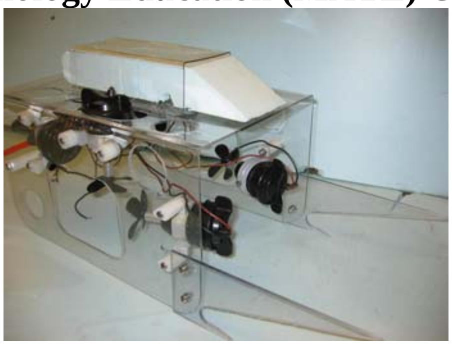
Technical Report
"Poseidon" ROV

Submitted By the
Eastern Edge Robotics "Ranger" Team

to the
Marine Advanced
Technology Education (MATE) Center



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Abstract

This Technical Report describes the Remotely Operated Vehicle “Poseidon”, designed and constructed by the Eastern Edge Robotics team, located in the St. John’s area of Newfoundland & Labrador, Canada.

This ROV was created to compete in the 2005 MATE (Marine Advance Technology Education) Center/MTS International ROV competition, hosted by the Johnson Space Center, Houston, Texas. This is the 4th annual MTS International ROV competition.

This year’s Ranger class mission is an underwater Olympics competition. This ROV was designed to compete as a multi-purpose unit that could search, identify, and complete multiple tasks in a limited time span.

The ROV was designed to complete the three following tasks:

1. Close a valve to stop the flow of oil, simulating capping an oil well in the Gulf of Mexico.
2. Take a communication probe to the ocean floor and insert it into the open port on a junction box.
3. Install a new instrument module on the Hubble space telescope.

Each task is allotted five minutes for completion and may be attempted twice.

This report includes a full description of our ROV, its design specifications, design rationale, troubleshooting techniques, challenges and future refinements. For more information about our ROV you can visit our website at http://easternrobotics.dyns.cx.

Team Introduction

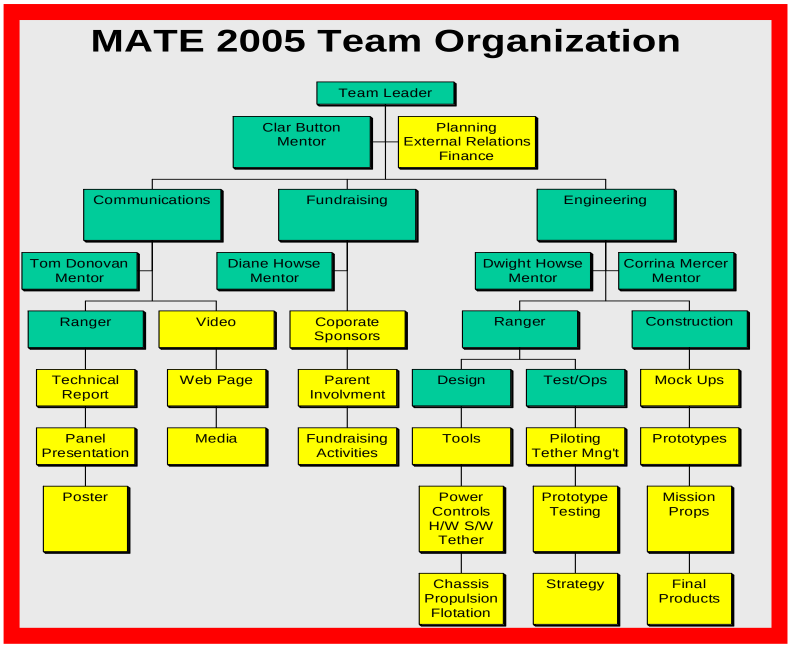
The Eastern Edge Robotics "Ranger" Team is made up of high school students from St. John's, Mt. Pearl, Paradise, and Conception Bay South. The team consists of 23 male and female students, who meet every Saturday from 10:00am to 4:00pm, and several nights during the week at O'Donel High School. The team members come from many schools on the Avalon Peninsula including O'Donel High School, Gonzaga High School, Holy Heart High School, Mount Pearl Senior High, Booth Memorial and Bishops College. The Eastern Edge Robotics Team will compete in the 4th annual MTS International ROV competition at the Sonny Carter Training Facility's Neutral Buoyancy Lab in Houston, Texas.

Eastern Edge Robotics "Ranger" Team Picture

Project Management

During the first meetings, the team constructed a Gantt chart using Microsoft Project. The team used this chart to manage time efficiently. It enabled us to allot tasks, and assign projects to be done by established deadlines. It also permitted the designation of individual tasks to team members. In this way, the work output was optimized and no time was wasted. The Gantt chart was vital to the completion of our ROV. At the beginning of every team meeting, it gave us somewhere to start from and a deadline to reach.

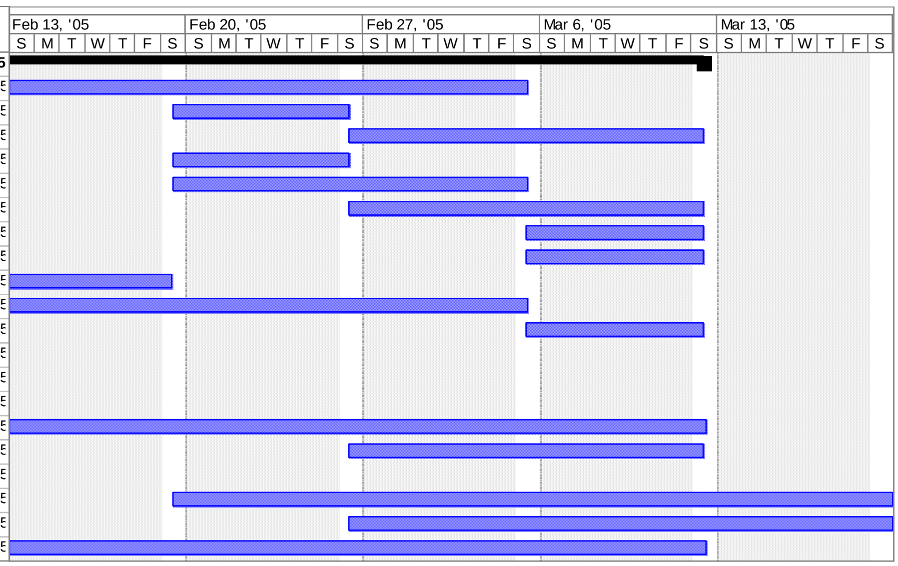
An organizational flow chart was designed to delegate work effectively. Team leaders and mentors were placed in charge of each group to oversee the completion of tasks. The three main groups were Fundraising, Engineering, and Communication.



This year the team designed and used weekly planner sheets. These sheets designated tasks that each team wished to complete by the end of the week, and assigned a team leader to present team accomplishments to the group as a whole. In this way, everybody was informed of the team's accomplishments.

Sample of Ranger Gantt Chart

ID		Task Name	Duration	Start
1		**Build Mock Ups**	**3.75 days**	**Sat 2/12/05**
2		Build valve unit	3 days	Sat 2/12/05
3		Acquire water hook up	1 day	Sat 2/19/05
4		Develop closing device	2 days	Sat 2/26/05
5		Build the probe with cable	1 day	Sat 2/19/05
6		Build holding unit for ROV	2 days	Sat 2/19/05
7		Build patch	2 days	Sat 2/26/05
8		Build patch target	1 day	Sat 3/5/05
9		Build Holding Unit for patch	1 day	Sat 3/5/05
10		Order Materials	1 day	Sat 2/12/05
11		Await Arrival Of Materials	3 days	Sat 2/12/05
12		Build First Prototype	1 day	Sat 3/5/05
13		Test Prototype	1 day	Sat 3/26/05
14		Refine Prototype	1 day	Sat 4/9/05
15		Build Final Product	10 days	Sat 5/7/05
16		Develop Webpage	4 days	Sat 2/12/05
17		Arrange Travel	2 days	Sat 2/26/05
18		Travel	2 days	Sat 6/11/05
19		Documentation	10 days	Sat 2/19/05
20		Fundraising/Sponsorship	5 days	Sat 2/26/05
21		Accounting	4 days	Sat 2/12/05



Design Specifications

Main Structure Design

1. Structure Frame
After much consideration of a strong and water resistant material, the team decided to go with 3.2 millimeter thick Lexan® material bent to form an upside down "U," held together with polypropylene (plastic) rods. It contains all stainless steel and brass hardware to prevent corrosion. The motor mounts are made of PVC and the dimensions of the ROV are 0.3 x 0.3 x 0.4 m.

2. Remote Control System
The controller system is from IFI robotics; it is an Isaac 16 system. This system is capable of driving 8 pulse width modulated (PWM) Victor 883 motor controllers and 4 spike (on/off) reverse polarity relays. It can also read 4 analog inputs and 8 switches. For our controller, the ROV required a 3 pulse width modulated motor controllers and 1 spike relay. User interface is through 2 joysticks each of which has x-y motion, one wheel motion and 2 switches. The controller uses a stamp processor that is programmed through a windows-based utility application. The programming language is BASIC.

3. Video Cameras
The ROV uses an *Inuktun* "FireflEYE" underwater camera. Inuktun is a Canadian hi-technology firm with products in the underwater services sector. The camera can operate to a depth of 300M. It contains a 0.64 cm CCD chip with a 5 Lux minimum light level. It has an underwater field of view of 39°. It also contains ten 8W LEDs distributed in a circle around the main camera lens, for a better underwater picture.

4. Tether
Our tether consists of eight wires plus a coax cable. There are seven 16-gauge wires and one 75 ohm coax cable. The plastic coating of our tether is waterproof, brightly colored for visibility and neutrally buoyant. The tether can operate at temperatures of 0°C to +80°C and weighs 251 g/m in air. For further information and technical schematic, please refer to Appendix B.

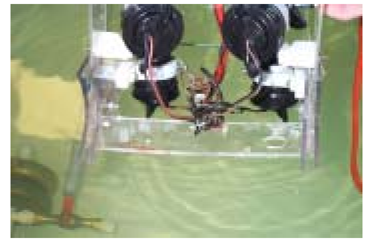
5. Thrusters

The ROV uses six Mayfair Marine 1250 GPH sealed bilge pump motors as the drive mechanisms of our thrusters. These 12 volt motors have a maximum current draw of about four amps with the four-bladed, 70mm diameter, medium (35mm) pitch, plastic propellers selected from our Bollard Pull testing. The propellers are shrouded from external obstructions and internal mission tools by the external frame of the ROV.

Separate Tasks and Tools

1. Task 1- Oil-well Valve

The ROV is required to push a handle a 1/4 turn from an open position to a closed position to stop the flow of "oil" through the valve. The pilot intends to land the ROV on the pipe; two bracket guides (24.5x9cm) are attached to either side of the ROV, made out of Lexan®. This bracket guide will catch the valve handle and the ROV will then turn, closing the valve.



2. Task 2- Communications Probe

We must insert a communications probe into the open port on the junction box. This re-establishes the communications link. The team has created a tool that uses a 16.1 cm long Lexan® V-shaped device to guide itself to the science package. The tool consists of three conjoined pieces of Lexan®, 22.9 cm long, with the V-shaped device. This tool is attached to the front of our ROV. The pilot drives the ROV into the target and lowers it slightly, which pushes a trigger and releases a spring mechanism. A pin is released, and the probe drops into place. This tool has a 16.5cm long trigger.

3. Task 3- Hubble space telescope and instrument module

The final task is to install a new instrument module on the Hubble space telescope. This task is only a simulation; it is designed to test the ability of an ROV in a space environment, as water and space are quite similar. Our tool contains an adapter, guide, and release mechanism. The patch is inserted into a notched PVC pipe called the 'Adapter'. The adapter provides the connection between the patch and the spring mechanism. The adapter is in the shaft of the tool. A section of PVC pipe is used to aid in aiming the patch. Once in line, the ROV pushes the patch onto the matching circle. This causes the aiming pipe to slide back attaching the instrument module to the telescope.

Design Rationale

Main Structure Design

1. Frame
We chose the material Lexan® as our primary chassis material because it is lightweight, strong and durable and is suitable for use underwater. Lexan® is easily shaped with heat and forms to our design needs. It is clear and almost invisible in water, which provides and unobstructed view all around the ROV. The stainless steel and brass rods were used because they are corrosion resistant.

2. Control System
Our Control system is the standard used in many Robotic competitions. The IFI Robotics equipment uses Pulse Width Modulation for proportional control of motors, providing a higher degree of precision in tight spaces. Furthermore, it can be programmed to complete different tasks. We have used this equipment in previous robotic competitions.

3. Video Cameras
There are many benefits in using the ***Inuktun*** "FireflEYE" camera. It is lightweight and can be secured to virtually any surface. It is versatile and can fit through small openings. The camera itself can be connected to video recorders, monitors, and televisions. The camera met our budgetary constraints as it was donated by ***Inuktun***.

4. Tether
This particular tether was selected because it met all necessary wiring specifications for our motors and cameras. It has a small diameter, is neutrally buoyant and highly visible in water, making it an excellent choice for our ROV.

5. Thrusters
Mayfair Marine provided 1250-GPH bilge pump motors that we are using as thrusters. They are used because they are waterproof, having been tested at a depth of 10 meters in seawater without failure. Our Bollard Pull test indicated that these motors are the most powerful in their size class and they fit our limited budget as we received a discounted price from the manufacturer.

Separate Tasks and Tools

1. Task 1- Oil-well Valve

The "oil" valve has to be closed quickly and efficiently without damaging it. Only one Newton of force is required to close the valve, so the focus for this task was design over power. A guiding device was attached thus allowing the valve to be closed efficiently and effectively in one attempt.

2. Task 2- Communications Probe

The team's original design centered on a scoop shape, but this took too much time when tested. The final design allows us to hold and release the probe. A guiding device was added to the bottom in order to increase efficiency as well as allowing us to drop the probe accurately.

3. Task 3- Hubble space telescope and instrument module

When designing this tool, the team modified a prototype from a previous competition. The team designed a more efficient aiming mechanism, which was tested and works quite effectively in the water. A new release mechanism was designed for better efficiency. Incorporating new ideas into an old design has given us the ability to hit the target on the first attempt.

Technical considerations of the mission tasks:

Organization and planning are the keystones of any undersea operation. We will designate specific team members and a back-up individual to be:

i. pilots
ii. tether managers
iii. pre-dive checklist technicians
iv. tacticians
v. pit management crew
vi. equipment handlers to manage ROV movement and from the dive site
vii. presenters for the engineering panel discussion
viii. still photographers and videographers

The team has checklists for pre-dive, dive, and post-dive operations in order to ensure readiness of our ROV and to increase efficiency in each of the specified areas. This will ensure that all specialists remain attentive to the task at hand.

Troubleshooting Techniques

Like with any project, there were various problems with the original designs. All tools had to be redesigned and tested several times to achieve the best results possible.

One problem encountered was the system for the patch release. The design team that worked on it was baffled with how to design an aiming mechanism without disturbing the rest of the tool. Based on last year's experience, the team wanted a more accurate design. After many prototypes, the group designed a very efficient and accurate mechanism.

In order to obtain the most optimal results from our thrusters, several tests were performed to compare the results on different number of blades and size of prop.

Equipment used for the Bollard Pull Test: Regulated power supply for voltage, digital Fluke ammeter for amps. A spring scale was used for the Bollard Pull force.

The Bollard Pull tests conducted this year using the Mayfair motors were completed using a standard motor and again with the motor being compensated with Varsol. This was done to see if a compensated motor would give us more power. From the results gathered, we concluded that the compensation did create a more efficient motor.

Motor Voltage and Force

	Unaltered motors		Compensated motors	
4 blade V	4 blade N	3 blade N	4 blade N	3 blade N
13.5	16	14.5	19	17
12	11	12	14.5	13.5
10	8	9	8.5	10
8	6	7.5	6	6.5

Conducting "Bollard Pull Test"

***Refer to Appendix C for complete Bollard Pull Test results.**

Challenges

Following our success at last year's competition, the team has doubled in size. Due to our large size, we felt that it was necessary for us to enter both classes of the competition. This caused administration and organizational problems. Using the Gantt chart, we have overcome this logistical challenge. The size of the team has also caused many financial problems. This required the team to do more fundraising in order to attend the competition.

Another challenge has been the timing of the competition. Conflict has occurred between the dates of the competition and Newfoundland's high school and government exams. As a result, arrangements were made with the provincial government and individual schools in order to write these exams during the competition.

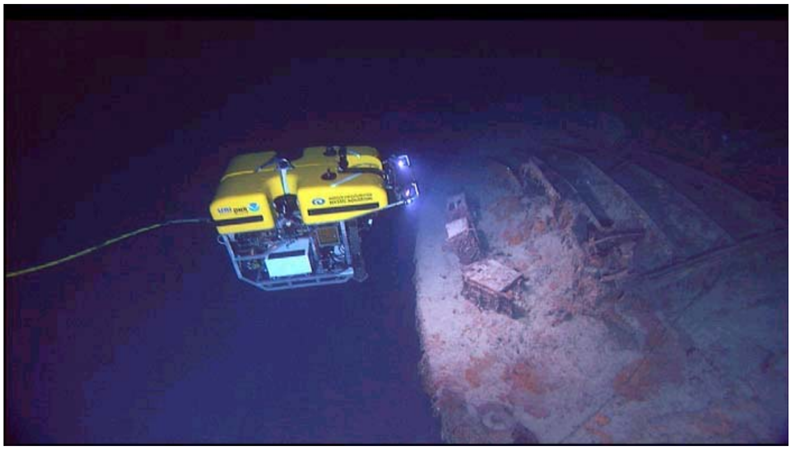
Future Refinements

The team's ROV is nearing completion. New ideas for refinements are still emerging and being tested. The ROV works in the facilities we have used, but there is uncertainly as to whether it will work in the Neutral Buoyancy Lab at the competition. For example, the communications probe team would have liked to make the tool smaller so it would take up less space on the ROV. The team would also like to have more time for further testing on the ROV. In the future, we would establish more practice time as a major priority for the team. We are always trying to find more reliable solutions to problems as they arise.

Lessons Learned

We as individuals have gained skills, knowledge and personal benefits beyond what was thought possible, especially those of us who came to the team with little or no knowledge of robotics. As a team, we learned that individuals have strengths that can be refined and developed, but we should let ourselves diversify and experience every aspect of the ROV. We found that, when coming to the final phases of construction, we as a group had set limits on what each member of the team would do. For example, most team members worked on the same piece of equipment every week. This worked well because we could show up each week and know exactly what needed to be completed. Unfortunately, we are now finding that most of the team is highly knowledgeable on certain parts of the ROV and ignorant about others. Next year we plan to rotate the team members so that everyone works on every aspect of the ROV at some point.

ROVs and the Oil Industry



The Remotely Operated Vehicle (ROV) has been in development since the early 1950's. Early ROVs were not 100% reliable and were used mostly as cameras, providing stable platforms for videos, still cameras and lighting systems. These visuals could be used for various inspection tasks. The main advantage of these ROVs was that they were expendable; the loss of the ROV did not put lives in danger. The first groups to develop ROVs were Navies around the world. These ROVs could travel to and explore areas of the ocean inaccessible to divers. As technology improved, it was made possible to apply ROVs to commercial applications such as oil prospecting, oceanography and fisheries. Today the use of ROVs is very common.

ROVs are not only common in the oil industry; they have become essential to other industries as well. The ROV is not only the eyes into the underwater construction world but also the ears, mouth and hands. It has gone from being used as a camera platform to a vehicle capable of performing intricate engineering studies with precision tools where the exact location of the vehicle, viewpoint and tool are required.

The acoustic-surveying technicians of a project must work in conjunction with the ROV technicians to mount surveying equipment on the ROV. Each individual project has a unique set of equipment needed to accomplish the tasks. Today, most of the electronic tools mounted on the ROV take their power from the ROV itself so wiring to the surface has been limited.

ROVs are used to accomplish many different projects for oil companies such as capping oil wells. ROVs ensure the safety of human divers and are very cost efficient for companies.

Sources: http://www.rov.org
http://www.nurc.uconn.edu/technologies/rovs.htm
http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html
http://www.diveweb.com/rovs/features/uw-sp98.03.htm

Budget and Financial Statement

ESD Robotics Team – 2005

Expenses

ITEM	COST ($ CDN)
AIRFARE (Return St. John's to Houston)	
18 students @ $798.50 (tax-in)	14373.00
2 mentors @ $798.50(tax-in)	1597.00
ACCOMODATIONS	
20 persons/ 7 nights +meals U of T at Clear Lake @ $135 US/person = $2700 US	3,408.48
9 rooms/7 nights @ $110 US/night = $6930 US	8,748.43
GROUND TRANSPORT	
Van rentals+ gas & Insurance (5) 7 days @$85 US/day = $2975 US	3,755.64
MEALS	
20 persons x 7 days @ $25 US/day = $3500 US	4,418.40
AIR FREIGHT	
Return air freight St. John's - Houston	450.00
MATERIALS & FABRICATION COSTS	
Parts, motors, propellers, wiring, metal stock, plastic stock, electronics	2500.00
Promotional items (banners, t-shirts, plaques for sponsors, etc.)	1200.00
TOTAL	$40450.95

Revenues

ITEM	FUNDS ($ CDN)
Private Sector Contributions	7000.00
School Board Contributions	0
Public Sector Contributions	0
Team Member Contributions	
18 Students @ 1481.86 each	26673.48
TOTAL	$33673.48

Materials Donated and Estimated Values

Dominion (food for fundraising)	36.00
Inuktun (2 cameras, tether)	2500.00
Aliant (Donated t-shirts)	400.00
Marine Institute (donated money and t-shirts)	2700.00
Mayfair Marine (thrusters)	500.00
TOTAL	$6136.00

Acknowledgements

The Eastern Edge Robotics "Ranger" Team would like to thank the many contributors who made this project possible. We would especially like to thank the following:

Dominion Grocery Stores (food donation for fundraising efforts)

Eastern School District, Newfoundland (use of facilities)

Inuktun, Nanaimo, B.C. (donation of two cameras and tether.)

Marine Institute of Memorial University, St. John's, NL (test facility and financial aid)

MATE, Monterey, Ca. (monetary travel allowance)

Mathew Handcock (technical support for web-page)

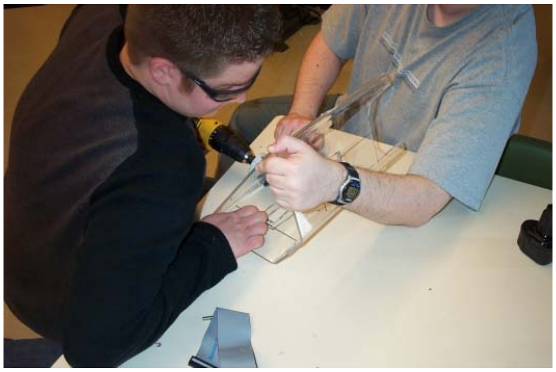
Mayfair Marine (thrusters)

O'Donel High School, Mount Pearl, NL (use of facilities)

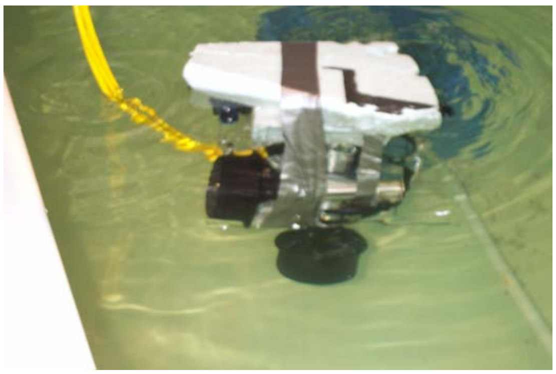
Our parents (for their generous support)

Our mentors (for their guidance, patience and dedication)

Appendix A: Photo Album


Working on Chassis


Working on tool prototypes


Prototype Testing

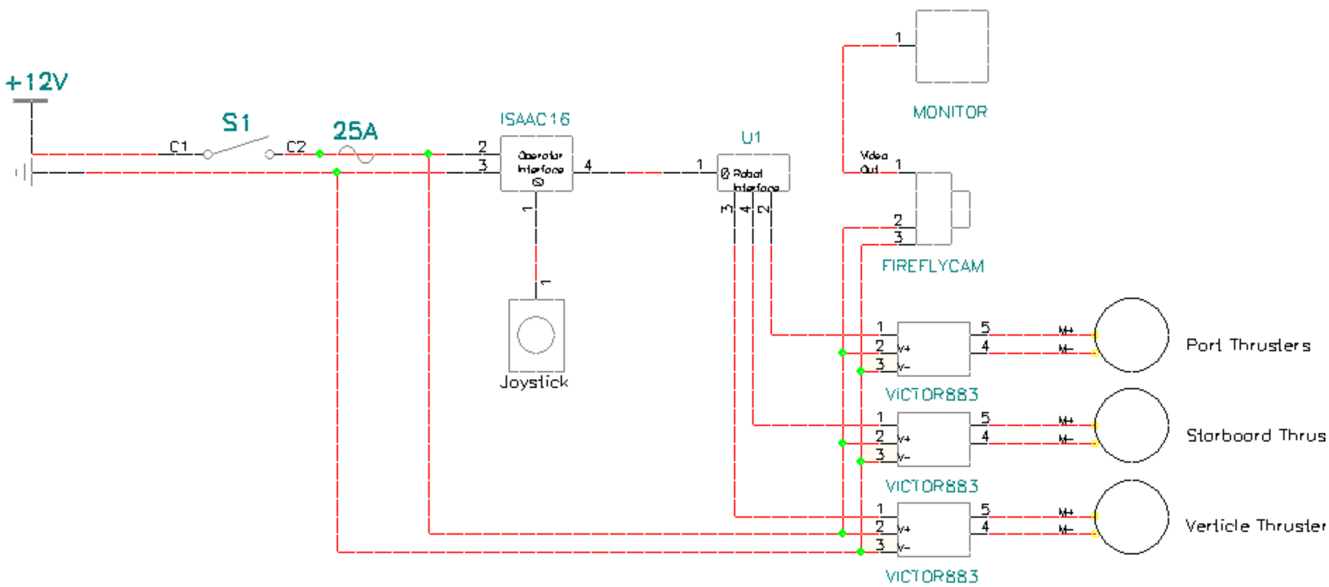

Working on the ROV’s electronics


Website and Technical Report work

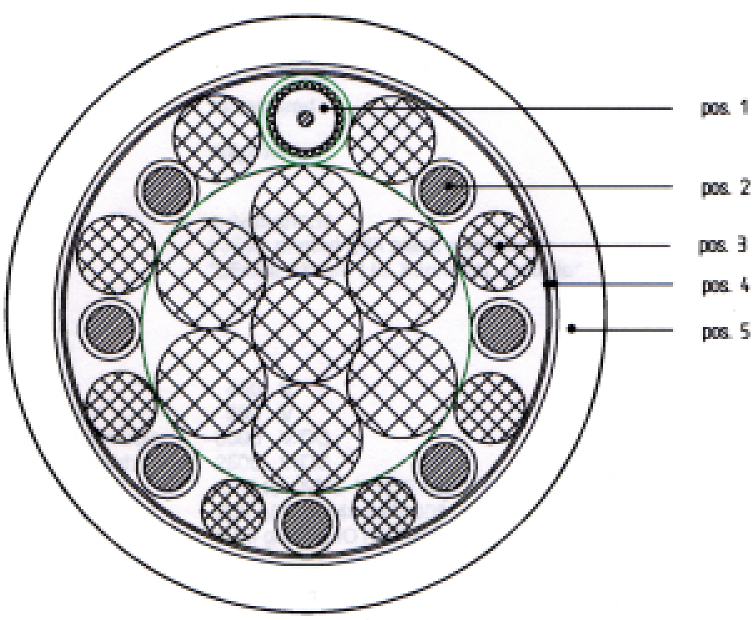

Cleaning the O’Donel ROV test tank

Appendix B: Technical Schematics

Ranger Class Electrical System



Tether Schematic

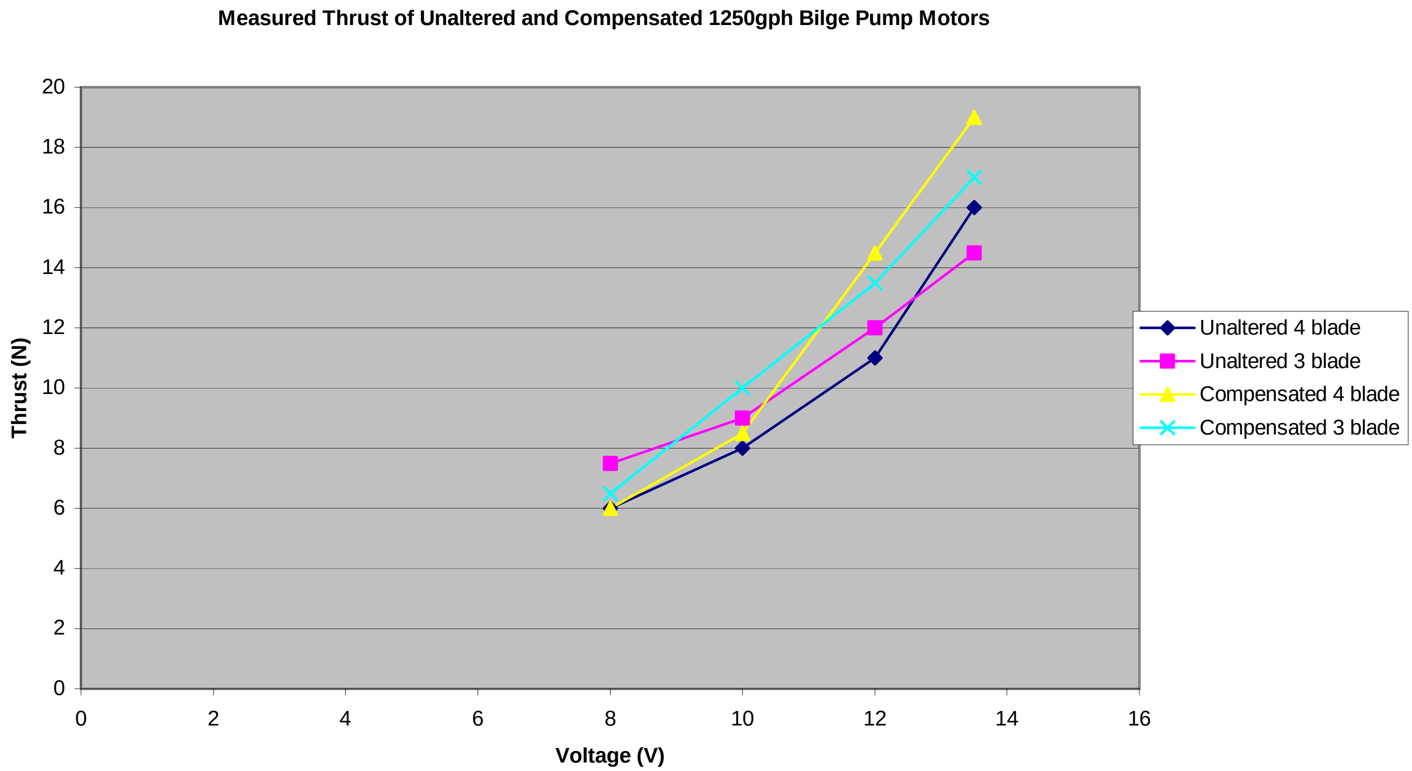


Pos 1: 1 x coaxial cable
Pos 2: 7 insulated wires - 1.0mm2 /16 AWG
Pos 3: fillers
Pos 4: bindings (polyester)
Pos 5: outer jacket (polyurethane)

Appendix C: Bollard Pull Test Results

Johnson (Mayfair brand) 1250 gph bilge pump motor -unaltered)						
Time	**Motor**	**Blade**	**Voltage**	**Amperage**	**(N)**	
Trial 1 - 3-blade propeller (60 mm diameter)						
4:22	1250 GPH	3 Blade, 60mm Diameter	13.5	7	12.2	trial
4:24	1250 GPH	3 Blade, 50mm Diameter	13.5	7	12.4	trial
4:25	1250 GPH	3 Blade, 50mm Diameter	13.5	7	12.5	trial
4:26	1250 GPH	3 Blade, 50mm Diameter	13.5	7	12.8	
4:27	1250 GPH	3 Blade	12	7	11.2	
4:27	1250 GPH	3 Blade	10	6	8.2	
4:28	1250 GPH	3 Blade	8	5	6.2	
Trial 2 - 4-blade propeller (70 mm diameter)						
4:04	1250 GPH	4 Blade, 70mm Diameter	13.5	7	8.8	
4:07	1250 GPH	4 Blade	12	5.5	7.3	
4:09	1250 GPH	4 Blade	10	6	7.1	
4:10	1250 GPH	4 Blade	8	4	5.6	
Trial 3 - 4-blade propeller (70 mm diameter)						
4:14	1250 GPH	4 Blade	13.5	7	10.3	
4:16	1250 GPH	4 Blade	12	6	8	
4:17	1250 GPH	4 Blade	10	5.5	6.2	
4:19	1250 GPH	4 Blade	8	5	4.8	
Johnson (Mayfair brand) 1250 gph bilge pump motor - compensated)						
Time	**Motor**	**Blade**	**Voltage**	**Amperage**	**(N)**	
Trial 4 - 3-blade propeller (50 mm diameter)						
4:12	1250 GPH	3 Blade	13.1	10	18	
4:13	1250 GPH	3 Blade	12	8.5	11	
4:14	1250 GPH	3 Blade	10	7	9	
4:15	1250 GPH	3 Blade	8	5.5	6	
Trial 5 - 3-blade propeller (50 mm diameter)						
4:18	1250 GPH	3 Blade	13.5	10	17	
4:19	1250 GPH	3 Blade	12	9	13.5	
4:20	1250 GPH	3 Blade	10	7.5	10	
4:21	1250 GPH	3 Blade	8	6	6.5	
Trial 6 - 4-blade propeller (70 mm diameter)						
4:30	1250 GPH	4 Blade	13.5	10	19	Off Scale
4:31	1250 GPH	4 Blade	12	9	14.5	
4:32	1250 GPH	4 Blade	10	7	8.5	
4:33	1250 GPH	4 Blade	8	5.5	6	

Appendix C: Bollard Pull Test Results (continued)



Graph 1:Voltage (V) versus Thrust (N) on the compensated and unaltered motors