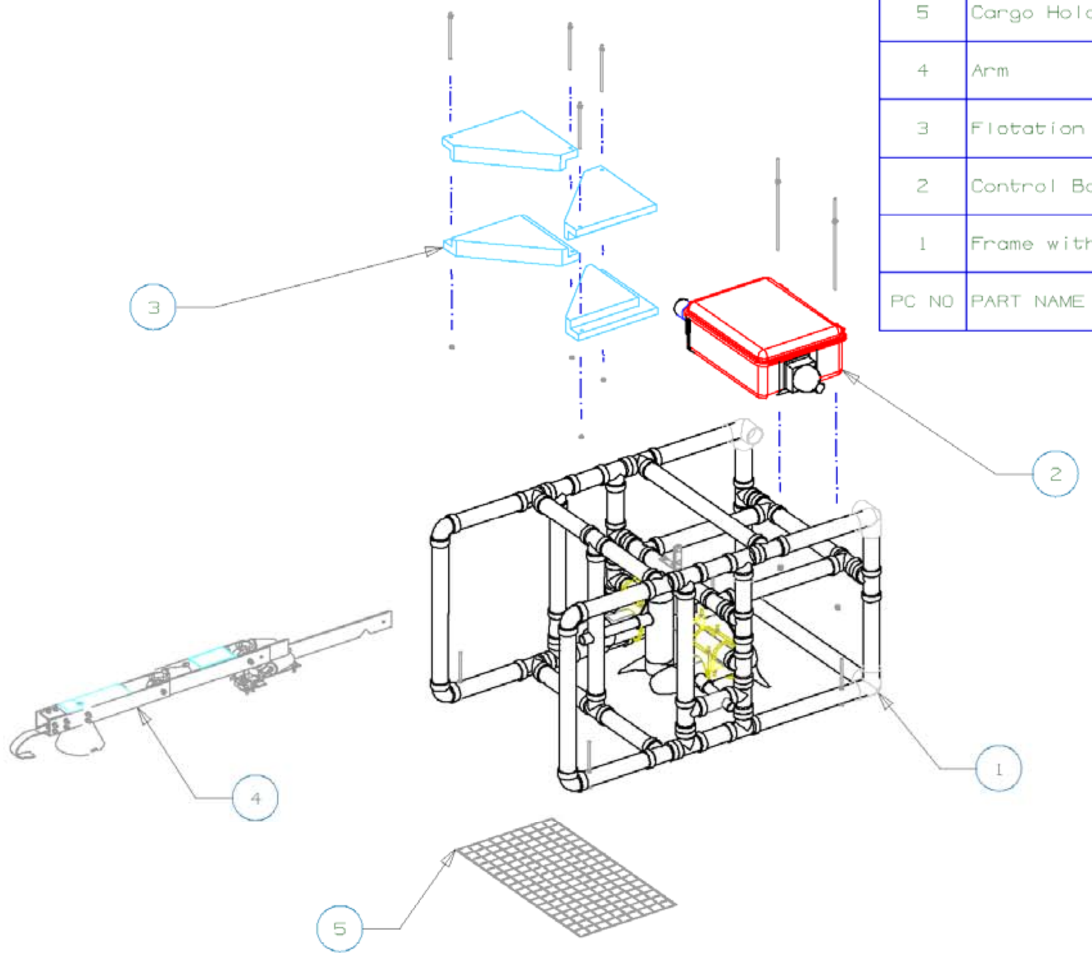


Exploded View



Isometric View Scale 1:5

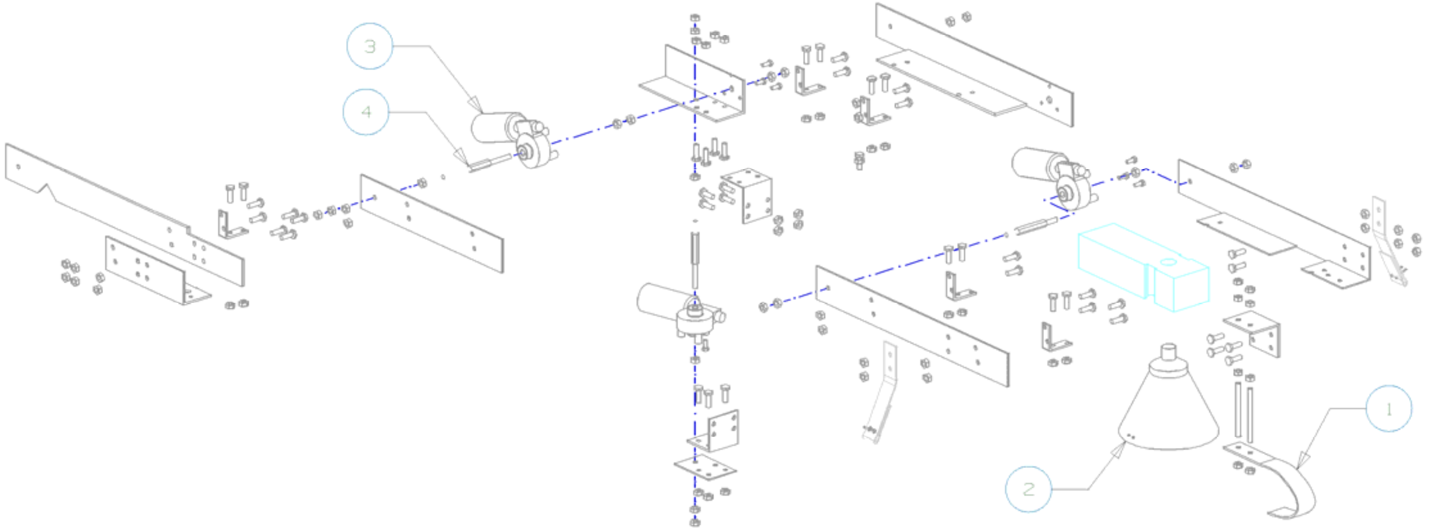
2008 MATE ROV Competition	Drawing: Detailed Motor Mount
Dalhousie Privateers ROV Team	Date: 24th June 08
	Units: mm / Scale: 0.075:1 / Sheet: 3/5



PC NO	PART NAME	QTY
5	Cargo Hold Mesh	1
4	Arm	1
3	Flotation Pads	4
2	Control Box	1
1	Frame with Motors	1

	Drawing: Overall ROV Schematic Explode		
2008 MATE ROV Competition	Date: 24th June 08		
Dalhousie Privateers ROV Team	Units: mm	Scale: 0.06	Sheet: 2/5

PC NO	PART NAME	QTY
4	Threaded Hex Bolts	3
3	Winshield Wiper Motor	3
2	Funnel (Contains Temperature Sensor)	1
1	Claw	1



	Drawing: Exploded View Arm
2008 MATE ROV Competition	Date: 24th June 08
Dalhousie Privateers ROV Team	Units: mm / Scale: 1:8 / Sheet: 5/5