2009 MATE International ROV Competition

Technical Report
Ranger Class
Cambridge Rindge & Latin School

CRLS Underwater ROV Team
Presents
KISS

Team Members:

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Mentors:

Paul McGuinness, Ross Benson

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Abstract:

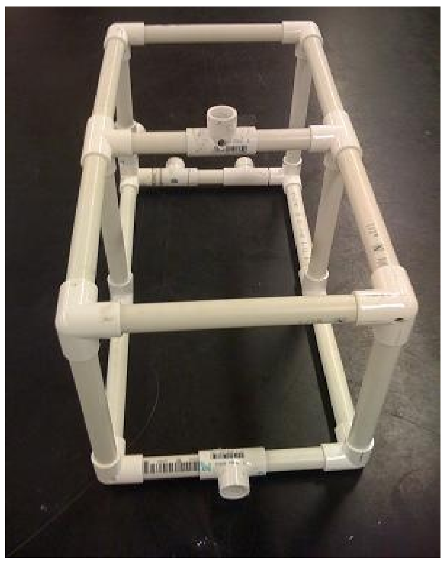
The 2009 CRLS underwater ROV (remotely operated vehicle) is described. This ROV is designed to complete the four tasks as outlined in the ranger mission specifications. It employs static manipulation devices and a new variable speed drive system to achieve these tasks. In addition, technical specifications of the ROV and the control system are detailed.

All the members were new to this competition except one. They learned how different this year's competition was from the last year's competition. Then they first focused on researching and debating of how the general ROV was going to be like. After final decision team members put their best effort in constructing the ROV that could efficiently and quickly accomplish the missions according to the rule.

This report includes: detailed descriptions and diagrams of the ROV and its components; challenges we faced and overcame along the way; lessons we learned and some we didn't; a list of things we would like to improve on next year; a description of a submarine rescue system, a detailed budget; reflections of the process and experiences of each team member, a list of all those individuals and groups who helped us get here.

Design Rationale:

Structure: After long heated debate about the structure, we decided the structure of our ROV to be a cube. We decided to use the cube shape because it is simple and allows easy accessibility to the devices. We are using PVC pipes because they are the most abundant materials in our working area. These materials worked efficiently past years and they were easy to work with (no money spent on the structure of the ROV). We minimized our structure to have easy access for the ventilation.



Structure of ROV

Propulsion: Our vehicle has five thrusters. Two thrusters are used for vertical movement. The other two thrusters are used for horizontal movement. The last thruster is used for additional boost for the turning of our bot. The position of each thruster was also another major issue we had to deal with. We did our best to place the vertical thruster in the center of the ROV. We also had to take account of vision of the cameras for the position of thrusters. Thrusters are now placed in the position we wanted.

Each thrusters produce 3N thrust. One thruster use 40.8watt at full rpm. One thruster draws 3.4Amps under full load. We measured the thrust by using spring scale. We also measured the speed of our thrust. We timed how long it took from the front of the submarine to the back of the submarine, and the velocity of our vehicle was .41m/s. It took 6.3 sec to rotate 360°.

Thruster

Buoyancy: The buoyancy was another main part of our ROV. This year we covered our tethers with shedding. It was a very good choice because it made the visual look of ROV much nicer and helped with the evening out buoyancy. In addition, we also ordered two new black kick boards. This new kick boards work as buoyancy of the body of ROV and it looks very sexy and clean.

Kick Boards

Tether

Sensors: We are using two RadioShack Black and White security cameras. It is waterproof as it is. One camera is used for the view of front side of our ROV and the other camera is used for the view of opposite side of our ROV. It is carefully measured and can sight all the devices with its view.

RadioShack Black & White security camera

System Design: Our vehicle is able to use all of its static devices to complete the mission tasks. We have different types of static devices that are fit for each mission. These efficient uses of static devices are our strength as well as our simple design or our vehicle. Our static devices are suitable for each mission tasks and our simple structure enhances its effectiveness. The use of our static devices reduces the risk of having technical issues of mechanical devices. The only weakness of our design would be that it requires skilled control. Experienced driver is essential to this vehicle since the static devices needs accurate control over them to accomplish the mission without a mistake. We did not have any safety issues since us only static devices. We only had to worry about the safety of propellers of the thrusters. We put 'Thruster shields' on the propellers. This component is works efficiently while designed not to interfere with the movement of the vehicle.

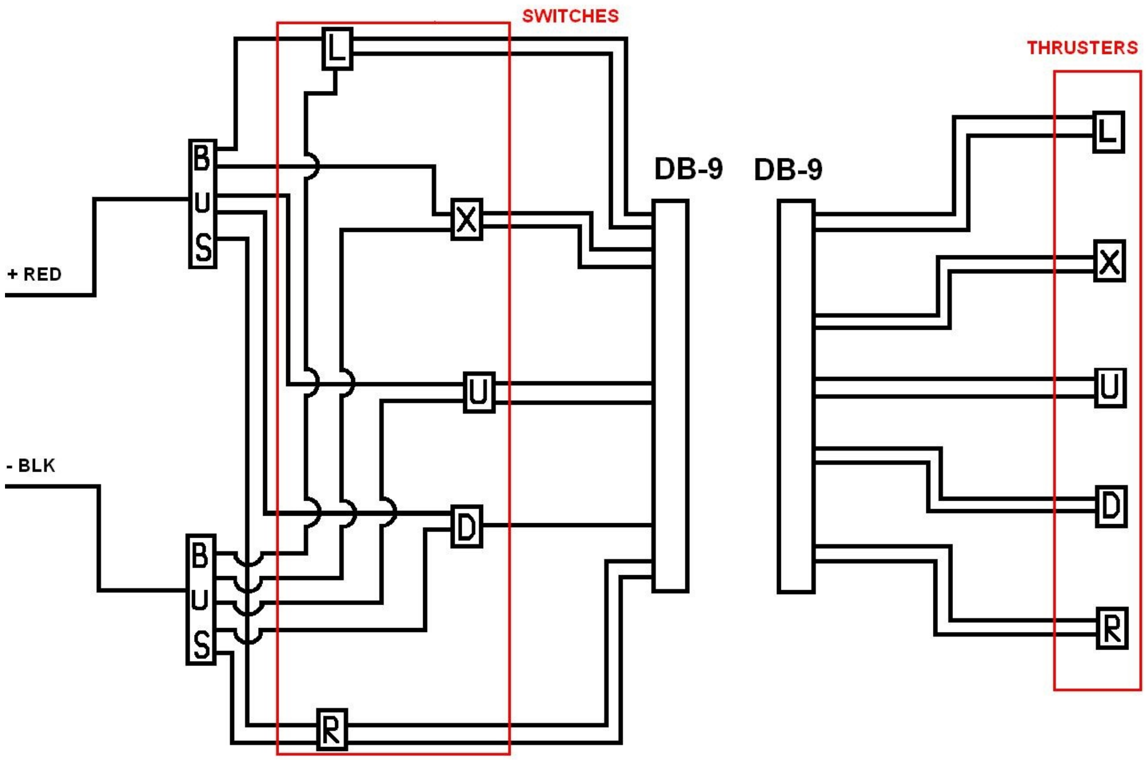
Originality: The design of our robot is unique because we used all static devices in our robot. The reason we chose to complete our missions with only static devices because we wanted to keep our vehicle as simple as possible. We thought that using mechanical devices instead of using static devices for completing this kind of mission is bad engineering method. We didn't make excess use of commercially-available systems.

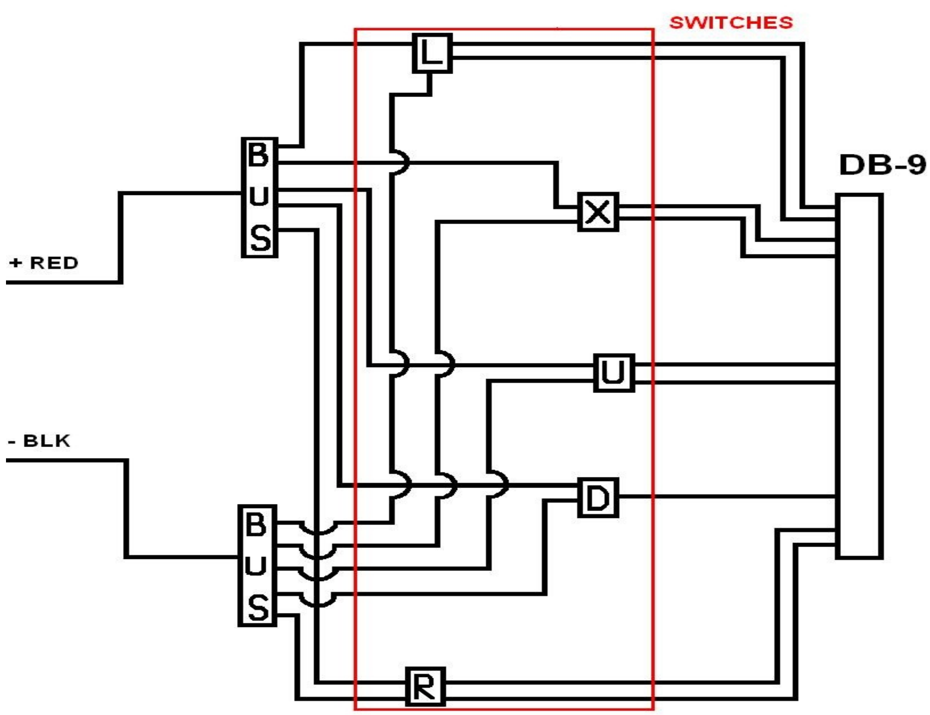
This year we tried to improve the control system of the vehicle. We decided to use an analog control system in order of using digital control system. A part of our team worked on the control system with the guidance of the engineering department of our school.

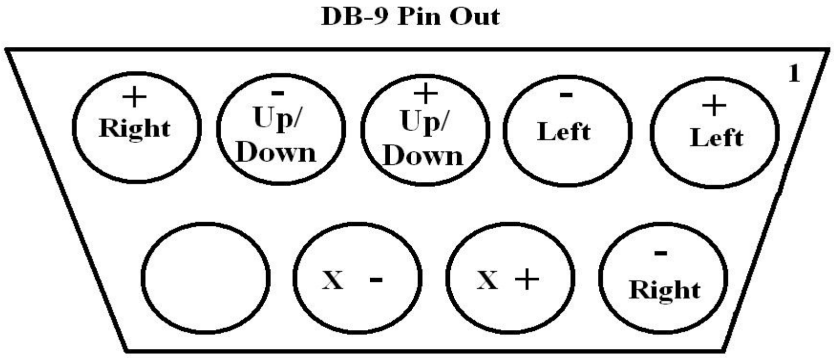
Workmanship: The Safety is the most important thing in this mission. So, we tried set up the electrical system of our BOT as accurately as possible. Electrical systems of our BOT are neatly run and wired. We supplied power to the thrusters with wires which stays inside of PVC pipe. So, that the wires are not messy and our BOT looks aesthetically pleasing. We tried to make the tether of our BOT neatly bundled and protected We used shrink rap to cover up all the spots and to make the tether waterproof. In our BOT it is easy to access components and maintenance. To run our BOT what we need to do is to connect the tether with the power source.

Safety: Our vehicle does not contain any safety hazards due to our use of static devices. We have covered the thrusters with the thruster shield to prevent potential hazard. Before any powers or electricity connects to the battery, we have a one person who checks if everything is set and safe before connecting. For instance, he will call out 'Tether!' and our tether man will say 'check' if all the wires are checked safe and connected.

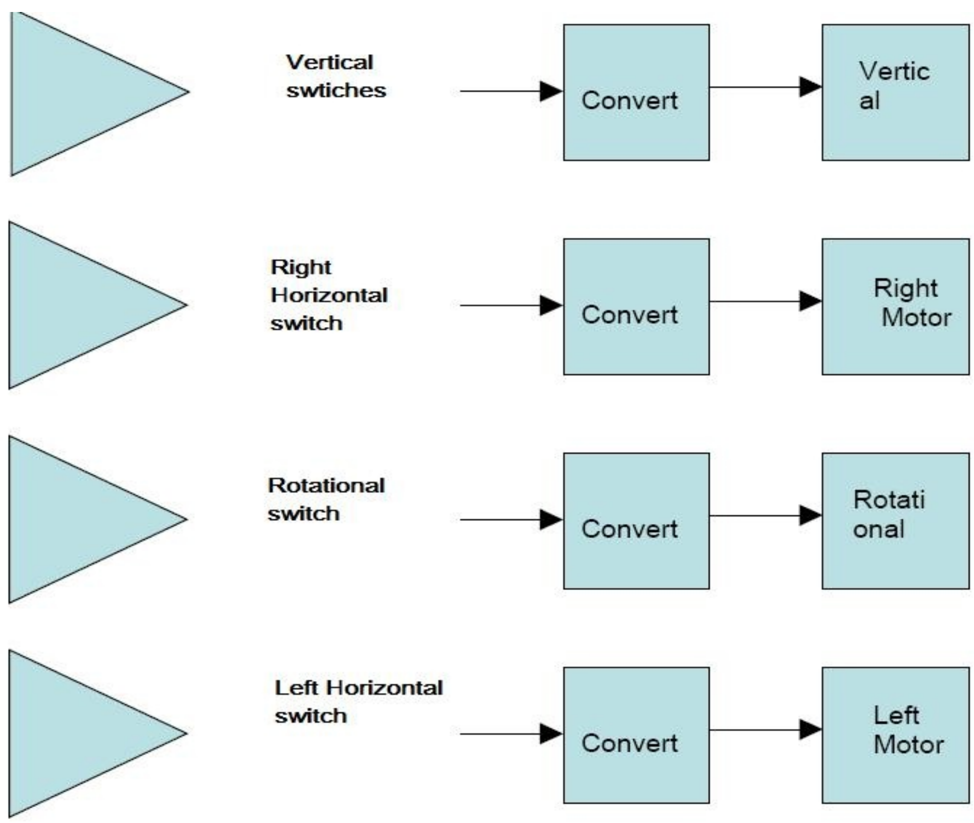
Electrical Schematics:







Software Flow Chart:

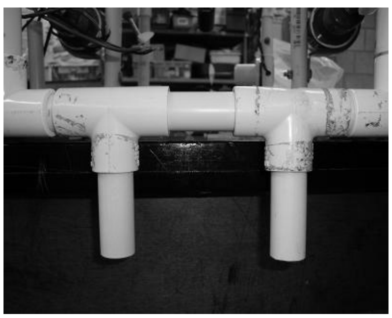


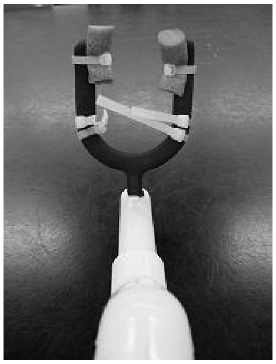
Payload Description:

We have three devices that can accomplish the missions. We have a stationary extended device that is able complete one main task and three sub tasks. The main purpose of this device is to transport the pods. However, this device can also unlock the hatch for the ventilation. After unlocking the hatch, it opens the gate. It also opens the wheel after the wheel is unlocked. Our second device is used to unlock the wheel. It is also stationary, and our vehicle drives on to the wheel and locks the device, and rotates the whole vehicle to unlock the wheel. Our last device is attached to this 2nd device. This third device is used just to hold the hose for the ventilation.

<u>Device Table</u>

<u>Task</u>	**<u>Solution</u>**
Picking up Pods 	ROV has static arm in front, end of rod curved upward, in line with camera. Moves into pods loop and lifts upward via thrusters. *Alexander first came up with this device after observing the towel hook in his bathroom. 

Lifting Hatch 	ROV uses same arm as picking up pods, same process *We thought of forklift for the task of lifting the hatch. Based on the its job of lifting boxes 
Locking/Unlocking Hatch 	ROV uses two- pronged fork like device perpendicular to the ROV. ROV hovers above hatch, drops onto top hatch and rotates hatch. *We decided on this design after thinking of the claw of a crab which is useful with holding the object 
Opening door/Closing 	ROV uses static arm to push door handle from the side *This device is used in real life for opening the door in emergency. We got our use of the ROV device based on this example as well. 

<table>
<tr>
<td>Holding Air Hose
</td>
<td>ROV holds air hose with a static rubberized claw, 90 degrees in the air, from underneath the wide part of the hose

*We got the idea for this device from the fork tuner used for instruments.
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</table>

Future Improvement:

For future improvement, making our robot more and more efficient is the primary goal. We still want to retain our original philosophy of "Keep it Simple Stupid (KISS)". We want to have a more reliable electrical system. This year our fuses had blown during the competition and it proved to be a relatively small error which could have been avoided. Making our robot lighter, therefore making it faster which decreases the load that the ROV's motors have to pull less, making it very important. Using more green and recyclable materials is a must; not only being more environmentally friendly but it also will help to not use as much money. In the future, the control system can be tried to work wirelessly. This will enable all of the motor-power cables to be within the robot rather than in a tether cable. The two joysticks can be attached to a transmitter, while the robot can house a receiver along with the microcontroller. In addition, the joystick buttons could initiate other autonomous robot functions, this can eliminate the clutter of a tangled tether and allow the ROV for more maneuverability and be able to travel even further.

Challenges:

We have faced lots of challenges so far. Two of them are mentioned below:

1. **Control System:** In the middle of February our team decided to develop a new control system. A part of our team worked on that and built the system by using new technology. But, unfortunately when we tried to test the new control system it blew out. At that time it was quiet impossible to repair the control system because it was just a week before the Regional Contest.

   How we overcame the challenge: Immediately our team decided to use the control system from the last year. It was an analog control system which was built without using any programming. We needed to fix some parts of it and replace some of the switches. After fixing the parts of it we tested it with our ROV and it worked very well.

2. **The Fuse:** We faced this challenge during our New England Regional Contest. Before the main competition we thought that our ROV is well prepared and able to do all the tasks. But, during our mission in the pool we faced a new challenge which we have never faced before. We blew up six fuses during our mission and we weren't able to control our ROV smoothly.

   How we overcame the challenge: We thought that we blew up the fuses because of our thrusters. We decided to replace new thrusters. We also changed the positions of the thrusters. Before the Regional Contest we used to use an old battery to test our ROV. We also decided to buy a new one to make sure that the power source of our ROV is safe.

Budget:

Date-Place	Material	Price
3/25/09 –Ace Hardware	Hook Peg (2x)	$5.98
3/25/09-Ace Hardware	Polyutherane Caulksaver (2x)	$12.98
3/25/09-Ace Hardware	Adapter (1x)	$0.49
4/16/09-Dicksons	Heat Shrink Tube (2x)	$4.58
4/16/09-Dicksons	LIQ Electric Tape (1x)	$9.49
3/25/09-Ace Hardware	Screw Holder Tool (5x)	$5.98
3/25/09-Ace Hardware	Poly Tee Insert (1x)	$1.29
4/05/09-Ace Hardware	Adapter (1x)	$2.09
4/07/09-Dicksons	LT Blu Planner (1x)	$3.69
4/07/09- West Marine	Calibrated CONT (1x)	$1.69
4/10/09- West Marine	1100Gph Pump-Bilge(2x)	$79.98
3/23/09- Home Depot	U-Bolt(3x)	$7.99
3/23/09- Home Depot	Caulk Saver(2x)	$7.34
4/23/09-Home Depot	Staples	$2.96
4/23/09-Home Depot	Strainer	$2.32
4/23/09-Home Depot	Stickers	$5.44
4/23/09-Mona Lisa Pizza and Grill	Pizza	$48.83
5/15/09- Swim Outlet.com	Black Kick boards	$50.00
Classroom	Other Materials	$0.00 (recycled)
Total		**$251.53**
Donations		**None**

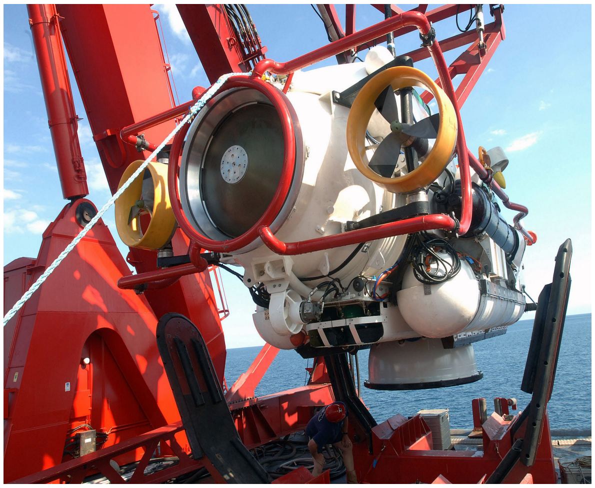
Description of a Submarine Rescue System:

Role of ROVs in this mission theme is very important because it is to save lives of those who are in broken down submarine. ROVs inspect the submarine, and this is a crucial role because the situation of submarine (cause of accident) must be reported before any actions to be taken. Another important role of ROVs is to consider the health and safety of those who are in broken down submarine. ROVs transport the supplies and equipments to the submarine. In addition, ROV also have to supply air into the submarine, which is essential. Finally, ROVs have to mate with the submarine to rescue survivors from the submarine.

Submarine Rescue System

The United Kingdom relies on the LR5 submersible rescue vessel to carry rescue drivers down to wrecked submarines and bring survivors back to safety. The LZR5 is quick and effective in it's job. Once the UK Submarine Rescue Service receives a notification, the LR5 is quickly put to use. It is flexible when it comes to deployment, numerous ships which have enough deck space to host the LR5 can be used at any moment to go to the area of distress. This makes it easy to access a ship and get to the survivors as quickly as possible. In order to deploy the LR5 from it's mother ship, an alternate method can also be used, this is known as the A frame and can be set up within 12 hours. Rescue divers are supplied with life support stores through the LR5. Once at the distress spot, the LR5 creates a watertight seal onto the distress submarines escape hatch. This allows the survivors and personal to move from the submarine to LR5 without the danger of high pressure from the sea. This way technicians and medical officers can also go to the submarine. The LR5 can carry unto 15 survivors at a time and can take eight trips in total, rescuing about 120 survivors before the need to recharge it's battery power supply. The Lr5 carries three submersible crew members- a pilot, co- pilot and a systems operator. The LR5 has a variety of tools at hand including a Slingsby manipulator, an electable claw, rope cutters and disc cutters. It has underwater telephones of 10 and 27kHz, and also an acoustic pinger. The LR5 can operate at a maximum depth of 500m and has a top speed of 2.5kt. The LR5 ability to dock on almost any ship and save up to as many as

120 people make it a very vital asset.



The LR5

The LR5's rescue chamber

Sources:

- http://www.janes.com/defence/naval_forces/news/jut/jut000816_1_n.shtml
- http://www.naval-technology.com/projects/lr5/

Troubleshooting techniques:

In general, we solved our problems by 'trial & error' technique. We first tested out our design, motors, and movement in a water tank that was brought into the classroom. During this process in water tank, we got to find the best position for the motors by testing its movement and fixing the position. Whenever our motor stopped working, it was due to the pin connected with the control box and this was easily fixed by soldering the pin again.

Luckily, this year we got new swimming pool in our high school. This was critical because we got to practice and test out the devices before the competition. The problem we encountered during these practice were efficiency of our devices. After each practice, we figured out what part of the device was causing the problem and we got to fix them afterwards

Lessons Learned:

During the design and construction of our ROV KISS we learned how to use the design process in order to manufacture the best product. We identified the need, by reading about the mission for the year; the goal was to rescue an abandoned sub by carrying pods, delivering water and delivering oxygen to the sub. From there we defined the problems we would face during the actual run. We realized buoyancy, wiring, structure and use of devices would all be problems we would have to solve. Afterwards we researched other bots, studied buoyancy, wiring, structure and many other fields. We then each brainstormed our own ideas for the bots structure and devices which we wrote on the board. We then critiqued each idea and picked the best ideas for the devices and the best ROV design. From there we built our prototype as close to the design as possible. We tested it, realized where it could be improved, and redesigned those areas to eventually produce a final bot.

The main thing that we learned while designing and testing the ROV was the basic engineering process. While we have taken classes in engineering and worked on several other science projects, most of us have never used the full design process completely. The ROV began as just an idea, which became a sketch, which became a prototype which became the model we use. We learned how to use trial and error, experimenting with several different ideas, succeeding in some areas and failing in others. Through this process we have all learned how to engineer the best product possible.

This was a great learning experience for all of our members. Compared to last year where we only had few active members. We learned how valuable the team members are this year. We became more efficient and successful in our job and we had much more fun. The importance of team members were definitely a huge lesson learned by us.

Reflections:

Daniel Kim: This year, I had an unforgettable experience by participating in the MATE 2009 competition. Being a captain and encountering new members for the year was very interesting and impressive. I am just so happy how active our members are this year compared to the last year. I hope we accomplish our goal together and enjoy this experience altogether.

Tanmoy Barua: The ROV team allowed me to express my creativity and hands-on abilities that I can't normally express in school. It was really fun and educational activity to do with my free time. I am glad to be a part of this team and looking forward to be a part of the team next year as well.

Simran Dhillon: The process of building an ROV was a great experience. I learned many invaluable lessons which I think can only be learned through practice and not theory. Understanding how teamwork shapes our performance, the communication between team members is vital. We really knew each other, and it helped a lot during completing specified tasks because we were able to communicate and acknowledge ourselves of the problems. I met new people in the team and made new friends. I was able to harness lots of technical skills which will be very useful in the future but most of all we had lots of fun!

Alexander Chiclana: This ROV experience has taught me to juggle responsibilities. I became interested in ROV because I am interested in Engineering. I thought it is a great opportunity to make use of the skills that I learned by taking Engineering classes.

Hannah Malenfant: Even though I was the only girl in the team, I learned many valuable life skills during my experiences with the Underwater ROV Team. Prior to this experience I was very interested in the specifics of robots and now hope to someday become an engineering expert.

Rishi Patel: This experience has been beneficial to me. My new knowledge of programming has opened up new career paths and opportunities that I look forward to exploring.

Jason Richardson: During the process of learning to build a Remotely Operated Vehicle and create a Technical Report, I realized that this experience will stay with me the rest of my life. I now have skills with tools that I'd never dreamed to acquire, and won't forget them.

Acknowledgements:

CRLS Underwater ROV Team would like to thank-

Paul McGuinness

Ross Benson

Keith Russell

Peter Kerrebrock – Draper Lab

Cambridge Rindge & Latin School

MATE

& all judges, officials, and pool staff for making this year's competition possible.

Photo Journal:

CRLS Underwater ROV Team

Jason is working on ROV

Tanmoy is fixing a thruster

Alex is working on the Technical Report