South Broward High School

REEF

DOGS

ROV TEAM

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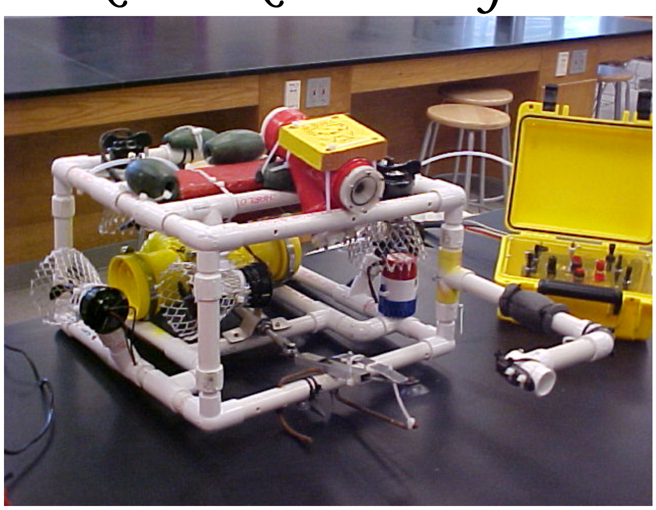
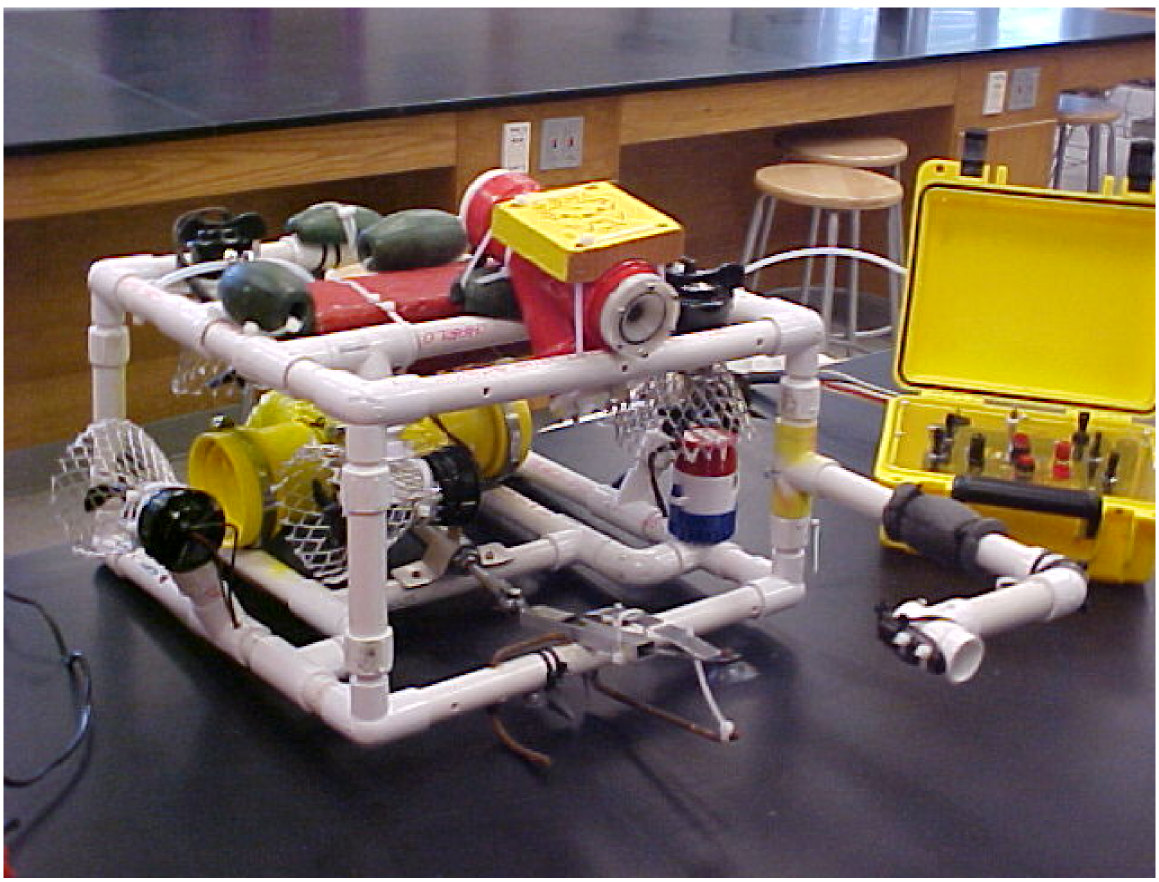
ROV: "REEF DOG"



Abstract

South Broward High School's ROV team constructed a remotely operated vehicle (ROV) named *Reefdog* to compete in the 2005 Marine Advanced Technology Education (M.A.T.E.) National ROV Competition in Houston, Texas. *Reefdog's* mission is to complete three "tasks", each of which has a specific theme that relates to how ROVs are used in the real world. The three mission tasks are: 1) Cap an oil well in the Gulf of Mexico, 2) Repair a damaged fiber optic cable connection to reestablish a communications link, and 3) Install a new instrument module on the Hubble space telescope. To accomplish these tasks, *Reefdog* is equipped with two arms. One is a pneumatic claw, designed to grasp the valve of the oil well and the fiber optic communication probe. The other arm is outfitted with a cotter-pin release system (CPRS). The control system is a custom-built control box that uses relays to drive six thrusters. This paper also includes a budget/expense sheet, an electrical schematic, design challenges encountered, troubleshooting techniques, lessons learned, and future improvements.

Completed ROV



Budget/Expense Sheet

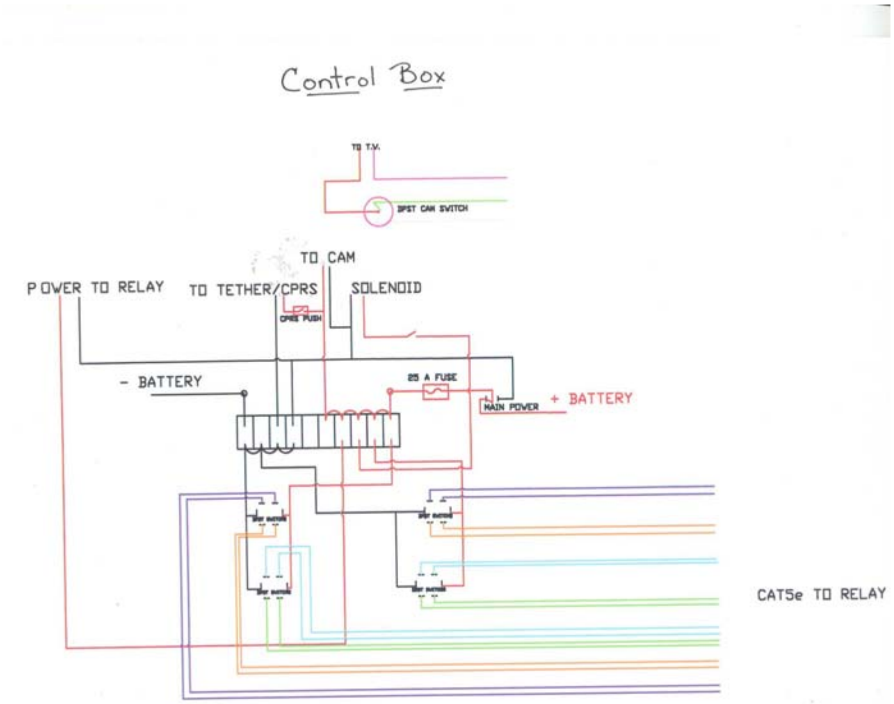
Date	Quantity	Items		Cost	Balance
	2	PS100XS B&W cameras		Recycled	
	1	Camera Housing		Recycled	
	1	Trash Picker-Upper		Recycled	
	1	12 Volt 2.5 Amp Bilge Pump		Recycled	
	2	Prop Shaft Adapters		Recycled	
	1	Ballast Foam		Recycled	
	1	Solenoid Valve		Recycled	
	5	O-Rings		Recycled	
	1	Sea-Con Connectors		Recycled	
	3	Hose Connectors		Recycled	
					$700.00
2/3/2005	2	Fittings		$0.88	
	2	Fittings		$0.48	
	1	1/2" THFPBRBV		$5.97	
	1	PVC Pipe		$1.59	
	1	1/2 PVC 40		$1.29	
	1	160 1-1/2X10		$2.29	
	1	CLS200 1X10		$1.34	
		Sales Tax		*$0.83*	
			Grand	$14.67	$685.33
2/17/2005		MATE Supply Check		$100.00	$785.33
2/17/2005	3	PVC Pipes		$4.77	
	4	Safety Glasses		$15.88	
	1	Zip Ties		$9.97	
	1	Aqua Epoxy		$3.79	
	10	Fittings		$14.50	
	10	Fittings		$4.70	
	7	Fittings		$1.68	
	6	Fittings		$1.08	
			Grand	$56.37	$728.96
2/27/2005	2	Bilge Pumps		$27.98	
	6	Replacement Cartri.		$113.94	

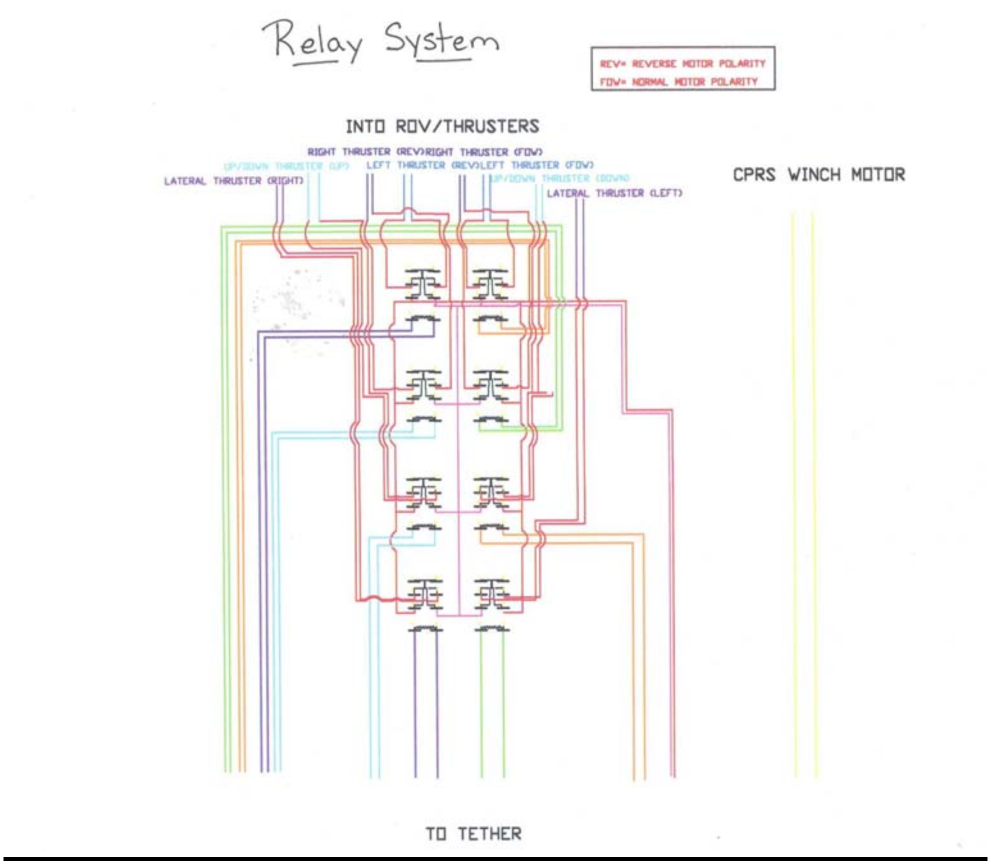
		Sales Tax		*$8.52*	
			Grand	$150.44	$578.52
3/3/2005	3	1/2 X10 PVC40 PE Pipes		$3.87	
	1	Cable Tie Assist.		$7.92	
	2	Multi-Tool Racks		$3.94	
	1	1/8 in. 32-Pc. Hook Assts		$2.27	
	4	3/4 45 Elbow S X S		$1.84	
	7	Male Adapter MIPTXS		$3.29	
	2	3/4" PVC Cross		$2.38	
	12	1" Snap On Saddle		$14.04	
	1	Condes. Trap-Running		$0.97	
	4	Curve PegHook		$7.08	
	3	Multiple Tool Holder		$5.91	
			Grand	$54.47	$524.05
4/4/2005	1	Aro Sylverair 1-1/16 Cyl		$25.65	
	1	Hose Connector		$1.92	
		Sales Tax		$2.14	
			Grand	$29.71	$494.34
4/12/2005	1	Solderless		$1.99	
	1	Solderless		$1.99	
	6	Boat Prop 60 mm		$28.20	
		Sales Tax		*$0.24*	
			Grand	$32.18	$462.16
4/25/2005	1	Drill Bit		$3.29	
	1	12 VDC Relay		$6.97	
	1	12 VDC Relay		$8.39	
	1	12 VAC Relay		$8.39	
	1	12 VDC Relay		$8.39	
	1	12 VAC Relay		$8.39	
	1	12 VDC Relay		$8.39	
	1	12 VDC Relay		$8.39	
	1	12 VDC Relay		$8.39	
	2	Fitting		$1.76	
	38	Wire		$6.08	
	38	Wire		$6.08	
	80	Wire		$16.80	
		Sales Tax		*$5.99*	
			Grand	$105.70	$356.46

5/8/2005	1	2OZ Plastic Can of Rosin	$5.99	
	1	Prem. Elec. Tape	$3.19	
	1	0.5OZ Solder	$1.59	
	1	10-12GA Butt Connector	$1.69	
	1	10-12GA Butt Connector	$1.69	
		Sales Tax	*$0.85*	
		Grand	$15.00	$341.46
5/11/2005	1	16OZ can foam insulation	$5.33	
	1	J B Weld	$3.92	
	1	Silicon Spry	$2.47	
	4	3IN Strainer	$7.96	
		Sales Tax	*$1.18*	
		Grand	$20.86	$320.60

Total Expenses **$479.40**

Electrical Schematic





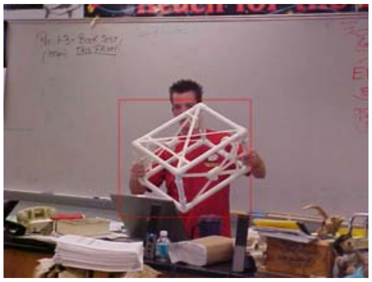
Design Rationale

Primary Constraints

- The Mate 2005 Competition Rules
- Budget of $800.00
- Size constraint of 80cm x 60cm x 60cm
- Must be able to perform mission tasks
- Power Limit of 13 volts/ 25 amps operated on DC voltage with a fuse
- Capable of traveling at least 35 feet to perform mission tasks
- Camera(s) and video monitors must run off the max. power supply

1. Frame

The shape of the vehicle was decided using a weighing scale that determined the team's overall thoughts on how the ROV should be built. We let everyone have their say on the shape of the ROV, then the team engineers came up with a way to incorporate all of the parameters that were predetermined by the entire group. The engineers then brought several designs back to the group to have a final discussion. The three designs were: long rectangle, short rectangle, or perfect cube. The major tasks were discussed and a democratic vote was taken on the ROV shape.



Basic frame

The materials we used were based on both our budget and the efficiency of the ROV. The materials had to be affordable and not hinder the operation of the ROV, once built. That is how we mutually agreed that the ROV should be constructed of PVC.

(This is the weight scale of task #2.)

Criteria	Weight (Range 0-10)
Appearance	3
Speed	8
Stability	10
Manufacture	8
Accuracy	9

2. Tether

Our tether was based on the idea of “less is better”; the smaller the tether, the less weight and therefore, the less drag on the ROV. We were able to restrict the diameter of the tether and still incorporate 25 conductors. Included in the tether are two CAT5e cables that run the relays, one 5-conductor camera signal wire, and two 14-gauge wires for main power to all motors. Also included are two 12-gauge wires that supply power to the CPRS, and finally an air hose to operate the pneumatic arm. The tether is 11.29 meters long, providing us with a range capable of reaching all the mission tasks.

3. Control System

The ROV control box holds all the switches that control the ROV and the connections for power. The system consists of six switches, four of which are double pole double throw (DPDT). The four DPDT switches control the thrusters; one switch controls the right thruster in both directions, and another switch controls the left thruster in both directions. A third switch controls both up/down thrusters in forward and reverse, and the final switch controls our "side-to-side" thrusters in forward and reverse. Also included is a momentary push button used to activate the CPRS. The pneumatic cylinder is powered by compressed air running through a solenoid that is controlled by a single pole single throw switch. A last single pole double throw switch was added to toggle from one camera view to the other. The relay system used on board the ROV allowed for a tether that was only 25% of the size and weight of a previously designed tether. The system uses a series of eight relays to reverse polarity on each motor. The power needed to run a single motor is 2.5 amps, and in order to pull the 2.5+ amps through the tether, we would have needed 10-12 gauge wires. This would have made the tether about 7.5 cm in diameter, which was unacceptable to this engineering team. Instead, we used an eight-conductor CAT5e cable, replacing the 10-12-gauge wire. The total number of conductors in our tether is 25 plus an air hose. This gave the tether a diameter of only 2 cm, instead of 7.5 cm. In order to house the relays, and protect their connection to the tether, we contained the whole relay system in a 7.5 cm PVC pipe with watertight end caps. The housing was then made further watertight by sealing the connection between it with 5200, a marine adhesive sealant.

4. Video Camera

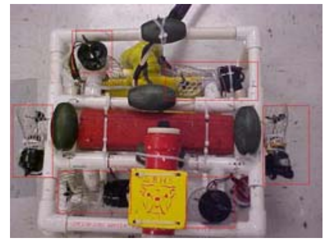
Two PC100xs black and white cameras were used as our visual sensors. The cameras were water proofed by encasing them in a camera housing made of PVC. Each camera end was sealed with clear Plexiglas and an o-ring, to allow for a watertight seal.

The two cameras are set 45 degrees apart, with the top camera giving us a full view forward and the bottom camera giving us a full view of the payload.

Custom made camera housing

5. Thrusters

The motors used on the ROV were six Mayfair Marine bilge pump replacement motors that push 750 gallons of water per hour. One motor was placed on both the right and left side of the ROV to propel the vessel forward and backward. Two motors were used for up and down movement and the last two motors were placed inside the frame to move the ROV left and right. We used 3 bladed, 60mm, right rotated propellers. After thrust testing several types of propellers, we determined that these propellers, with 10 Newtons of force, were the best to use.



Thruster location

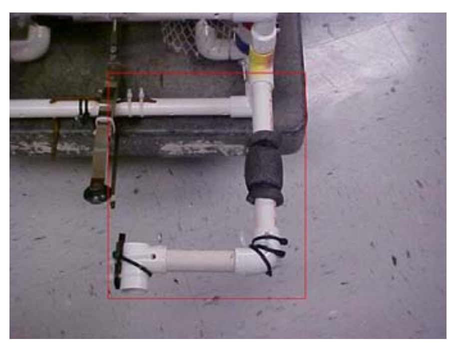
6. Special Systems

Two special systems were created to accomplish the mission tasks. A pneumatic grabber was designed to close the handle on the oil well mission and to pick up the probe on the telecommunications mission. A commercial trash-collecting claw was modified with a pneumatic cylinder to open and close the grabber. For the space telescope mission, a bilge pump was modified to pull a string, which releases a cotter pin holding the space module in place on the ROV's extension arm.

Pneumatic arm

Challenges

A very good example of a challenge that the team overcame was that our air hose for the pneumatic arm was somehow cut too short and, to patch it, we installed extra tubing from a Bunsen burner and two hose clamps. This allowed us to add extra air hose to the original piece, which increased the length of the tubing. Another challenge occurred when we realized that we had prepared for the wrong event at the regional competition and didn't have the proper arm to complete the correct task. With 20 minutes to start time, we inventoried our supplies, brainstormed, and quickly made an arm for the mission. Though we had to improvise with some of the equipment, the arm worked very well and we will keep the design for the national competition.



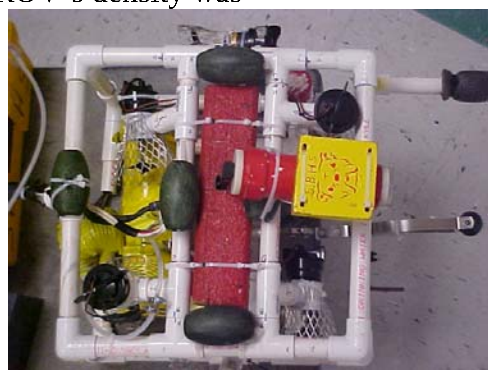
CPRS extension arm

Troubleshooting Techniques

Most of our problems arose from the electrical aspects of the ROV. The rather complex and unique relay system presented multiple problems, such as short-circuiting and reversal of polarity to the motors. To overcome these problems, we traced the wires from where they exited the battery to where they returned to the battery. We checked the continuity of the wires using a multi-meter in order to match the correct wire at both ends of tether and at varying points in the circuit. This multi-meter was used several times to troubleshoot the relays after they were fitted into the housing unit. The tight fit caused many wires to dislodge from their posts and even short out a few times.

Control Box

Not all of the problems were electrical, some problems that we faced dealt with the floatation. We tested the ROV's buoyancy both physically and mathematically. The mathematical testing was done with Archimedes principle. First the ROV's density was calculated (mass divided by volume) and then divided by the density of fresh water. This gave us the specific gravity or the amount of water that would have to be displaced by the floatation in order for the object to be neutrally buoyant. Then the physical testing was done in the school's pool. We placed the ROV in the water and added or subtracted weight to achieve a neutrally buoyant ROV. Small fishing weight, bolts, and nuts were among the objects used to increase mass in a specific areas. In a few cases we had to add flotation to level the ROV because we added too much weight. Between both the mathematical testing and the physical testing, we arrived at the same amount of displacement.



Floatation

Lessons Learned

From the problems that we confronted, there were many lessons learned. Due to our loss of time, we learned the importance of organization. It was during our last days before the regional competition that the team recognized that being organized and keeping structure to our plans was very necessary to build an ROV efficiently. The misplacement of tools and materials hindered the building process of the ROV. The team lost a lot of material, such as $200 worth of rigid foam and our extra length of air hose. By losing these materials, we were forced to find creative ways around these impediments to build the most dependable ROV possible.

The most important skill that we acquired was the skill of determining the buoyancy mathematically using Archimedes' Principle. Our physics teacher, Mr. Said, taught us this equation in one lesson. With this knowledge we saved time on physical testing of the ROV in the pool and were able to find the amount of floatation that would be needed for the ROV to be neutrally buoyant.

Future Improvements

Our future improvements for this ROV are to have the camera centrally located on the frame to provide as much viewable area of the pneumatic arm and of the CPRS extension as possible. We also decided to use a larger gauge main power supply to the relays because the current gauge was not able to transmit enough amperage to run more than three thrusters efficiently. Another improvement would be to use a more efficient type of control mechanism. The automotive switches we used are known to break or stop functioning properly. This will greatly decrease our run time and make the ROV easier to run. We hope to attain newer rigid PVC foam to provide buoyancy; this will give the ROV a more professional look and improve hydrodynamic properties. To add to this aspect of professional looks, we are going to use aluminum siding to build the frame of a future ROV. The aluminum will increase the strength of the ROV and provide a much cleaner look. As a final additive to the functionality and aesthetic properties, the team will use fewer zip ties and more marine grade epoxy to hold the ROV and its components together.

Discussion of Technology

In today's modern, technologically advanced world, communication is everything. From the ability to conduct business around the world to the convenience of talking to a friend, we could not function without the major advances in communications made in the past 20 years. Fiber optics has been the single new technology that has revitalized the technological revolution of the twenty-first century. They have taken over the telephone industry, and made it into a global communications network. But how exactly do fiber optic cables work?

If you can imagine a pipe that is lined inside with a continuous perfect mirror, you will have a good grasp on the concept of fiber optics. If light is shone into the pipe, it will reflect off the sides of the pipe and will be seen at the other end. Since the inside of the pipe is lined with a perfect mirror, the light is able to be seen on the other side, even if the pipe twists and turns! If you shine a light in an on-off code from one end, then someone on the other side could decipher your message, and communicate with you. That is the concept of fiber optics- communication with the potential to cover limitless distance. Of course, this technology has one major obstacle to overcome- the oceans of the world. *(http://www.oceancareers.com)*

The human race thrives on land, but the oceans have remained a barrier between the continents for hundreds of years. Even today, shipping and passenger liners simply use the ocean as a highway from one landmass to the next. Telecommunications cables have been laid on the ocean floor for years now, but often at high risk and expense. Ships had to carefully send the cables overboard to drift to the ocean bottom in the past. This method was risky to the ship, which could be pulled under if the currents dragged the cable down too quickly. Today we have a new method of laying cables on the ocean floor. A method that is safer and involves less human risk is the use of ROVs.

Remotely operated vehicles (ROVs) can be designed to perform almost any task-including laying telecommunications cables on the ocean floor. A few companies design and construct ROVs that specialize in laying telecommunications cables on the ocean floor. One of these companies is Perry Slingsby Systems. Perry Slingsby Systems has made ROVs for the past 50 years, and has unparalleled experience in constructing ROVs, Trenchers, Tether Management Systems, Submarine Rescue Systems, and Submarine Cable Plows. As you can see, some of these machines apply directly to telecommunications. "Trenchers" dig trenches on the ocean floor to bury cables in so they are not damaged or severed by trailing anchors or other obstructions. Submarine Cable Plows are ROVs specially designed to place the cable into the trench once it has been dug. No longer do ships have to throw cables overboard and wait for them to drift to the bottom; submarine cable plows now safely and effectively complete this task with minimal human involvement. *(http://www.perryslingsbysystems.com)*

Perry Slingsby TRITON

Obviously, companies such as Perry Slingsby Systems have mastered laying fiber optic telecommunications cable on the ocean floor. The challenge now is to provide higher speed connections with the capability to transport more information in a shorter amount of time. To accomplish this, newer and more advanced communications systems will have to be installed across the world's oceans. This will require the diligent and never ending efforts of ROVs. Though almost all ROVs are designed for different applications, they all contribute in connecting people around the world to each other. Without ROVs, people would still be risking their lives to lay down communication cables.

Perry Slingsby-T750

Acknowledgements

The Reef Dogs would like to thank the following people for helping us progress to the national competition. Most importantly, we would like to thank our instructor, Monica Ridlehoover for her guidance in this project. Secondly, we would like to thank Dr. Rick Driscoll at Florida Atlantic University and Mr. Bill Baxley for their professional expertise and advice in the design and development of the ROV. We would also like to thank physics teacher, Mr. Said, for teaching us how to determine the buoyancy of our ROV and Mrs. Wilson for helping us convert this technical report into a PDF file. Last but not least, thanks to parents, Mrs. Nancy Scoble and Mr. James Decarreau, for their constant support and advice throughout this project.

Works Cited

1. Http://www.perryslingsbysystems.com
2. http://www.oceancareers.com