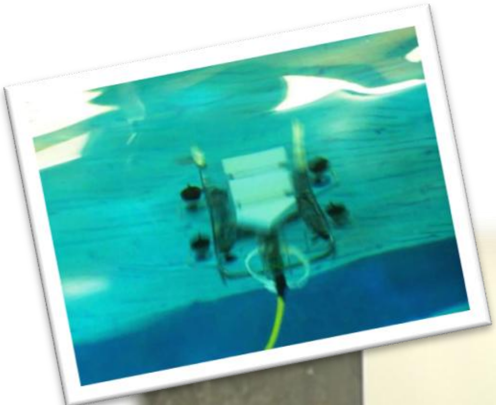
ROV 水神 (Suijin)



Front Row: Leslie Holloway, Jade Moss, Lindsay Holloway, Danielle Howse, Michelle White, Suyen Oldford

Back Row: Jonathan Young, Mark Chaffey, Shawn Collins, Michael Coles, Benji Penney, Gavin Diamond, Mr. Brody Morrison (mentor), Mac Brown (mentor), Andrew Maillet (mentor)

HERITAGE ROBOTICS

2009

Table of Contents

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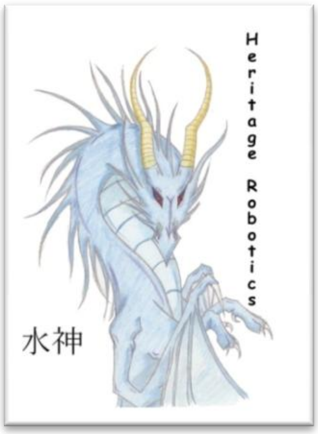
Abstract



Original Suijin artwork created by team member Jade Moss

The 2009 Marine Advanced Technology Education ROV competition focuses on a submarine rescue training exercise. There are four tasks outlined for the Ranger class, each providing its own challenge. Our ROV was designed to carry out these tasks with precision and agility.

The team spent numerous hours planning, building, and field testing our ROV. We had to be prepared to combat technical problems and overcome the challenge of differing opinions. Due to the diversity of the tasks, Suijin had to be very well designed. This required the creation of a rigid frame, useful end effectors, and a versatile propulsion system, a form of buoyancy, effective sensors, and proper wiring were also necessary. There were many ideas to consider and obstacles to overcome, but finally, we completed our masterpiece.

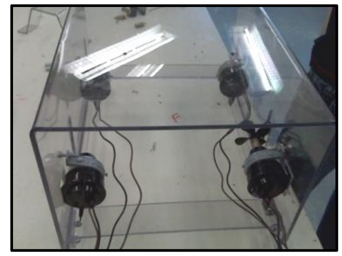
Heritage Robotics is very pleased to present the following technical report which communicates the details of Suijin, a remotely operated vehicle, created by students from Heritage Collegiate, Lethbridge, Newfoundland, Canada. This document includes: detailed descriptions and diagrams of Suijin's components; possible future improvements; trouble shooting techniques; the lessons we learned; the challenges we faced; information on the Submersible LR5; reflections; a thorough budget; and acknowledgments of all those who helped along the way.

ROV Suijin

Vehicle Systems

With past experience in mind, the team focused on two goals throughout the entire process: simplicity and originality. We felt that constructing parts that were simple, yet effective, would reduce the chance of failure.

Our robot contains original concepts and unique designs such as a frame that is made into a box shape. It has two open ends for the purpose of reducing drag and is completely constructed of Lexan. We chose Lexan as it provides a sturdier more rigid build than PVC piping, and is less expensive than molded plastics.

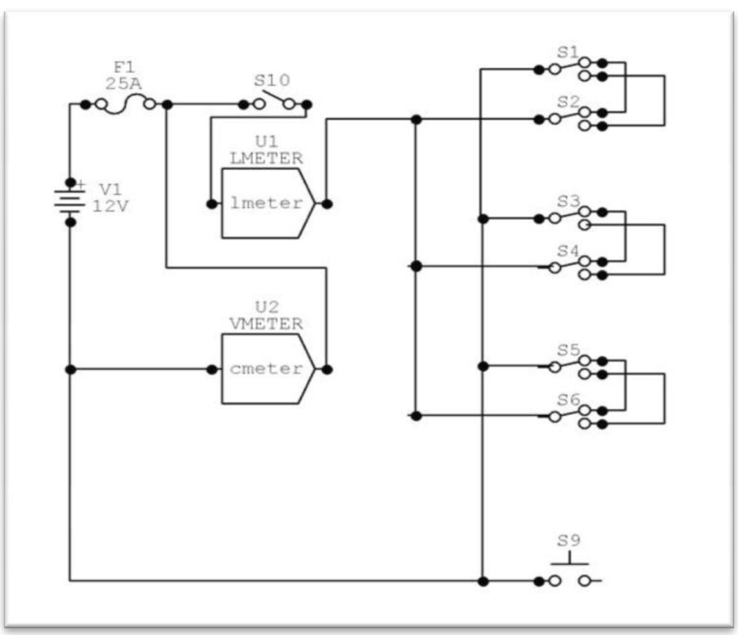


Open-ended box shape frame

The shape of its controller is another creative design that allows Suijin to maneuver with ease. Our controller is structured and molded to our pilot's hands. The control outlay, which contains two-way momentary switches, is positioned so that all controls are at the pilot's fingertips. Unlike past years, we constructed our controller from aluminum as opposed to Lexan, as it provides strength and resistance.

The end effectors on our ROV were constructed from simple and original parts such as pieces of aluminum to provide optimal rigidity. We also utilized a release mechanism that allowed us to separate the air supply from our ROV.

The team incorporated many other unique designs into our ROV. For example our propellers are made from custom machined cylindrical brass stock, we also maximized our ROV's safety by hand-molding Lexan into square guards for these propellers, and the buoyancy was cut from high density Styrofoam which was specially shaped with a point at the front to allow less drag and maximize speed.



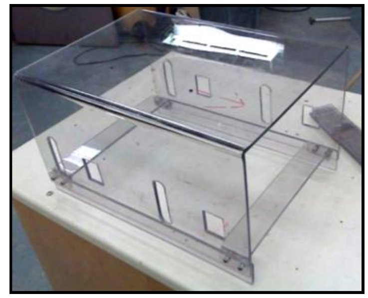
Subsystem Schematic of Controller

Design Rationale

A design was required that would allow Suijin to travel and maneuver easily while performing the assigned tasks. With this in mind, we planned six main components in great detail: frame, propulsion, buoyancy, sensors, electronics, and end effectors. Each of these components had to complement the others to produce a functional design.

Frame

After deciding to construct a completely new robot, as opposed to using the one from previous years, we considered changing the shape of our frame. However, through many hours of discussion the group decided to stay with our custom open-ended box shape. Our structure is approximately 45.7cm x 41.3cm x 24.9cm; we chose these dimensions to provide maximum maneuverability while still providing sufficient space for end effectors.



LEXAN FRAME

This frame appears simple but satisfies all of our requirements. It both reduces drag and provides easy access to the ROV's internal components for maintenance and trouble shooting. During forward motion water passes completely through the hull with virtually uninterrupted flow. In addition, the two vertical sides act as a keel sustaining straight motion while the horizontal top provides stability and maintains level flight.

Lexan was chosen as the building material because it is strong and sturdy, but can be easily bent and molded with the application of heat. We decided to use a thicker Lexan of 0.2cm as this resulted in a more rigid and robust structure. Moreover, the team drilled holes in the top of the frame to allow water to pass through freely. This increased the rate at which the ROV could dive and surface.

Buoyancy

COMPLETED BUOYANCY

When designing the buoyancy system, our goal was to make Suijin neutrally buoyant and stable underwater using the simplest method possible. In past years, we have found high density Styrofoam very effective since it compresses very little as the ROV submerges. With this in mind, we decided to utilize this form of buoyancy. The size of the Styrofoam was determined using the formula of density, gravity, and volume as well as trial and error. After much practice, we were pleased to find that our buoyancy seemed to be stable at any depth.

We customized this material to increase the speed of our ROV by making simple and original changes. The foam was cut into a rectangular shape and then trimmed to a point on one end to keep water resistance at a minimum. It is held to the top of our ROV using two Lexan brackets. Mild positive buoyancy was given in case of mechanical failure. This positivity was positioned towards the front of our ROV so the weight of the pods would not affect buoyancy.

Propulsion

The propulsion was modeled after an ocean liners' podded propulsor. The motors are taken from 5000L/h Johnson bilge pumps. The team had to remove the bilge pump housing, attach propellers to the end of the prop shafts, and then attach these shafts to the motors. Each motor exerts a force of approximately 7N and draws 1.3A of current out of water and 2.8A in water. A bollard test was used to determine this information. To attach these motors to the ROV each motor was first placed inside a short piece of 3-inch PVC pipe. This pipe was then glued to a plastic bracket and the set screws were tightened to ensure the motor would not shift. The motors were then attached to the frame of the ROV using brackets held by bolts.

The group decided to use four vertical motors to provide sufficient lifting force and speed. These were distributed throughout the ROV so there are two motors on each side. This allows the ROV's center of gravity to be at the structural center. Four horizontal motors were also used to allow the ROV to move swiftly and accurately in water with increased maneuverability. These were positioned at each of the ROV's inside corners to provide balance and stability.

PLACING THE MOTORS

MOTOR, PROPELLER, AND PROP SHAFT

Our propellers were chosen based on several important factors including: diameter, pitch, weight, price, and availability. To determine how they would affect the overall mission performance a series of investigations and bollard tests were administered. The diameter of the propeller blade had to exceed that of the motor to produce sufficient thrust. The pitch of the blade, which depends on the diameter and the rotational speed of the motor was also an issue. The propellers were selected to provide considerable thrust without drawing too much current. Suijin's propellers consist of four plastic blades that are 70mm overall in diameter. When the propeller rotates, the circle created has the same diameter. The pitch is 35mm, when no slip is assumed, and this causes the ROV to move forward 35mm for every full rotation of the propeller. The rake (the degree of the blade slant forward or backward in relation to the hub) is 20 degrees and the ROV has a 5mm female brass insert head. The propellers are lightweight and thin, which is optimum for higher speed applications. This enables our ROV to complete its missions quickly and efficiently.

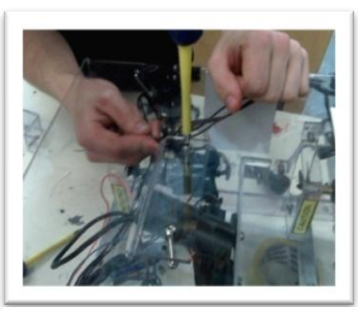
To attach the propellers to the bilge pump motors a shaft was machined from a brass rod. The shaft consists of a 5mm male brass head and attaches securely to the motor using a brass set screw. Brass was used to avoid corrosion of the shaft.

Sensors

Camera in mounted position

There are three sensors present on our ROV: the camera, the voltmeter, and the ammeter. The camera is used for underwater navigation. Suijin's camera is model LCA7700C supplied by Lights, Camera, Action. It has a highly sensitive colour module that requires only 0.0001 Lux. It is equipped with seven built-in infra-red LED's and IR-sensitive color reproduction. The LCA7700C has a horizontal resolution of 380 TV lines, an imager with 1.8cm colour CCD, a picture element of 290,000 pixels and a video output of 1V p-p obm composites. A 12V DC power source with a tolerance of 9-15 volts is required to operate this camera. It uses a 3.6mm 92 degree lens, and has a depth of 33 meters.

We chose this camera because of its amazing quality and user friendly features. It has a wide angle, it is lightweight, and it has a complete waterproof design. It also exhibits a live and vivid picture quality with built-in video enhancing technology, and has been specifically placed near the back of the ROV so that no obstructions impair the vision of the camera. It is angled slightly downward to provide the driver with a maximum viewing of the payload tools and slightly below the ROV.

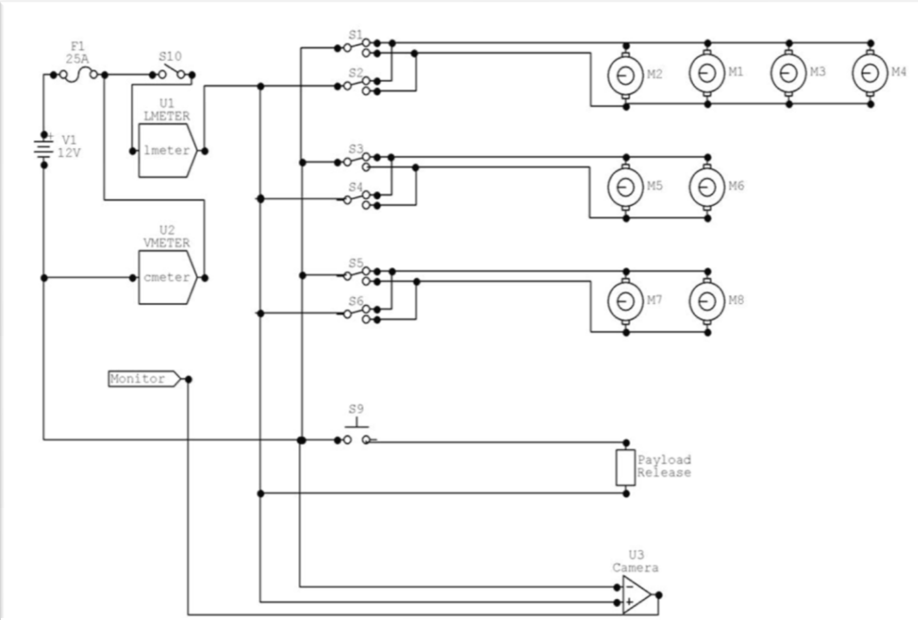


We adjusted the camera angle several times before finding the correct position

After choosing the camera, the next task was to determine where to mount it on the ROV. We knew how important its placing would be, so we strategically placed it to limit obstructions. As a modification from last year's robot, we reduced the angle at which our camera was tilted and moved it farther back. This also provides the driver with optimal viewing area as well as a better view of the payload tools.

The voltmeter, which measures the voltage of our ROV, helps us monitor the status of the battery or troubleshoot any electrical problems. Our third sensor is an ammeter. This allows us to measure the amperage drawn from our power source, and ensures we do not exceed MATE's amperage specifications. This is also placed on the controller for the pilot's use.

Electronics

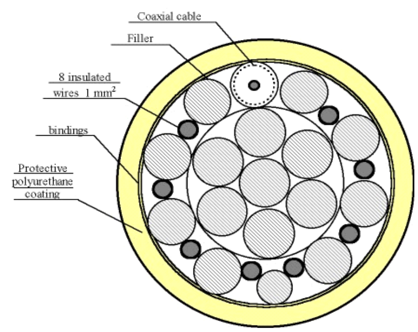


Complete Electronic Schematic

Electronic design is an important aspect of any ROV. Our ROV requires electronics to operate its motors, receive input from sensors, and send control signals. It is critical that our electrical system be efficient and designed to be used safely in water. With this in mind, the team designed and built an efficient electrical system.

Tether

Tether installation



Tether cross-sectional view

Suijin's tether contains nine wires, one of which is a co-axle cable used for the camera, while the other eight are used for the payload tools and powering motors. It measures 11.27m in length and is neutrally buoyant. This buoyancy is achieved through a filler located within the tether which eliminates air and causes the tether to be of the same net density as water. The tether also has a polyurethane coating that protects its managers from electric shock.

Controller

Our controller and incorporated fuse

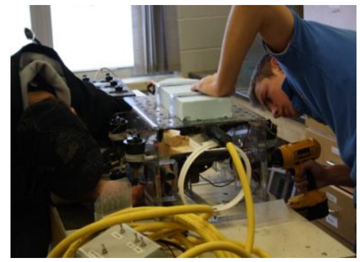
The electronic navigation controller consists of three double-pole, double-throw momentary switches which control Suijin's thrusters. It also includes one single action momentary switch which controls our payload release solenoid. A master switch is incorporated which cuts all power to the ROV in emergency cases. The casing is constructed of 0.25cm aluminum diamond plate. It was designed and tailored to fit the pilot's hands and allows multiple switches to be used with ease. The switch layout was tested and found to allow the precision control necessary for the movement of our ROV. This design was preferable to proportional controls because it is very reliable and low maintenance.

Fuse

A 25A inline fuse is incorporated into our ROV as a primary safety feature. This device causes an electrical circuit to stop working if the electrical current becomes too high, thus preventing fire and damage to our electrical components. The fuse is placed between the control box and the positive battery terminal. If a power surge or short circuit occurs, the thin metal filament will disintegrate, opening the circuit. The fuse can carry a maximum of 25A prior to breaking the circuit.

RESEARCH

BUILDING PROCESS



FINISHING TOUCHES

Features to Accomplish Missions

The most critical part of our ROV is the end effectors. Without these tools Suijin would be unable to perform any task or requirement other than motion. It is important that these tools are effective, yet simple in design and function. A simpler tool with the same ability of a complex tool is less likely to break.

Task #1: Survey and Inspect the Submarine for Damage

The first task requires us to conduct a visual survey and inspect the submarine to identify damage points. The fabrication of end effectors was not necessary to complete this task. However, we had to ensure that our camera was sufficient to display a clear image of all the damage points; therefore, we chose a model LCA7700C camera. We used this camera because of its quality and several other features that are helpful in completing our tasks. These features include a wide angle as well as a lightweight and completely waterproof design. The camera is placed near the back allowing no obstructions of view, and it angles slightly downward to provide the driver with maximum viewing area so that damage points are easily located.

Task #2: Pod Posting

The second task requires us to rotate a hand wheel to simulate the unlocking of a hatch, opening the hatch, transferring pods into the escape tower, closing, and locking the hatch. The end effector we designed to

ELSS COLLECTING DEVICE

accomplish this task was the ELSS collecting device. This device is a rectangular-shaped piece of aluminum with a pointed tip measuring approximately 49.5cm. We chose to create this tool out of aluminum because it is a very lightweight but sturdy material. This tool is located on the lower right side of the ROV, and is in the camera's field of view. It is tilted at a 10 degree angle in relation to the ground and is fitted with a bent bolt, approximately 2.5cm from the tip, to prevent pods from falling off. A string attached to the back of the rod keeps the pods from sliding back too far and also maintains the angle. We use this tool to remove pods from the carousel and deliver them to the escape tower. The ELSS collecting device is simple but very effective. In addition to the rod, this task requires the use of part two of our air delivery system for unlocking and opening the hatch.

Our alternative tool

Before deciding on this tool we considered other methods of completing the task. One method we explored for unlocking the hatch involved attaching a circular four-prong fork to a motor. Once inserted into the hand wheel, the fork would rotate to unlock the hatch. We decided against this because more precision was required, potentially sacrificing more time than needed. Another method we thought of for retrieving the ELSS pods involved the use of a large hook. However, we decided not to use this because of safety precautions. Furthermore, it was not as effective as we originally anticipated during testing.

Task #3: Ventilation

The third task requires us to deliver air to a submarine in distress. To complete this mission we utilized a combination of two payload tools which we call our Air Delivery System (ADS).

The first part of our ADS is used for insertion into the inlet valve connection. This is an aluminum rod approximately 60cm long which leads back through the center of the ROV. The airline is an extension of this and is attached to the front of the tool. Also attached to the rod, located approximately 25cm from the rear, is a release mechanism. This mechanism is based on an automotive trunk release. It uses a small brushed DC motor to turn a screw gear which, in-turn, releases the latch and allows us to completely detach this tool from the ROV. A large ring made of Lexan, at the back of this tool, allows for easy pickup.

ADS (part 1)

ADS (part2)

Part two of our ADS is constructed completely of aluminum and is placed on the lower left side of the ROV. One piece measuring 15cm in length faces downward while an 8cm piece extends at a ninety degree angle to the left. The vertical part is used to turn the hand wheel while the horizontal part could be used to turn the air supply on and off. We feel this multi-tool approach is very unique.

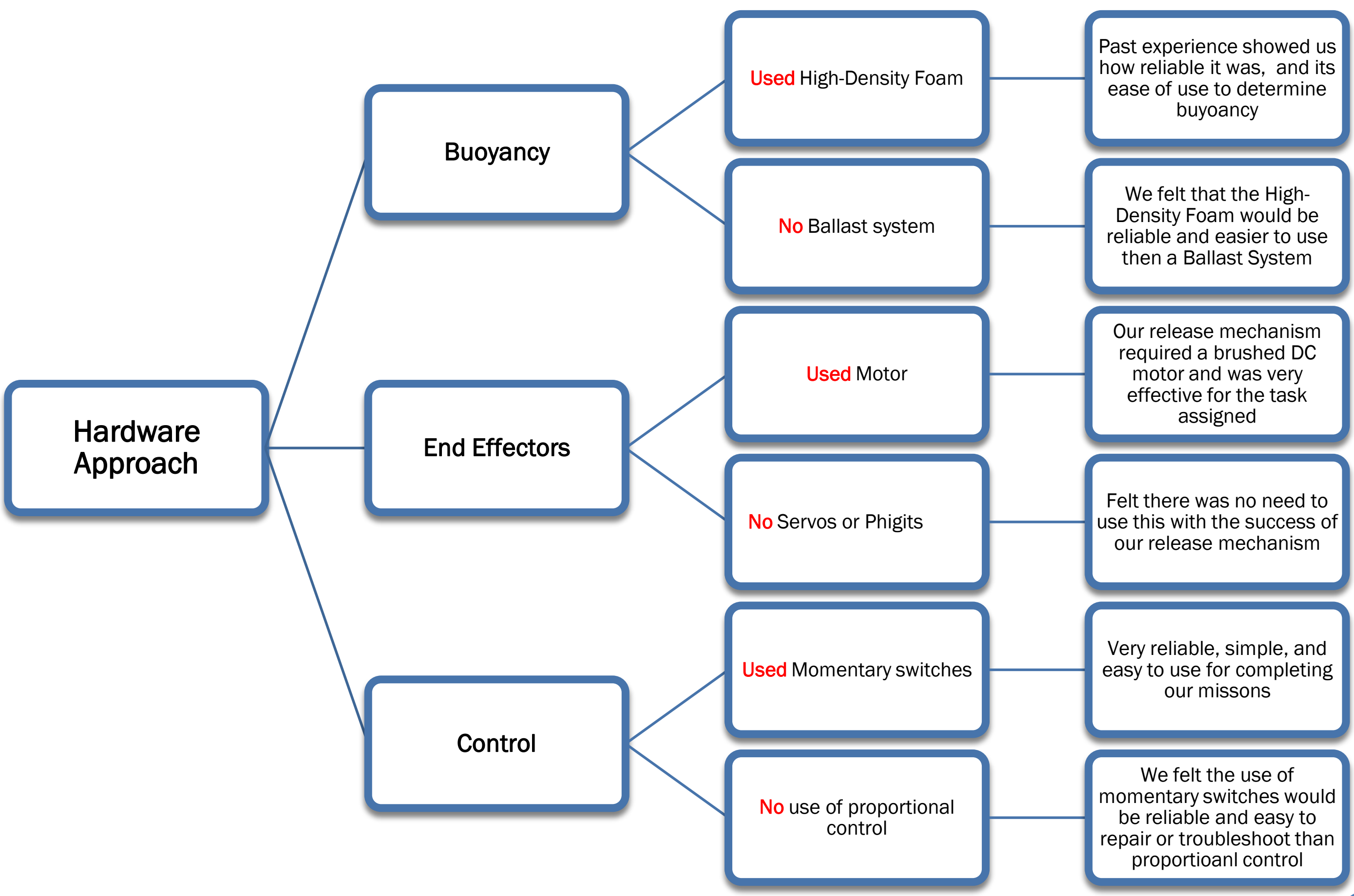
To insert the airline we considered developing a robotic arm. This arm would have been effective in placing the air supply in the inlet valve connection and removing it. Developing this would have been very time consuming and we felt it would increase the chance of error. After much thought, our team decided this method was not to our advantage.

Task #4: Remotely Operated Rescue Vehicle Mating

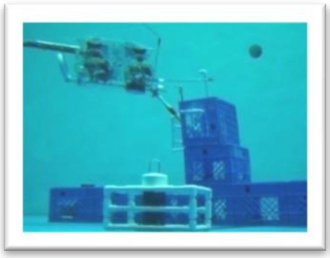

Transfer skirt

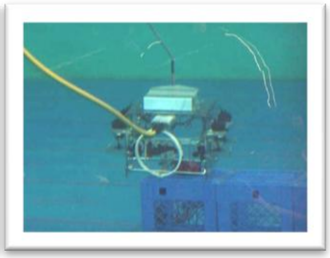
The fourth task requires us to hold the transfer skirt we created over the escape hatch. We constructed this tool from a PVC pipe end cap. This material was chosen because it is very lightweight and strong. It measures 11.5cm in diameter and is 3cm deep. It is attached to the ROV using zip ties placed through holes drilled at the top, which also helps reduce drag. Red tape was used to help with the visual acuity during the mission. The transfer skirt is attached at the bottom and in the center of the ROV. This allows the pilot to position the transfer skirt securely over the hatch.

To mate the transfer skirt to the escape hatch we considered creating our transfer skirt out of clear plastic. This would have allowed us to see the escape hatch more easily. We decided not to use this, however, because we could not find a plastic that was both clear and strong enough to use.



Hardware Approach Flow Chart





SUIJIN AT WORK

Future Improvements

Although our design has been extremely effective in all missions, there is always room for improvement. After this year's experience, the team has considered straightforward changes to enhance the performance of Suijin in the future.

The team believes that increasing the speed of movement is always valuable. With greater speed, Suijin would be able to complete the mission tasks much faster. We feel that our current design can be altered to achieve this. The most prominent aspect that hinders our ability to dive and surface quickly is our buoyancy. Currently our piece of high density Styrofoam, placed at the top of our robot, inhibits water flow. In order to counteract this problem changes could be made to relocate the foam. To accomplish this two foam pieces of equal weight, size, and density would be cut. Using Lexan brackets we would attach these pieces to each side of the outer frame and at the center of mass point. This would ensure that Suijin still maintains stability underwater. This change would leave the top of Suijin completely free of foam, enabling center holes to be drilled, which would lessen water resistance and allow the ROV to surface and dive swiftly.

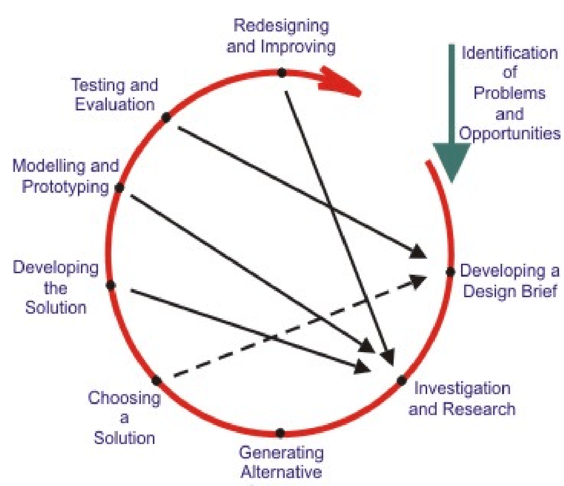
Troubleshooting

The Technique

Every team has to expect and prepare for difficulties along the way. We were no exception. This year, for troubleshooting, we used a trial and error technique. This method exposed flaws in our design and proved to be very effective. To determine appropriate actions to be taken the team decided that simple steps should be followed. First, the problem had to be identified, then the next step included developing and altering a design plan. We then had to research the possible solutions to note other possible improvements. Finally, we designed prototypes and thoroughly tested each to choose the best option.

Problems and Solutions

This year we found that past experience helped minimize the challenges we faced. This did not, however, eliminate all flaws and many hours were spent troubleshooting. The primary problem we faced occurred when Suijin was first placed in water. Our buoyancy point was positioned towards the rear of the robot; this caused the ROV to tilt downwards at the front once our payload tool was released. To solve this problem the team simply



DESIGN AND TROUBLESHOOTING PROCESS

decided to reposition the high density Styrofoam towards the front of Suijin. We found this also gave us better control while POD posting.

Another issue presented while testing Suijin in the water was the change in our field of view; the image in the water was larger than out of the water. This was due to the refraction of light as it hits the water. To correct this we decided to attach the camera using a transferable mount, ensuring our desired viewing position at any time. Once it was moved, using trial and error, we were able to obtain a full view of our ROV's attachments and the submarine. We also decided to tilt the camera at a downward angle. This took several attempts and we created numerous holes in our chassis, but in doing so we also created multiple prefixed locations to mount the camera in the future.

Once we thought we had all our problems solved we found that our release mechanism was beginning to seize due to water exposure. This caused our Air Delivery System (ADS) to be unable to detach from Suijin, and this prevented us from completing our assigned task. After careful inspection prior to undertaking of missions we concluded that the quickest and most reliable way to fix this was to simply replace this mechanism. To ensure this was possible, we added the functionality of ADS to our pre-launch checklist and incorporated an ADS quick removal and install protocol.

Lessons Learned

Throughout the process of building our ROV, we have learned many lessons and acquired countless skills in both the technical and interpersonal fields. The most prominent of these has been our improved ability to use power tools, work as a team, and speak publically.

New members working on ROV

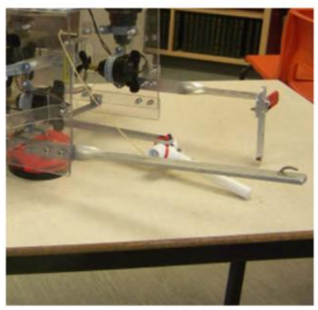
When it was time for the construction phase of our project the new members of our team were able to gain knowledge on how to correctly and safely operate power tools. Each member was able to effectively use a heat bender, drills, saws, and sanders. What we have learned in this process will not only benefit us in building ROV's, it will benefit us for the rest of our lives.

Through experience, and much thoughtful consideration, we ascertained that using standardized parts and materials allows for more efficient repair. In past years all hardware was unique, requiring more time and ingenuity to exchange parts during competition. All of Suijin's nuts and bolts are of the same diameter and all Lexan used is of the same thickness, this allows us to use the same size nut for any bolt that we utilize on our ROV. We have learned the effectiveness of consistency with relation to building materials and it has proven to be a valuable asset when changes are required.

We have also learned that effective teamwork is essential to complete a project of this magnitude. Although we have worked independently on certain projects, our ROV would not have made it this far if our ideas were not incorporated. By considering each member's ideas and suggestions we were able to evaluate many options and make an informed decision. In the end this has allowed us to see the value in working as a team, and our teamwork cannot be understated. When we had to depend on and trust each other during our presentation we found that all members were there to help and build confidence in one another. Although public speaking took much time and practice to master, it will continue to help us in various situations throughout the competition and in our future careers.

Team working to launch Suijin

Pod Retriever Before modifications



Pod Retriever After modifications

Challenges

Throughout this experience our team has faced various challenges. During practice, and in the regional competition, we had difficulty inserting the air supply to the inlet valve connection. When completing this task we encountered such problems as our payload tools getting 'stuck' in the handle at the top of the milk crate/submarine. This occurred because our payload tools extended above the top of the robot's structure, and were longer than our ADS (air delivery system) payload tool. To correct this problem the team decided that shortening our tools and lowering them on the frame would be of great benefit. This allowed our ROV to fit perfectly inside the milk crate and with our shortened tools the air supply could be placed into the ventilation hose with ease. With these simple modifications, Suijin was able to complete this task proficiently.

Another challenge that our team faced during practice occurred when picking up ELSS pods using our pod retriever. We were able to successfully remove the pods from the carousel assembly, but they would not stay on properly. To fix this problem, the team decided to place our pod retriever on a 10 degree angle, with respect to the ground, causing the pods to slide back and stay on. This, however, created another problem as the pods were difficult to get off. We easily corrected this by placing a piece of string across half the length of the rod, which extends from the rod to the top of the frame and stops the pods from sliding back too far. Both of these modifications kept the pods securely on when needed and allowed them to be removed without difficulty.

Submarine Rescue System

The United Kingdom's submarine rescue program, controlled by the Royal Navy, has been one of the world's most comprehensive for years. This rescue service remains on permanent standby and is ready to mobilize to any site worldwide within twelve hours.

The key asset of this rescue system is a submersible vehicle, the LR5. The LR5 hosts a pilot, copilot, systems operator, and three crew members. It is equipped with several tools including a Slingby manipulator, an ejectable claw, rope cutters, and a 305mm disc cutter. Two six-kilowatt electric motors give the LR5 a maximum speed of 2.5KT and it is capable of operating at a depth of 500M. The LR5 submersible is also fitted with an integrated navigation and tracking outfit. This system provides the mother ship with real-time images of the distressed submarine.

Before any action is taken, the Navy determines the position of the distressed submarine and identifies nearby ships. The LR5 is then airlifted for speedy installation on the mother ship. Once deployed, the rescue submersible makes a water tight seal onto the submarine's escape hatch. Technicians, medical officers, and emergency life supplies can be transferred to the distressed submarine, and up to 15 survivors can be evacuated at a time. The LR5's 120V batteries allow it to make up to eight trips to the distressed submarine before needing to recharge the power supply. Once the LR5 has surfaced, portable decompression chambers installed on the mother ship are used to treat the survivors.


SUBMERSIBLE LR5


LR5 IN THE WATER


LR5 ABOARD MOTHER SHIP


INSIDE THE LR5

Making Parallels Between the LR5 and Suijin

Much like our own remotely operated vehicle, the submersible LR5 is equipped with tools capable of locating and aiding a distressed submarine. Both vehicles feature DC motors as the source of main propulsion. Underwater video cameras are found on the frame's exterior of Suijin and the LR5. However, our ROV uses one camera with a highly sensitive color module, while the LR5 uses two black and white cameras, and one color camera. The LR5 is fitted with a mating skirt which makes a watertight seal over the submarine's escape hatch, allowing the transfer of personnel and supplies. A similar mating skirt is incorporated into our ROV for the same purpose. Unlike Suijin, the LR5 is powered by on-board batteries. The major difference between the two vehicles is the fact that the LR5 is controlled from the inside, while Suijin requires a tether to allow operation of the ROV.

All references can be found on page 18.

Reflections

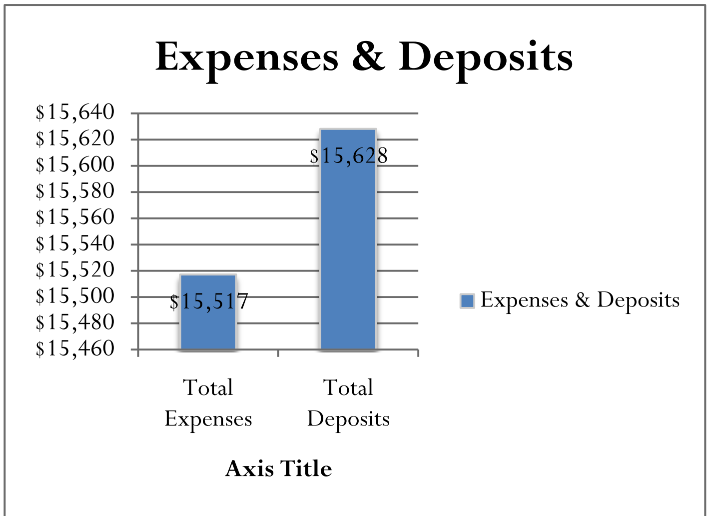
Looking back, the competition has taught us a great deal about teamwork, innovative problem solving, and commitment. We have had many obstacles to overcome, none of which have been easy. Firstly, our former mentor accepted a teaching position at another school. Furthermore, more than half of our team members had no experience with ROV's. Despite this, we met all challenges with both vigor and dedication. All members experienced or not, felt that we had to live up to our name.

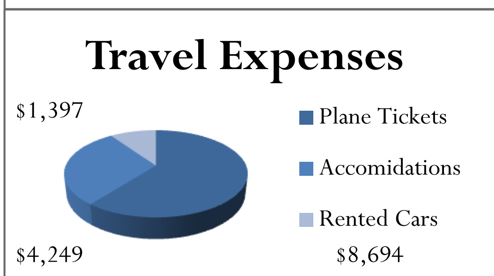
As a group, we feel that this experience has been both invaluable and rewarding. We learnt a great deal about the importance of effective communication and working together to accomplish our goals. As the competition drew nearer it became clear that, as a team, we devised solutions more easily than when we came together in the fall. This showed us just how much we have grown over this time period. We entered the competition as individuals with differing opinions, but leave as one group with a collective identity.

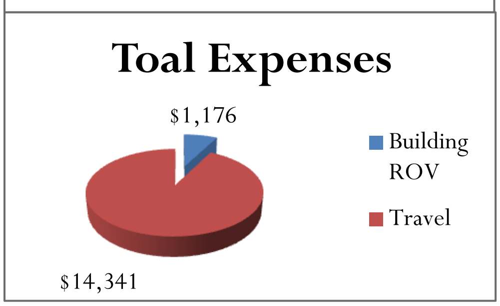
From redesigning, to building, to testing, to retesting, Suijin was completed to what we call 'perfection'. The culmination of our hard work and dedication peaked when we won first place at our regional competition. This recognition gave evidence to support just how valuable the group's time and effort had been. It has also helped some team members decide to apply, and accept positions, to post-secondary institutions which offer programs focusing on ROVs. In fact, three of our team members have already been accepted to Marine Institute, an institution in our own province, to begin this program in the fall.

This experience has not been easy; we have certainly faced many challenges. Nonetheless, it has been amazing and much more rewarding than we could have ever thought possible.

SMALL EXAMPLE OF TOTAL WORK







Budget

After strategic deliberation and planning over finances, our project stayed on budget and in the positive. As this was our fourth year competing, many of the needed power tools had already been purchased. However, this year we decided to build a new ROV, which used a large portion of our budget.

To cover the expenses, the team depended on student resources, donations and fund-raising. Each student helped with the variety of fund-raisers including: a bake sale, flea market, and selling tickets on homemade quilts donated by family members. Various organizations also donated money and resources. This included a large test tank which was built for and donated to the school.

Since our school is located in the rural community of Lethbridge, there were additional expenses associated with competing. Total expenses including travel were $14,341.15, which currently leaves us with a net balance of $110.85.

Budget/Expense Sheet

School Name: Heritage Collegiate (Lethbridge, Newfoundland & Labrador, Canada) From: 1/9/2008

Instructor/Sponsor: Mr. Brody Morrison To: 05/25/2009

Funds Date	Deposit or Expense	In Canadian Dollars Description	Amount	Balance
9/01/2008		BALANCE CARRIED OVER FROM LAST YEAR	498.67	
9/11/2008	Deposit	Refund from last year	$ 997.70	$ 1,496.37
9/11/2008	Deposit	Refund from last year	$ 600.00	$ 2,096.37
11/14/2008	Expense	Materials for practice props	$ 19.64	$ 2,076.73
1/5/2009	Expense	Water pump for pratice tank	$ 151.64	$ 1,925.09
2/10/2009	Expense	Materials for practice props	$ 73.16	$ 1,851.93
2/24/2009	Expense	Materials for robot	$ 18.94	$ 1,832.99
3/18/2009	Expense	Payment for bilge pumps	$ 412.07	$ 1,420.92
3/26/2009	Expense	Lexan for new chassis	$ 163.85	$ 1,257.07
3/31/2009	Expense	Canadian Custom charges for bilge pumpes	$ 51.00	$ 1,206.07
4/21/2009	Expense	Materials to fix props	$ 10.58	$ 1,195.49
4/29/2009	Expense	Materials for robot	$ 28.25	$ 1,167.24
5/12/2009	Expense	Materials	$ 247.00	$ 920.24
5/15/2009	Deposit	Donations for internationals	$ 3,581.76	$ 4,502.00
5/20/2009	Deposit	Donations for internationals	$ 50.00	$ 4,552.00
5/21/2009	Deposit	Donations for internationals	$ 350.00	$ 4,902.00
5/25/2009	Deposit	Donations for internationals	$ 750.00	$ 5,652.00
5/15/2009	Expense	Plane Tickets for Internationals	$ 8,694.58	$ (3,042.58)
5/15/2009	Expense	Hotels	$ 4,249.08	$ (7,291.66)
5/15/2009	Expense	Rented cars	$ 1,397.49	$ (8,689.15)
5/18/2009	Deposit	Down Payment on Plane Tickets	$ 2,800.00	$ (5,889.15)
5/22/2009	Deposit	Regional Competition 1st Prize	$ 4,000.00	$ (1,889.15)
5/24/2009	Deposit	Quilt Ticket Sales	$ 2,000.00	$ 110.85
Total Deposits	**$ 15,628.13**	**Building ROV**	**$ 1,176.13**	**Net Budget**
		Travel Expenses	**$ 14,341.15**	**$ 110.85**
		Total Expenses	**$ 15,517.28**	

Acknowledgements

Heritage Robotics would like to thank the MATE Center, OceanWorks International, and the Deep Submergence Systems Office for organizing this competition, as well as the Marine Institute and Massachusetts Maritime Academy for hosting. We appreciate the time and effort that has been put into this event and are pleased to have the opportunity to participate. Special thanks to our teacher sponsor, Mr. Morrison, and mentors, Andrew Maillet and Mac Brown. They have given up countless hours after school and on weekends to make this project a success. Without their encouragement, we would not have made it this far. A huge thank you goes to our parents and guardians for their constant support and willingness to provide money and transportation. Furthermore, thanks to Mrs. Strong, Mrs. Chatman, and Mrs. Harnum for overseeing all finances. As well, we would like to gratefully acknowledge all local business, corporate, and personal donations. It is through their continued support that this competition has been made possible. Special thanks to J-1 Contracting for providing us with a practice tank. This contribution has greatly benefited our team over the years and will continue to do so in the future.

Corporation, Organization, and Local Business Support

(In no particular order)

- ADI
- All Care Home Healthcare
- Bayview Lounge
- Bluebird Investment
- Clarenville Drydock
- Core Engineering Ltd.
- Crosbie Job Insurance
- Deep Submergence Systems Office
- DFB Group
- DOF Subsea
- Exon Mobil
- Fortis Concrete Inc.
- Geo Century
- Government of Newfoundland & Labrador
- H&R Excavation Ltd.
- HRCM Consulting Ltd.
- Husky Energy
- J-1 Contracting
- JM Services Ltd.
- Marine Institute
- Marport Deep Sea Technology
- Massachusetts Maritime Academy
- MATE
- Matheson & Co.
- Mycom Canada Ltd.
- Newdock
- North Atlantic Cougar Engineering
- Ocean Choice International
- OceanWorks International
- Park Investments Ltd.
- Red Rooster Eatery
- Scotiabank
- Sexton's Lumber Co.
- Young's Industrial, Recreation and Marine Refrigeration

Personal Support

(In no particular order)

- Mr. Andrew Maillet
- Mr. Brody Morrison
- Mr. Ivan Greening
- Mr. Kevin King
- Mr. Mac Brown
- Parents/Guardians
- Mrs. Bernice Little
- Mrs. Donna Coles
- Ms. Jackie Butt
- Mrs. Janice Harnum
- Mrs. Ruby Chatman
- Mrs. Suzette Strong

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