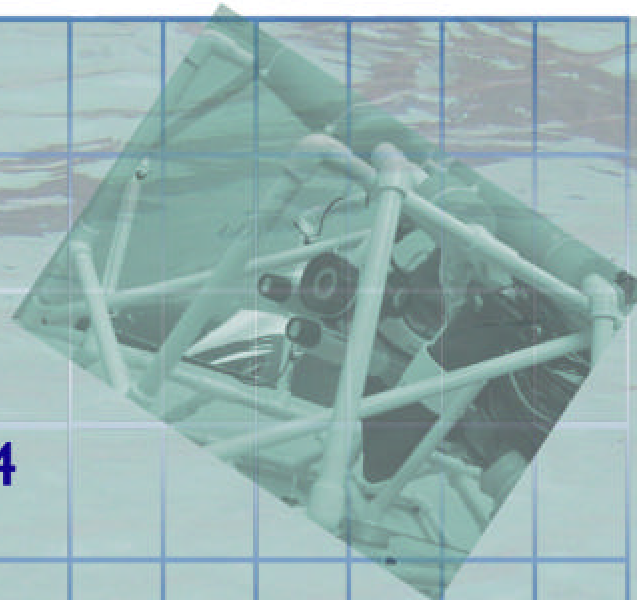
REMOTELY OPERATED VEHICLE

ROV Competition



DATE: June 25-27, 2004

LOCATION:
University of California
Santa Barbara

FREEBIE II

CCSP

TEAM MEMBERS:

Boris Bazan
Anna Hegedus
Monica Miranda
Karol Medina
Michael Rodriguez

MENTORS:

Loretta Adoghe
Haniel Pulido Jr.

Miami Dade College

CCS Program

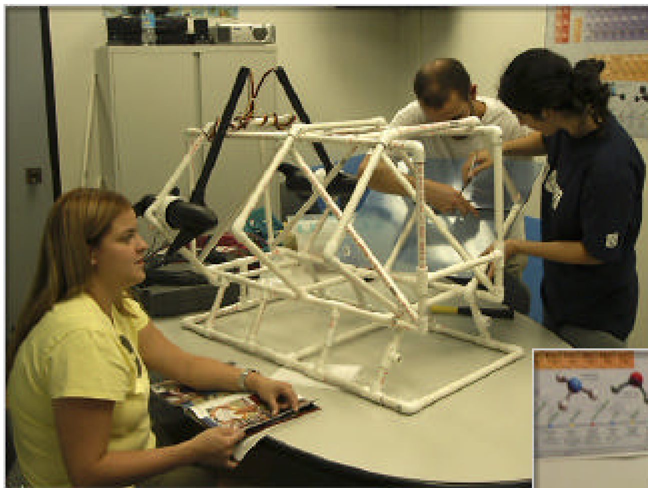
Abstract

The Remotely Operated Vehicle, Freebie II, was constructed with the purpose of competing in the 3rd Annual ROV Design and Building Competition for High School and College Students. The competition aims to explore a mystery reef and perform scientific measurements and recover items scattered throughout the reef.

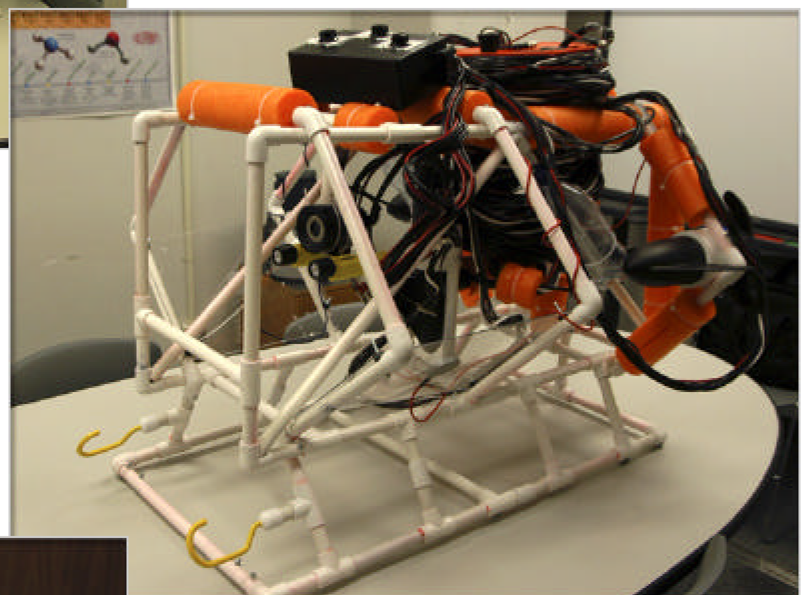
The methodology employed involved splitting each of the major components/systems of the vehicle into stages, each of which would be assigned to sub-groups composed of no more than two team members. The systems are: audio/visual systems (camera & power requirements, console video display, hydrophones, console audio analyzer/speaker, testing and signoff), power and electrical (electrical schematics, power source, console wiring, ROV wiring, fuses, tether, testing and signoff), propulsion systems (thrusters & power requirements, physical control systems, testing and signoff), housing/case (ballast, testing and signoff), additional systems/sensors (depth & temperature sensors and digital readout, liquid extraction system, object recovery system, measurements system, testing and sign off), and control console. Integrated systems testing was performed once all individual systems were tested and the ROV was assembled.

This report also covers photographs, electrical schematic, challenges faced, troubleshooting techniques, lessons learned, future improvements, as well as a description of how ROV's are currently being used to explore and understand our national marine sanctuaries. Acknowledgements are included at the end of the report.

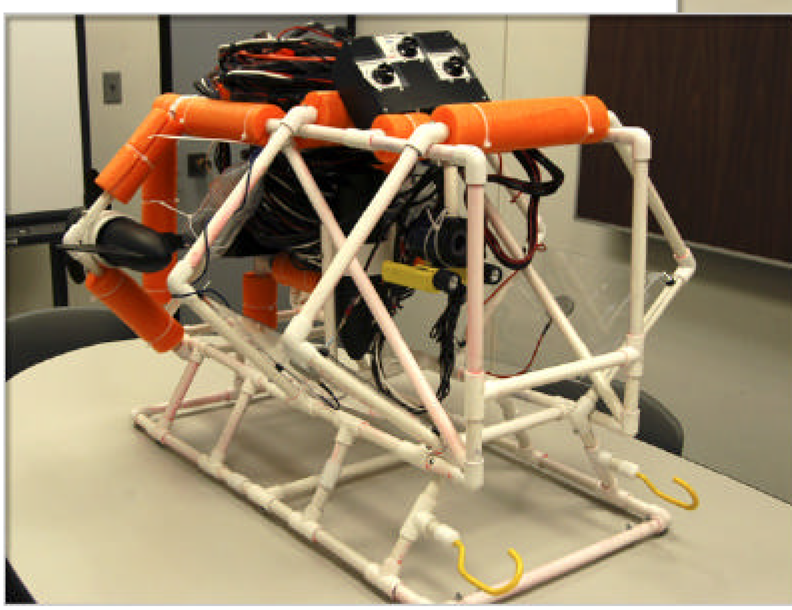
Photographs



Picture 1. Students building Freebie II ROV frame

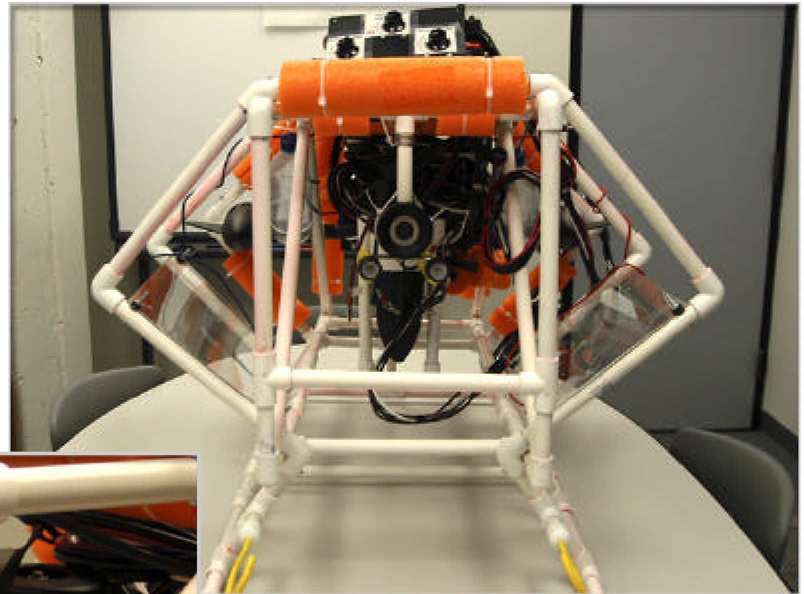


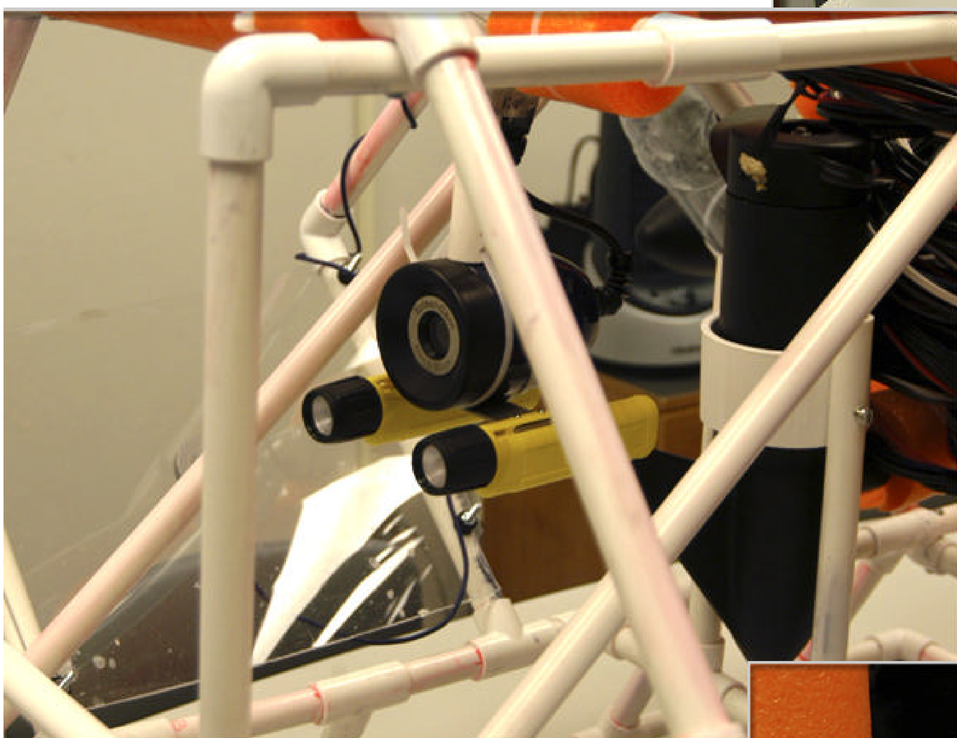
Picture 2. Freebie II ROV (port side)



Picture 3. Freebie II ROV (starboard side)

Picture 4. Freebie II ROV (bow)

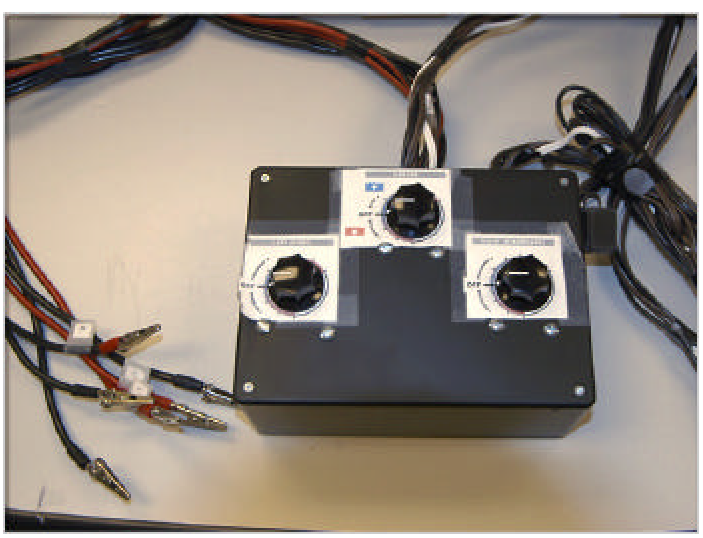




Picture 5. Freebie II ROV Deep Blue underwater Camera closeup

Picture 6. Freebie II ROV thruster (Minn Kota Endura 40 Trolling Motor)

Picture 7. Freebie II ROV control box



Budget

The following expense sheets include the prices and balance for all expenses, including travel, involving the project. The approximate price of the ROV, including materials, tools, and supplies and accessories was $5075.

2003 MATE/MTS ROV Committee Student Competition

Budget/Expense Sheet

School Name: Miami Dade College

Instructor/Sponsor: Loretta Adoghe / Haniel Pulido Jr.

Period: From: 2/6/04 To: 4/29/04

Funds

Date	Deposit or Expense	Description	Notes	Amount	Balance
2/6/04	Expense	½ PVC pipe	Home Depot purchase	1.28	-1.28
2/20/04	Expense	Deep blue camera	Underwater camera	1169.00	-1170.28
2/20/04	Expense	QVS USB-AV USB video	USB adapter	84.78	-1255.06
2/26/04	Expense	DolphinEar	Hydrophone	429.00	-1684.06
3/6/04	Expense	GP 1/8" SPLG-2Jack 6' w 1/8" ST Plugs	Adapters from Radio Shack	11.75	-1695.81
3/26/04	Expense	Wet/dry vac + PVC pipe fittings	Home Depot purchase	87.92	-1783.73
3/31/04	Deposit	Funds for supplies for ROV	MATE Check # 15352	100.00	-1683.73
4/16/04	Deposit	Miami Dade College sponsorship	Office of the President	5000.00	3316.27
4/16/04	Deposit	Monteray Power Corp. sponsorship	Check # 104921	3000.00	6316.27
4/16/04	Expense	x2 Minn Kota trolling motors	Walmart purchase	309.92	6006.35
4/23/04	Expense	12V DC motor, x2 knobs	Radio Shack purchase	10.46	5995.89
4/23/04	Expense	PVC pipe + fittings	Home Depot purchase	16.10	5979.79
4/29/04	Expense	PVC pipe, fittings, drill bits	Home Depot purchase	18.19	5961.60
					5961.60

Expense Sheet – Page 1

2003 MATE/MTS ROV Committee Student Competition

Budget/Expense Sheet

School Name: Miami Dade College

Instructor/Sponsor: Loretta Adoghe / Haniel Pulido Jr.

Period: From: 5/4/04 To: 5/22/04

Funds Date	Deposit or Expense	Description	Notes	Amount	Balance
5/4/04	Expense	Temperature sensor, depth level sensor + digital readouts	Davis Inotek purchase	1541.00	4420.60
5/7/04	Expense	Dolphin Ear	Hydrophone	429.00	3991.60
5/7/04	Deposit	Travel funds	MATE Check #12-275354	1500.00	5491.60
5/8/04	Expense	Piezo buzzer, batt. holder	Radio Shack purchase	11.54	5480.06
5/12/04	Expense	Cables, PVC pipe fittings, 100' tubing, plexiglass	Home Depot purchase	105.73	5374.33
5/14/04	Expense	x8 12V 7.5 AH batteries	Batteries	183.92	5190.41
5/21/04	Expense	Knob, electrical tape, project box, batt. holder, etc.	Radio Shack purchase	29.87	5160.54
5/21/04	Expense	Minn Kota trolling motor, mirrors	Walmart purchase	209.62	4950.92
5/21/04	Expense	Screws, 14" back saw, 9V pack	Home Depot purchase	44.88	4906.04
5/22/04	Expense	Wire, wire connectors	Radio Shack purchase	61.23	4844.81
					4844.81

Expense Sheet – Page 2

2003 MATE/MTS ROV Committee Student Competition

Budget/Expense Sheet

School Name: Miami Dade College

Instructor/Sponsor: Loretta Adoghe / Haniel Pulido Jr.

Period: From: 5/22/04 To: 6/9/04

Funds Date	Deposit or Expense	Description	Notes	Amount	Balance
5/22/04	Expense	Fittings + drum sanders	Home Depot purchase	11.95	4832.86
5/22/04	Expense	x3 project boxes	Radio Shack purchase	22.44	4810.42
5/28/04	Expense	Wire + fuses	Radio Shack purchase	73.72	4736.70
5/29/04	Expense	Wire	Radio Shack purchase	16.04	4720.66
5/31/04	Expense	x2 toilet wax	Home Depot purchase	3.41	4717.25
6/2/04	Expense	x2 toilet wax	Home Depot purchase	3.41	4713.84
6/5/04	Expense	PVC pipe cleaner	Home Depot purchase	5.32	4708.52
6/6/04	Expense	Wet/dry vacuum, PVC fittings + other items	Lowe's purchase	183.35	4525.17
6/6/04	Expense	AA flight from Ft. Lauderdale to LAX	Viewtrip.com Reservation # PS9708	1894.90	2630.27
6/8/04	Expense	Car rental for 4 days	Budget. Reservation # 48701806US6. Pick + return at LAX	497.94	2132.33
6/9/04	Expense	UCSB housing		805.00	1327.33
6/9/04	Expense	Male/female team T-shirts	Design Wear purchase	233.20	1094.13
					1094.13

Expense Sheet – Page 3

Electrical Schematic

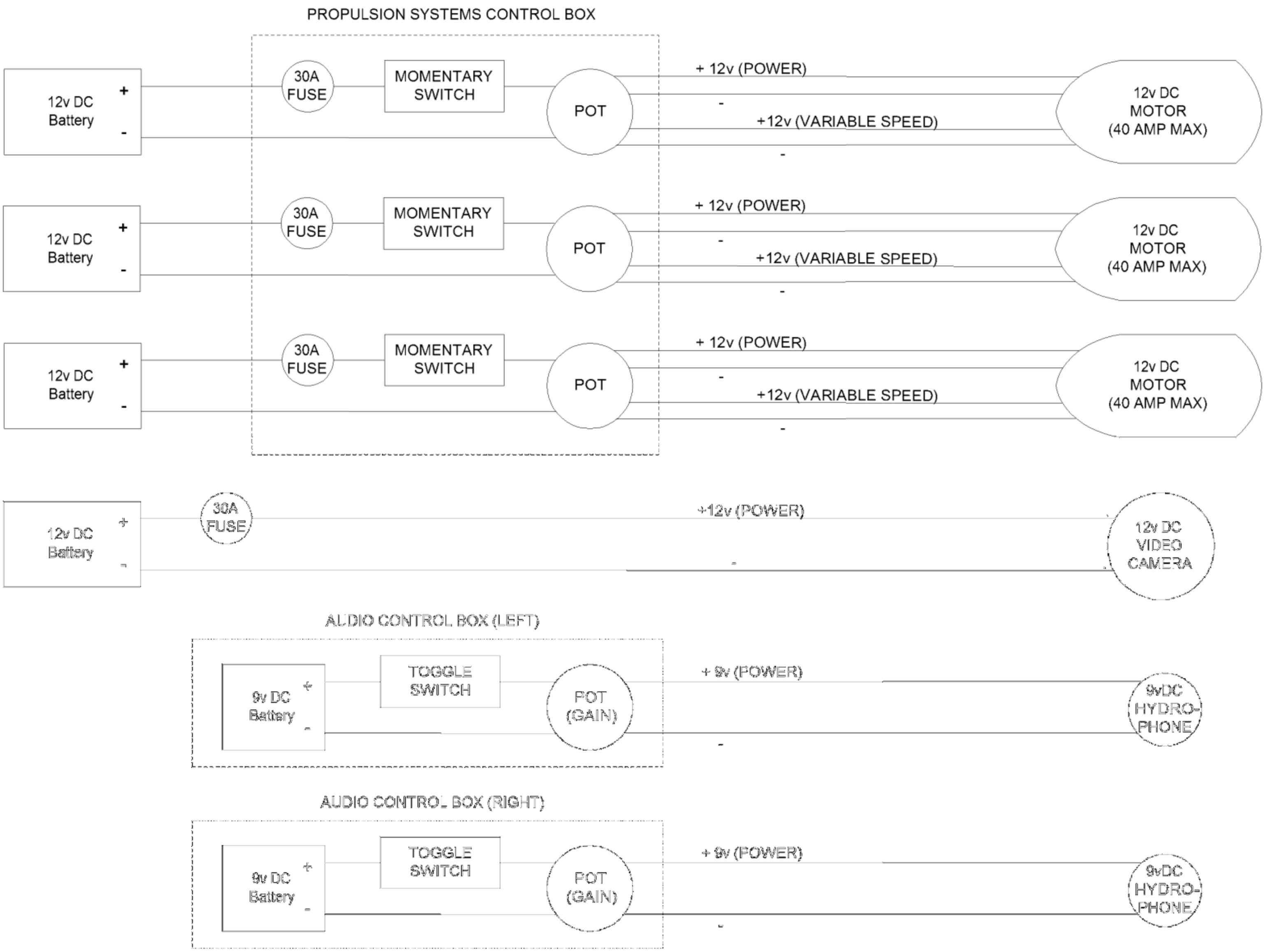


Figure 1 – Electrical schematic for Freebie II ROV

Design Rationale

Each of the major components/systems of the ROV vehicle were subdivided as follows:

Audio/visual Systems

- Camera & power requirements: We chose the Deep Blue Pro Color underwater camera as our main visual system for the ROV. Although the camera became the most expensive item in our budget, it provides excellent video quality, it is waterproof and made to withstand impact from rocks, cables, and debris. It also comes with lights and 45.72 meters of umbilical cable to transfer the digital signal back to the surface. The camera is also very convenient due to its power requirement of 12 V, making it very easy to plug in to one of our batteries.

- Hydrophone: For our audio system, we purchased two Dolphin Ear hydrophone systems. Each was attached at a 45º angle on the port and starboard ribs of the ROV frame in order to allow for better hearing of sounds coming from below the vehicle. The hydrophones provide a frequency range of 7 Hz to 22,000 Hz along with a 32 meter cable jacketed in high quality, low noise neoprene/PVC. Each hydrophone is powered by a 9V battery.

- Console audio & video analyzer: At the surface, our console consists of a Dell D600 laptop with a Pentium M 1.7 GHz processor and 1 GB of RAM. The cables from the camera and hydrophones are connected with the appropriate adapters as follows:
    - Camera connects using video cable to USB adapter.
    - Hydrophone connects using red/black y-adapter audio cable to speaker port of the computer.

Power and Electrical

- Power source: The power for our propulsion and video camera come from four 12V 7.5AH Werker batteries, each with a mass of approximately 2.73 Kg. As mentioned before, the hydrophones use a standard 9V battery. The wet/dry vacuum used to extract the liquid uses a standard 110/120 V AC power source.

- Console wiring: The console wiring includes the control box, and all connections from the camera, hydrophones (see section on Audio/visual Systems), to the power source. Our wiring is a simple and easy to maintain circuit that was created in order to allow a direct connection to the variable speed controls for each thruster. See Figure 1 – Electrical schematic.

- ROV wiring: As in above, see Figure 1 – Electrical schematic.

- Fuses: The control box contains three inline fuse holders with 30 A fuses to act as a safety measure for the circuit(s). See Figure 1 – Electrical schematic.

- Tether: The 30.48 meters tether is composed of several electrical and one non-electrical conductors as follows:

- Three power 16 AWG two-conductor speaker wire (one for each thruster)
- Three variable speed 18 AWG two-conductor speaker wire (one for each thruster)
- Camera umbilical
- Two hydrophone cables
- Temperature sensor cable
- Depth sensor cable
- Clear tubing for liquid extraction

Propulsion Systems

- Thrusters & power requirements: As we researched parts and materials for the ROV, we found pictures and examples of other organizations and teams using trolling motors as their main propulsion sytem. After much deliberation and having agreed that such a technique would be successful, we decided on the smallest available motor we could find: the Minn Kota Endura 40 Trolling Motor. We purchased three motors to be mounted on the vehicle as follows:
  - One on aft-port rib and the other on aft-starboard rib to allow for tight turns and smooth propulsion forward and backward
  - The third motor is positioned in the center of the ROV to allow for vertical movement

  Other factors leading towards this particular motor include: each motor provides approximately 18.14 Kg of thrust, five speeds forward and three speeds backwards, as well as a waterproof enclosure minus the shaft, which is waterproofed inside the termination can.

Housing/case

- Frame: Since we were limited to common household tools, we decided to make the ROV frame of PVC schedule 40 pipes because it provides flexibility in achieving the modeled design using different connectors (90º, 45º elbows, T's, etc.). The dimensions are 1.09 m (length) x 0.889 m (width) x 0.66 m (height).

- Ballast: After installing the thrusters and testing them in a pool, we installed a ballast system composed of pool noodle foam tied on the stern of ROV along with two 1 L bottles of water attached to the sides of the vehicle.

Additional Systems/sensors

- Depth sensor/console readout: In order to meet the requirements of measuring the depth within 5 cm of the benchmark, we chose Ametek's Model 575 Submersible Level Transmitter connected by a 30.48 meters cable to a digital readout that can be programmed to output the depth in PSI, meters, or centimeters.

- Temperature sensor/console readout: In order to measure the temperature of the cold spring to within 1 -2 º C of the benchmark gauge, we chose a Type K thermocouple sensor (potted against moisture) connected by a 30.48 m cable to Fluke's Digital Themometer 51/52 II. The readout, at the push of a button, can display the temperature in C, F, or K.

- Liquid extraction system & power requirements: To extract 500 ml of the liquid from the leaking barrel, we decided to use a wet/dry vacuum. The ShopVac wet/dry vacuum Model LPV 650 uses a 120 V AC power source and provides 6.5 horse power at peak. The liquid is extracted through a 30.48 m vinyl clear tubing (attached as part of the tether) that measures 0.9525 cm for the outer diameter and 0.635 cm for the inner diameter.

- Object recovery system: In order to recover the towfish and the captain's bell, we equipped the ROV with the following:

    - Two plastic coated hooks attached to each side of the bow. See pictures 2 & 3.
    - A net attached to the bottom base of the frame
    - A scoop made of plexiglass that will be used to scoop up and recover the pinger

- Measurements system & power requirements: To measure a length of no more than 5 m, we employed a very simple system composed of a 6.1 m measurement tape and a rope loop installed at the opening of the tape. Together with the propulsion system of the ROV, the tape can be used to hook itself to one of the marked posts on the U-Boat mockup and measure the full length to the second post.

Challenges

One of the first challenges we encountered were time issues with regards to the acquisition of funds from sponsors and construction materials. Although some of these problems were beyond our control, we tried to expedite the process by following up with our contacts and continued maintaining good communication with the respective individuals from each organization.

Another challenge that was present throughout the duration of the project involved dealing with the dynamics of working in a group. Personal, communication, and/or meeting attendance issues were present. Fortunately, we were not delayed as much as we could have been due to the way each stage of the project was organized. We have a total of five members including our overall group leader. We assigned the responsibilities of each system to individual members: one acting as the head person for that system, and another as a backup. As a result, if one or more people were absent during the construction of the ROV, a backup person for any particular system would be available to attend to any issues or problems, especially during systems integration and testing.

The biggest technical challenges in the project were in the initial choice of the propulsion system (size of thrusters) and towards the end, trimming and balancing the ROV appropriately. Initially, once we decided on the Minn Kota trolling motors, we had to figure out a way of installing them to the ROV frame and waterproofing the motor shaft. Furthermore, once we actually saw the motors, we decided that the frame dimensions (originally designed in Discreet's gmax) could be smaller in order to provide better maneuverability and control of the vehicle. We eventually cut down the PVC frame by 18.75% and attached the modified motor shaft to the waterproof wiring box with silicone sealant thus solving two problems with one solution. The trim and balance of the ROV were also affected by the weight of the three motors, two of which are located at the stern (aft starboard, aft port) of the ROV. Therefore, trough trial and error, we had to provide enough floats to counter the weights of the motors.

Troubleshooting Technique(s)

As mentioned in the previous section, we divided each major system of the ROV and assigned those responsibilities to members of the group. As such, we were able to test and configure individual systems and isolate problems at that time. In order to minimize problems, we chose an electrical system that was both easy to wire and replace and/or maintain should a problem arise. However, with the first type of wire and electrical scheme we chose (x2, one red, one black, 30.48 meters 8 AWG, one conductor), we were unable to properly complete the circuit to turn on/off each thruster individually:

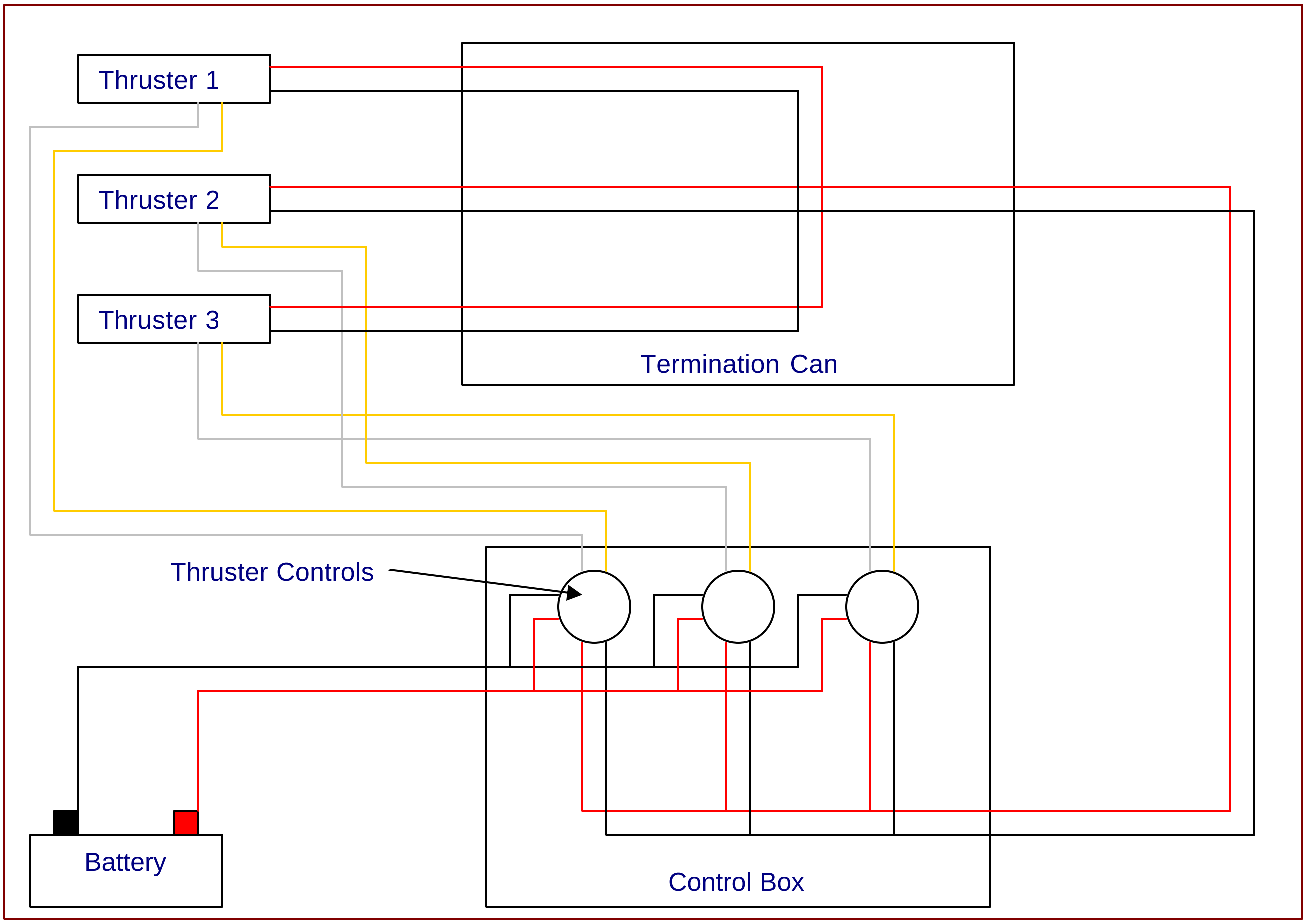


Figure 2 – Troubleshooting thruster circuit

As pictured in this diagram, we thought we could reduce the weight and width of the tether by sharing the power to all three thrusters and only separating the thinner yellow and white/gray cables to control the speed of each motor. We began testing by connecting one motor at a time, however, we soon realized that even though only one motor was connected, all three would turn on/off. After further testing with two, and then all three motors we decided to isolate the power to each thruster using a smaller gauge cable (30.48 meters 2 conductor, 18 gauge speaker wire).

Lessons Learned

Participating on this competition for the first time, our team learned valuable lessons including:

- Open a bank account dedicated to the ROV project to allow easy access to funds from MATE and other sponsors.
- Research all materials and parts early and thoroughly.
- Keep the design and components simple. Minimize problems by creating a detailed and well thought model (using modeling software such as CAD or gmax) and following through from model to reality.
- Visualize and focus on the tasks of the mission. Spend less time dealing with personal and communication issues that usually occur when working in a group such as arguing about decisions that were discussed and made in prior meetings.
- Improvising on the fly, especially when we were trying to waterproof the motors and all the PVC pipes that were connected to them.

Future Improvements

For future competitions, it will be essential to commence the search for sponsors and funds at least one month earlier in order to compensate for any delays. We would also need to open a bank account solely dedicated for ROV projects so as to have easier access to funds for purchasing materials and travel expenses. Finally, we would further need to emphasize the need to "keep it simple", begin designing and working sooner on the actual system(s) and further explore all the possibilities for parts including: thrusters, frame, and accessories. As a mean to achieve this, all the information, including parts lists, description of challenges, procedures, will be documented in a notebook along with this technical report for the next competition.

With regards to the Freebie II ROV, we would like to work further on the cosmetics and overall look of the vehicle including professional painting along with the logo and ROV name printed on the ROV.

How ROV's are currently being used to explore and understand our national marine sanctuaries

Currently, ROV's are being used throughout the United States for various underwater exploration missions of our national marine sanctuaries. In particular, as recently as May 2004, photography and sonar taken with the aid of ROV's are helping scientists gain insight into the ocean floor of the central and northern California coast. "The project, a 21-day expedition in April, featured federal researchers on a 224-foot ship towing an underwater camera and using other high-tech gear to uncover some of the agelessness that lies beneath Monterey Bay, Gulf of the Farallones and Cordell

Bank national marine sanctuaries." The team, composed of scientists from the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey, took approximately 200 hours of video, which will be of great use to future scientists in determining and comparing fish populations and "geological details of their undersea world."

Another important ROV use involves exploration and discovery of shipwrecks and other objects of archeological/historical value. One of the best examples was the discovery and exploration of the Titanic wreck in the Atlantic Ocean. More recently, exploration missions took place on the Thunder Bay National Marine Sanctuary and Underwater Preserve (TBNMSUP) which "is the newest of the thirteen National Marine Sanctuaries and is only the second dedicated to the understanding and preservation of submerged cultural resources. It is suspected that over a hundred wrecks lie within the boundaries of the Sanctuary in waters ranging from 20 to over 200 foot depths." As a mean to promote awareness for the "rich cultural history" available on the floor of Lake Huron, the project involved the development and launching of a wireless network to broadcast high-quality video from the ship to a land base. With the aid of NURC's Phantom III S2 ROV, a live webcast was successfully tested and broadcasted. The ROV was launched from the ship R/V Shenehon to explore the wreck of the Montana lying 60 feet below and 9 ½ miles offshore. For a half-hour, the ROV followed two divers "as they conducted a reconnaissance of the wreck, including documenting the distribution of two invasive species - the zebra mussels and round gobies." The ROV sent the video signal through the tether to the ship where it was transmitted over the wireless network to the land base providing clear images of the sanctuary.

References:

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Acknowledgements

We would like to thank our two sponsors, Miami Dade College and Montenay Power Corp., and all the dedicated staff at each organization for their time and financial contributions to the Freebie II project:

Miami Dade College

- Loretta Adoghe, Program Director & mentor
- Haniel Pulido Jr., Instructional Technologist & mentor
- Jennifer Walsh, Instructional Assistant & Peer Tutor
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    - Dr. Wasim Shomar, Kendall Campus President

Montenay Power Corp.

- Tony Guillen, Sr. Project Engineer
- Gonzalo Aleman, Environmental Engineer