Technical Report
Palm Beach Lakes Community High School ROV Team
West Palm Beach, FL

2009 MATE International ROV Competition
ROV Submaris Eripio
Explorer Class

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ABSTRACT

This technical report describes the ROV, ***Submaris Eripio***, built by the Palm Beach Lakes Community High School ROV Team to compete in the 2009 MATE International ROV Competition. The cost of building the ROV was $525. The cost of travel to the competition was $1,500. The frame of the ROV was constructed from Schedule 40 Poly-vinyl-chloride (PVC). The thrusters were made from 500 gallon per hour bilge pump motors mounted with 3 inch by 2 inch carbon fiber propellers. Grappling hooks were created to open the hatches. A simple grasping claw was created to hold the airline. A motor was modified to turn the hatch. The ROV was controlled using simple switches and automotive relays which were sealed in acrylic. The tether consisted of a Category 5e wire and two speaker wires. New technical skills such DC circuitry and fluid dynamics were learned and put to application. Teamwork and teambuilding skills were honed as well as problem solving skills under extreme conditions. The ROV was built to accomplish tasks associated with a simulated submarine rescue.

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1. Budget and Financial Statement

Item	Cost (in US Dollars)
ROV Frame Components	
PVC Pipe (3/4 inch schedule 40)	12.00
PVC Fittings (3/4 inch)	25.00
PVC Cement	12.00
ROV Electronic Components Cylinder	
PVC	5.00
PVC end caps	7.00
Plumbers Putty	9.00
DPDT Automotive Relays 3 x $9.00	27.00
SPST Automotive Relays 3 x $7.00	21.00
Acrylic for waterproofing	20.00
Cameras	
CCD Cameras 3each 15.00	45.00
Fiberglass Resin	12.00
PVC connectors	3.50
Plexiglas sheet	6.00
Wires for each camera	25.00

Thrusters	
Atwood 500 gph bilge pumps 6 x $15.00	96.00
Connector nuts	3.00
carbon fiber 3 blade propellers 6 x $6.00	36.00
Control Box	
Project Box	4.00
DPDT momentary automotive switches 3 x 3.00	9.00
DPDT automotive switch	3.00
Tether	
12 gauge wire	60.00
Category 5e	25.00
Miscellaneous	
Caulk	5.00
Wire ties	10.00
Hose clamps	20.00
JB Weld	8.00
6 minute epoxy	8.00
Rope	14.00
Electrical connectors	20.00
Tape	12.00
Battery connectors	6.00
Total	

2. DESIGN RATIONALE

2.1 Frame

PVC was used due to its low cost, water-proof nature, availability and it requires no special tools to work with. The ROV was shaped like a triangular prism; this shape was selected due to its high stability and low overall hydrodynamic resistance (a low cross-section). Buoyancy was provided by sealing the PVC pipes which made up the frame. The frame was constructed as to support necessary tools for the tasks ahead. The posterior of the frame was outfitted with a large cylindrical PVC pipe, to serve as an electronics canister which would concentrate the ROV 's mass upon a small surface area (adding some degree of negative buoyancy to counter act high levels of positive buoyancy given by the hollow PVC, thus progressing towards neutral buoyancy), further stabilizing the structure. Two PVC 'arms' protrude from the starboard and port sides of the ROV as to support motors, angled so that they may increase turning capability. Two other PVC limbs extend from the bow and aft to support motors for upward and downward thrust.

2.2 Propulsion

Atwood 500 gph bilge pumps were used for thrust, located on all four sides of the ROV's anterior (fastened to each side using hose brackets). Each of the bilge pumps were fitted with carbon fiber three blade propellers. One thruster was fixed upon each of the ROV's anterior sides. Two thrusters were attached on the aft and bow of the structure, to be used for upward and downward thrust. The other thrusters were placed on the starboard and port sides for turning force.

2.3 Camera

Three basic CCD cameras were bought, as they were cost effective. Upon reception they were waterproofed. The cameras were glued to individual sheets of Plexiglas, leaving an **air** pocket as not to obscure the lens. A small PVC cylinder was then glued unto each piece of Plexiglas as to surround each camera. Fiber glass resin was then poured into the structure, with the assurance that no cavities (which might allow water infiltration) were present. Once waterproofing was complete, the cameras were fastened to the ROV using hose clamps. A camera was fastened to the posterior bow as to have full view of the skirt (to be used in task #4). The other cameras were placed upon the anterior; one facing sideways full vantage of the tools on the side as well as for surveying the Submarine (to be used for tasks # 1 and 3); and another facing forward to keep track of the ROV's movements as well as for surveying the submarine (task #1).

2.4 Tether

A category 5e wire was used to carry the signal from the control box to the ROV. Since relays were being used on the ROV only a minimal amount of current would be required. The wires were bound to one another as to make a single tether which is to be covered in poly-propylene rope as to make the entire tether positively buoyant (to avoid it impeding the ROV's movement or rapping around the submarine).

3. CONTROL SYSTEM

A project box was selected and outfitted with automotive switches. These were selected as they were durable, cost effective and required no special equipment or programming. Two switches were used to control the forward reverse thrust motors. A switch was situated on the right hand side of the control box that was used to control the right hand thrusters. Switches on the left hand side did like wise. Pushing both switches forward created forward motion, pushing both backwards created reverse motion. Pushing the right switch forward and the left backward creates a left hand turn and visa versa. A single switch was used to control ascent and descend, the switch was oriented in a vertical position, with up being up and down being down.

4. ELECTRONICS

Simple switches, solenoids and relays were used throughout the vehicle. These were selected because of their hardiness and reliability. All electronics were water-proofed by encasing them within pourable polymer compounds that hardened upon reaction. To further ensure that they were further protected they all were placed within an electronics canister which was then filled with Plumber's putty (this added ballast to the canister as well).

5. TOOLS

Task 1: A camera was mounted viewing to the side in order to survey and inspect the submarine for damage.

Task 2: A large servo was mounted and modified with a coupling unit to turn the hatch. A hook was mounted to the bottom of the ROV to open the hatch and remove the ELSS pods. The servo that was used to turn the hatch in order to open it will also be used to close said hatch.

Task 3: To insert and remove the airline a grasper claw was constructed using PVC pipe that was sliced in half. These pieces were put together around a central fulcrum; rubber bands were used to keep the claw in a closed position. A solenoid was used to force open the claw. The solenoid was operated via a switch on the control box. To open the hatch, an arm was constructed out of PVC in the shape of an 'L'. This arm was mounted on the side of the ROV allowing the forward motion of the ROV to open the hatch. A servo similar to the one used in task 2 is used to turn the valve.

Task 4: PVC coupling with an internal diameter of 11.5 cm was mounted to the bottom of the ROV to act as a transfer skirt. A camera was mounted on the bottom of the ROV, to monitor the coupling as it is being mated to the submarine. The downward motion of the ROV will hold the ROV and the submarine together.

6. CHALLENGES

Funds were most definitely a limiting factor throughout the whole experience. The team sponsor was the only source of monetary support. This severely limited the material available for use. Time was another challenge, having to meet only twice a week after school. Most, if not all of the teammates had little or no prior knowledge of circuitry. Many of the team members were not available for several weeks due to senior activities (¾ of team are seniors). The size of team was also another limiting factor.

7. TROUBLESHOOTING TECHNIQUES

Since simple electronics were used, troubleshooting was handled using multimeters. Due to the simple design very few problems were encountered after the initial construction.

8. FUTURE IMPROVEMENTS

In the future we would like to try to use propellers that are better suited for the type of motors we used. It would be wonderful to improve upon the appearance of the overall structure, learning how to use CAD to create a proper wiring schematic. Recruitment improvements would be particularly helpful to the number of team members available to work on the ROV.

9. LESSONS LEARNED/SKILLS GAINED

This experience has vastly improved each team member’s problem solving skills, communication skills, electrical skills and team work capabilities.

10. REFLECTIONS ON THE EXPERIENCE

This experience has been a series of ups and downs for everyone involved. There were moments when we all felt completely engaged and dedicated to ROV and there were moments when coming to ROV was like going to the dentist, overall though it was an incredible experience. We learned a great deal on new concepts such as DC circuitry and working in underwater environments. We also had an opportunity to develop and hone our problem solving skills and learned to work together as a team in the face of adversity. Many of us are headed off to college in the fall, where perhaps we will start our own ROV clubs; others are looking forward to next year and forming a new team with new faces.

11. DESCRIPTION OF A SUBMARINE RESCUE DEVICE

Scorpio ROV - Scorpio 45

The United Kingdom operates ROV **Scorpio 45**, which is based at the UK's Submarine Rescue Service headquarters in Renfrew (near Glasgow, Scotland). It carries three remote cameras, two manipulator arms (including cutting equipment) and two sonar devices, as well as six 250-W lights. It is capable of operating at a depth of 925m (in sea water), with the depth being determined by the length of its umbilical cable. Scorpio 45 may also travel at a forward speed of up to 4 knots. The ROV is owned by the UK Ministry of Defense and is operated by James Fisher Rumic Ltd, who provides the rescue service to the Ministry. The vehicle is deployed along with a control room which is within a standard shipping container. The vehicle's primary role is to assist in locating a distressed submarine, survey the damage, clear obstructions from the escape hatches and then transfer life support stores in special containers via the submarine's escape hatch. Scorpio 45 was extensively modified to support manned submarine emergency and rescue facilities. James Fisher Rumic Ltd took over ownership of the ROV after reaching agreement with the Ministry of Defense's Disposal Services Agency in November 2006 to acquire the operating assets of the UK Submarine Rescue Service.

References:

Photo credit: newsimg.bbc.co.uk/media/images/40663000/jpg/_...

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[2] http://www.janes.com/articles/Janes-Underwater-Security-Systems-and-Technology/Scorpio-45-United-Kingdom.html

[3] http://www.experiencefestival.com/a/Scorpio_ROV_-_Scorpio_45/id/2134135

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