2004 MATE Center/MTS ROV Competition

Technical Report

SD-3

CAPE FEAR COMMUNITY COLLEGE

Team Members

Mechanical Engineering Technology


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Gary Simpson

Grant Moyer

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Jim Martin

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Joel Spencer

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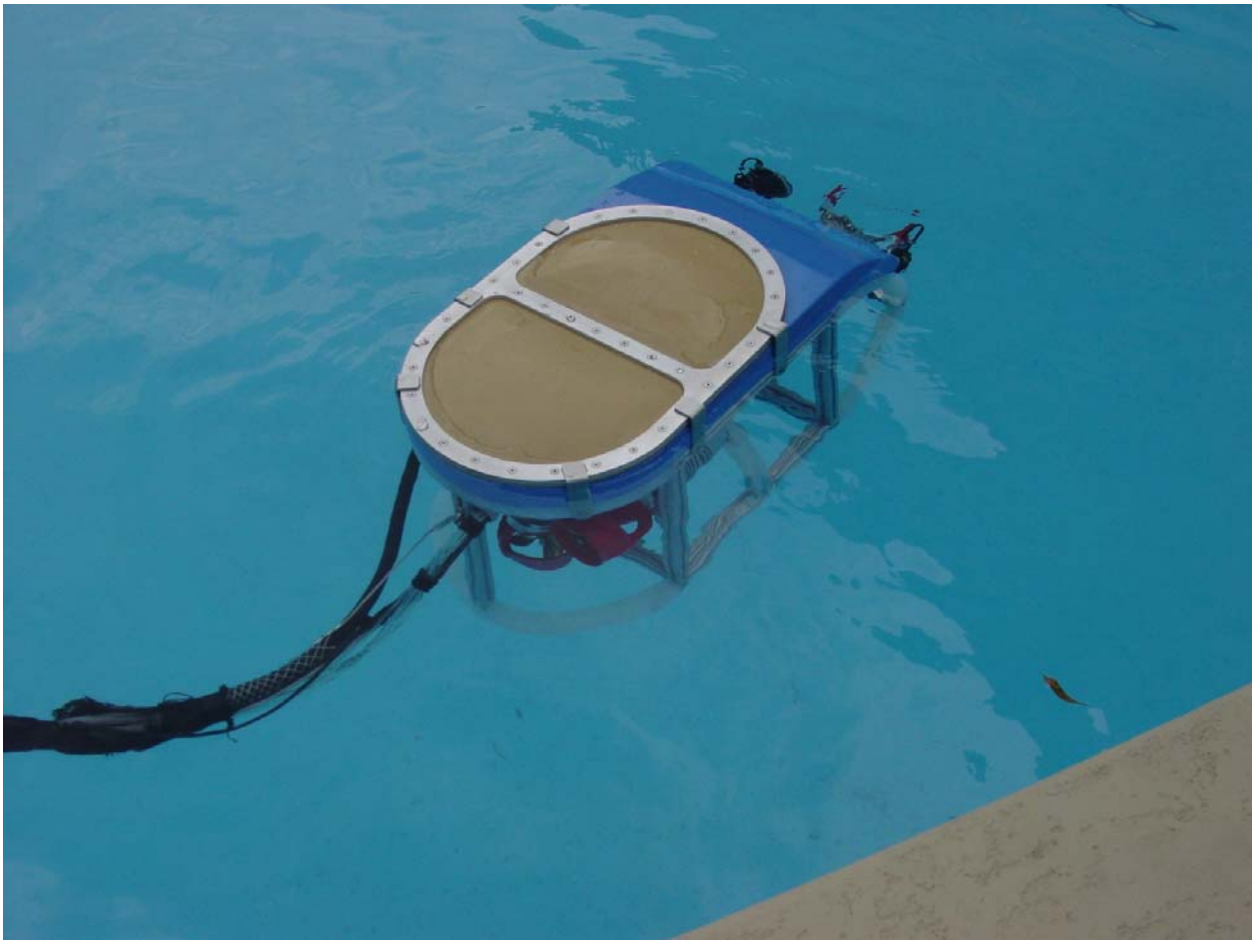
Abstract

The **Sea Devil-3** (SD-3) is designed to perform various tasks to simulate underwater research by gathering data. The design team's goal is to keep the ROV simple and lightweight, yet maintain stable control to gather data. The rectangular frame is constructed of aluminum slotted extrusions for weight efficiency and to allow for modifications. The propulsion system includes four independent motors, a pair of motors for vertical motion and a pair for horizontal motion. The ROV is designed to have neutral buoyancy and a foam flotation core is located at the top to aid in stability. A two-chamber bladder sits on top of the foam to control ballast by adding or removing air. The simplified gripper will clasp the various targets. And finally, a more flexible tether will not hinder the movements of the **Sea Devil-3**.



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Budget/Expense Sheet

Date	Description	Notes	Donation	Deposit	Expense	Balance
5/5/02	Cart and Control Panel	Purchased Cart/Scrap Wood	$75.00			$0.00
5/5/02	Gripper Assembly	Previous ROV	$100.00			$0.00
3/3/03	(4) Pittman 14000 DC servo motors	Previous ROV	$270.56			$0.00
5/5/03	(4) Motor Housings	Previous ROV	$200.00			$0.00
9/15/03	MET Budget For ROV			$4,000.00		$4,000.00
1/20/04	CFCC Mini Grant			$1,000.00		$5,000.00
1/27/04	Mate Donated Funds For Supplies			$100.00		$5,100.00
1/4/04	Funds from SGA			$1,000.00		$6,100.00
1/27/04	Monitors	On Loan	$800.00			$6,100.00
1/29/04	McMaster Carr				$260.60	$5,839.40
	(1m) SS Shaft 6mm Dia	6493K18				
	(PKG) SS SHCS	92196A151 & 92196A153				
	(8) SS Shaft Collar	6462K12				
	(6) Alum Shaft Collar	6157K41				
	(2.5m) Long, Aluminum Extrusion	47065T123				
	(PKG) T-Nuts	47065T142				
	(2) Drop-In Nuts	47065T151				
	(2) Zinc Anchor	47065T153				
	(2) End Fastener	47065T155				
	(PKG) Double T-Nuts	47065T147				
	(2m) Long, Aluminum Rod 8m Dia	8974K27				
2/4/04	Nature Vision INC	2 Cameras			$694.50	$5,144.90
2/18/04	RobotQ	2 Motor Controllers			$953.37	$4,191.53

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Date	Description	Notes	Donation	Deposit	Expense	Balance
2/18/04	Intuitive Control Systems	2 Joysticks			$268.36	$3,923.17
3/9/04	Graybar Electric	Support Grips			$76.23	$3,846.94
3/16/04	McMaster Carr				$185.45	$3,661.49
	25mm X 0.5m X 0.5m Polypropylene	8742K421				
	(15) SS Socket Head Set Screw	92311A546				
	(PKG) SS Socket Head Set Screw	92311A564				
	(PKG) SS Nyloc Nuts	91831A120				
	(PKG) SS Flat Washer	92141A027 & 91950A027				
	(PKG) SS Socket Head Flat Screw	92210A548 & 92210A550				
	(PKG) SS Hex Nuts	91841A195				
3/27/04	Orbitz	Airline Tickets			$2,868.50	$792.99
4/6/04	Gulf Stream Steel and Supply	Aluminum(ballast)			$113.03	$679.96
4/6/04	McMaster Carr				$97.83	$582.13
	(2) 3mm Tank Valve	8063K31				
	(2) 3mm Tank Valve	8063K33				
	(2) Sample Packs	85995K666 & 8611K333				
	(0.5m) Long, Latex Rubber	8611K18 & 8611K15				
	Viton O-Ring	9464K234				
	(PKG) FHCS	92210A301				
	Metric Measuring Tape	6802A57				
4/22/04	McMaster Carr				$126.76	$455.37
	(30cm) Long, 10mm Dia Nylon	8541K34				
	(1) Nylon Plate	8540K118				
	Brass Nipples	4568K126 & 4568K113				
	(PKG) SS Should Bolt	90298A537 & 90298A539				

Date	Description	Notes	Donation	Deposit	Expense	Balance
	(PKG) Springs	9435K72				
	(2m) Aluminum Tubing	8996K47				
	(1) Nylon Plug	48335K152				
	(PKG) Buna O-Ring	9452K19				
	(PKG) SS Socket Head Set Screw	91375A101				
	(30m) Black Elect Wire	7587K53 Black				
	(30m) Red Elect Wire	7587K53 Red				
	(PKG) Quick Connect Terminals	7243K26				
	(0.5 m) Long, PVC Type II Rod 10cm Dia	87025K672				
5/15/04	Total Material Cost of Rapid Proto Parts				$352.39	$102.98
5/17/04	Polo Shirts				$176.55	-$73.57
6/1/04	MATE Donated Funds For Travel			$1,500.00		$1,426.43
6/14/04	Shipping ROV to CA	Paid by Shipping Department	$1,000.00			$1,426.43
6/25/04	Lodging	2 Additional Students			$370.00	$1,056.43
6/25/04	Expenses During Competition	Unknown				
		Totals	$2,445.56	$7,600.00	$6,543.57	

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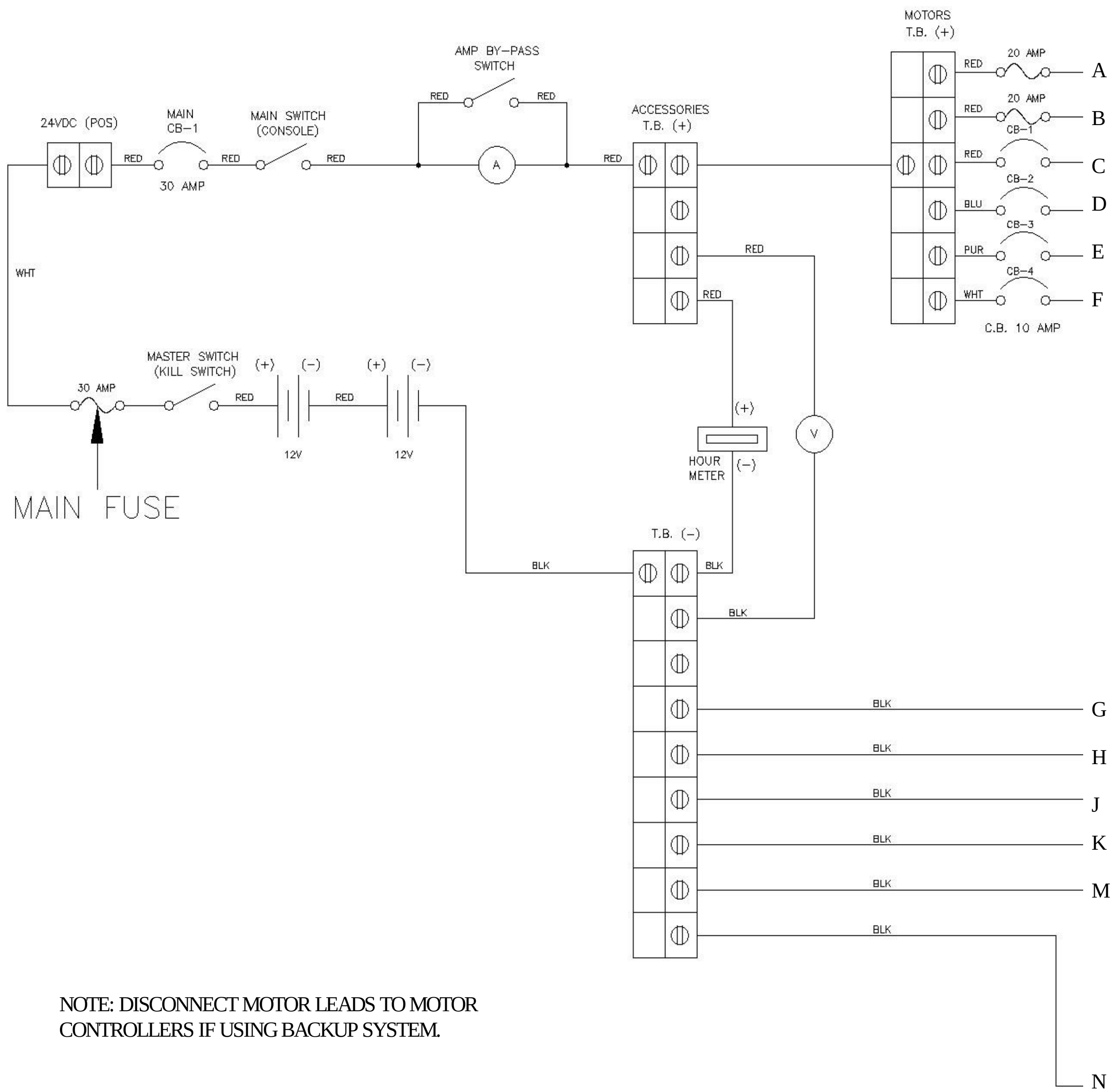
Wiring Schematic

24V Schematic - Part 1/3



NOTE: DISCONNECT MOTOR LEADS TO MOTOR CONTROLLERS IF USING BACKUP SYSTEM.

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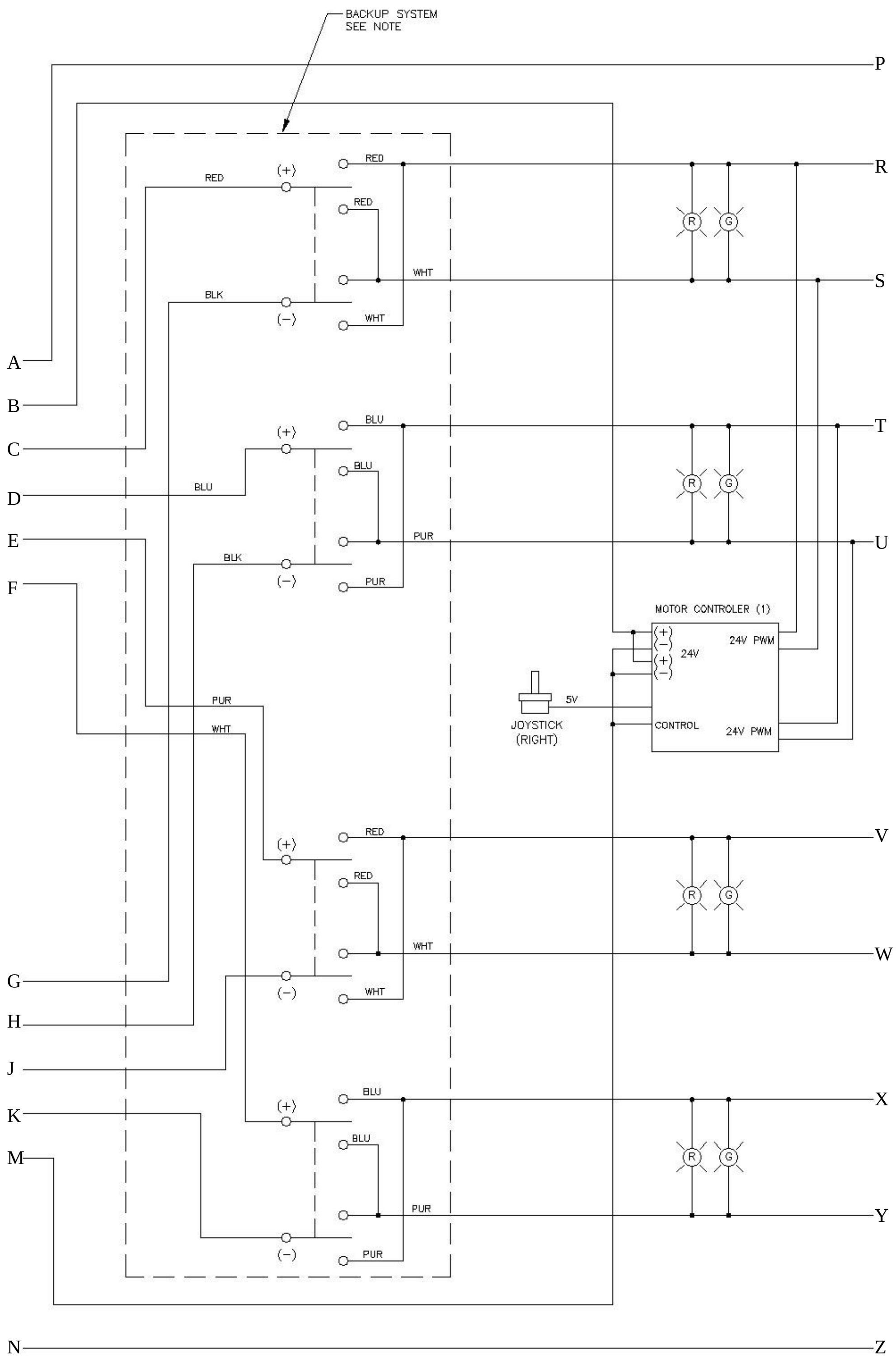
24V Schematic - Part 2/3



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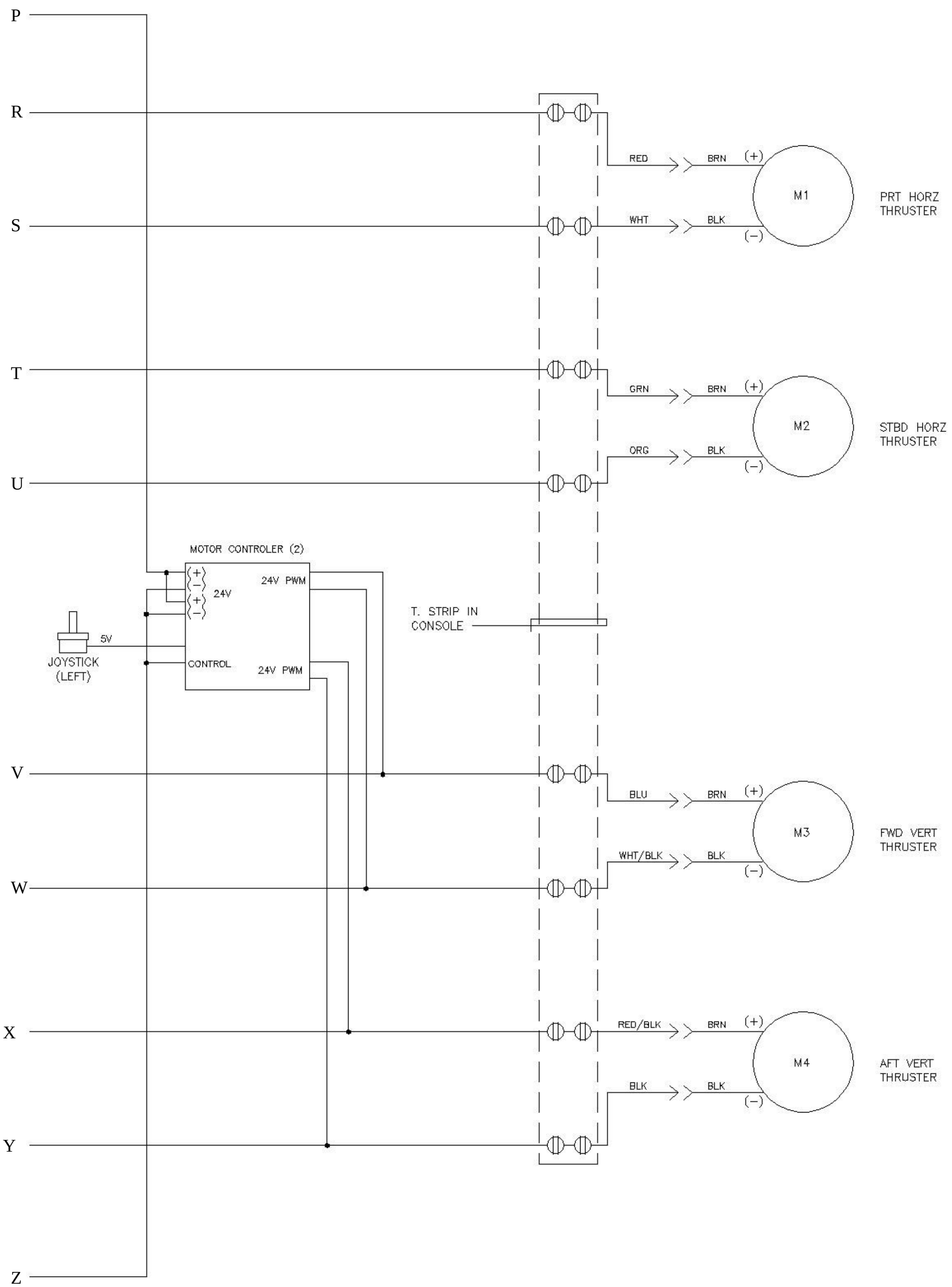
24V Schematic - Part 3/3



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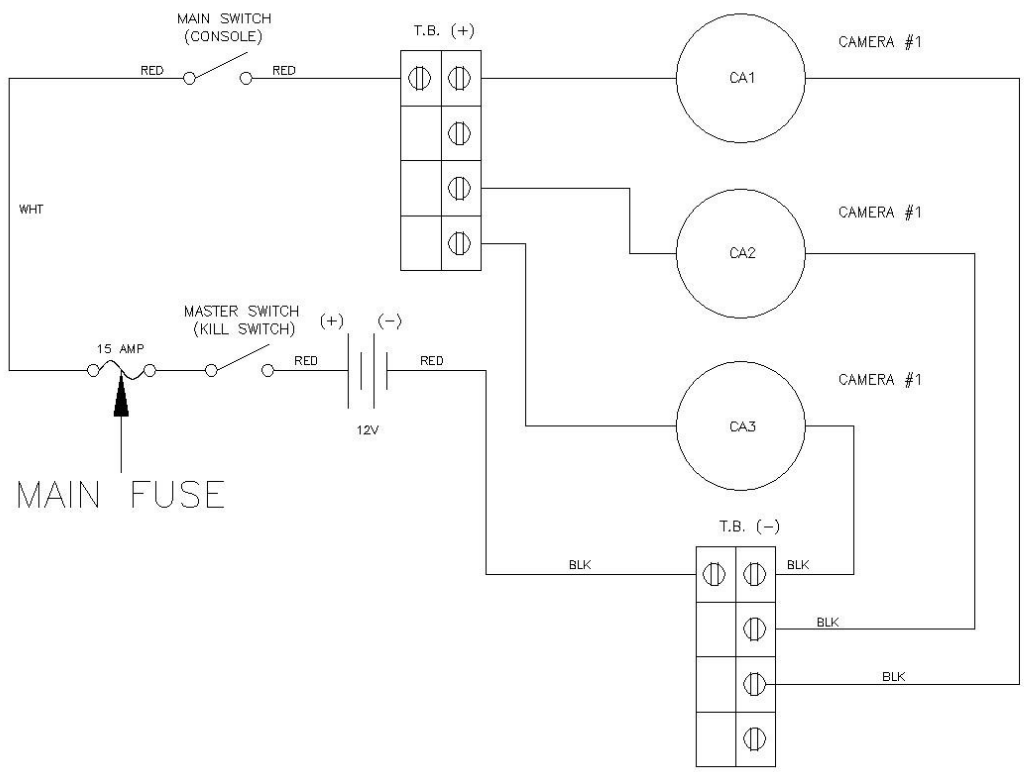
12V Schematic



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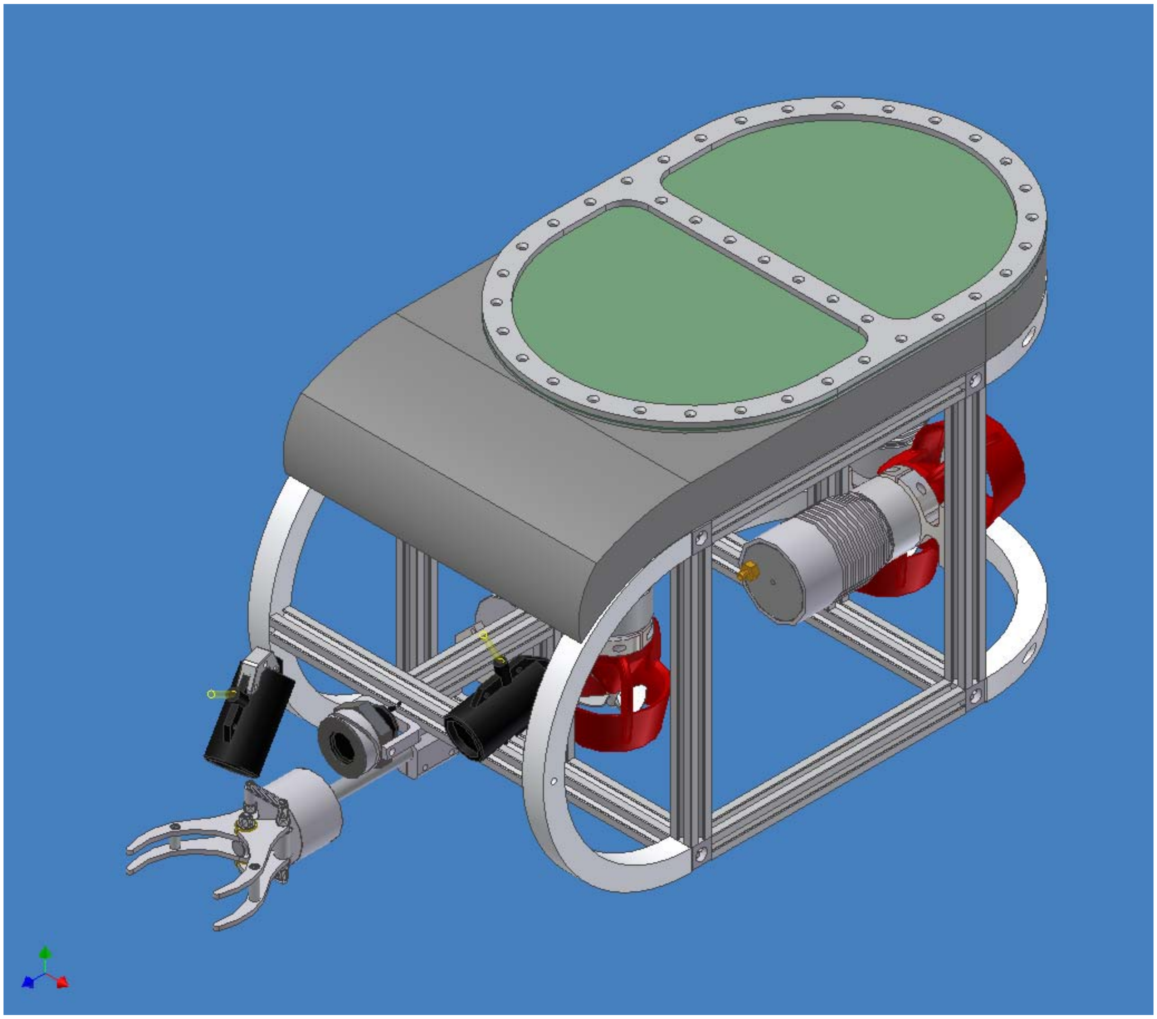


Design Rationale

Early in the design process the Cape Fear Community College Team concluded the ROV needed to be constructed in a manner to allow modifications and alterations quickly and easily. The ROV needed to accommodate any attachments and apparatus needed to perform the difficult tasks contained in the mission. Goals of the design team also included keeping it as simple as possible while maintaining a lightweight vehicle with extremely stable control that could accomplish the tasks at hand.

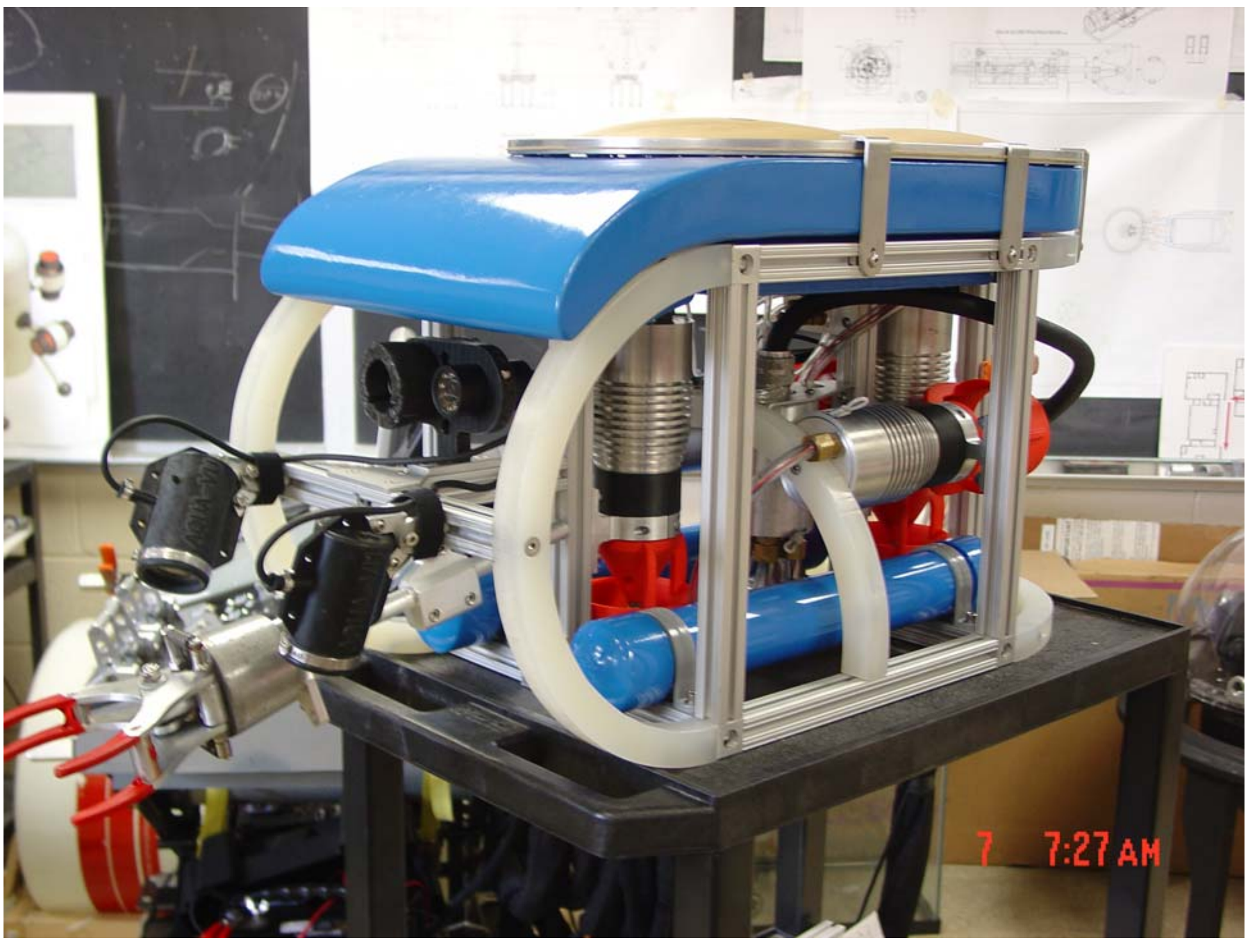
Supporting the versatility concern the team opted to use a rectangular configuration for the frame design. After researching ROVs the team concluded the working class of ROV is typically of a rectangular design, which reiterates the design logic. Although the frame design went through many minor alterations the principles remained the same. After much research the team agreed to use aluminum slotted extrusion manufactured by 80/20 Inc. for the frame. This product offered a high strength to weight ratio, was very cost effective, and is resistant to corrosion. The slotted extrusion material configured in the rectangular design would prove to accommodate brackets and attachments easily allowing precious time to be spent on other tasks.

The ROV is propelled by four Pittman 14000 DC servo motors housed in a watertight cylinder designed and machined by students at CFCC. Two motors are located vertically and two horizontally, each controlled independently. All four motors are equipped with Kort Nozzles engineered for maximum thrust and manufactured in-house on the Rapid Prototype Machine out of an ABS plastic. Controlling the motors are two programmable variable speed motor controllers along with two full function joysticks. This will allow hovering and extremely precise control of the ROV while performing the difficult assignments.

The three cameras located on the SD-3 are comprised of an Aqua-Vu DT, an Aqua-Vu ZT and a color camera. Due to the variance of tasks, the Team decided three cameras would be beneficial to cover all angles of view the ROV would be working. The Aqua-Vu DT is equipped with a direction sensor, temperature, depth and multicolor lights. This wide-angle camera unit really helped our team “keep it simple.” The Aqua-Vu DT’s integrated features were extremely helpful at a price much less than a regular camera. Strategically placing Aqua-Vu DT matched with the other two cameras should give SD-3 an excellent field of view and an advantage during the competition.

Several other subsystems make up the construction of the SD-3. The buoyancy control system for the SD-3 is extremely effective. The system starts with a fiberglass covered foam flotation core located at the top of the vehicle to aid in stability and counter the weight of the vehicle. A two-chamber bladder was then designed to sit on top of the foam, enabling the pilot to control ballast by adding or removing air. These features will aid in the stability of the ROV. The SD-3 Team also included a simplified pneumatic gripper. The Team concluded a gripper was necessary to accomplish several of the tasks listed. Staying with the design plan the gripper was constructed to be as simple and as lightweight as possible and still complete the tasks.

Due to report length restrictions it is impossible to include design rationale for the entire project, but the highlights were listed. The CFCC SD-3 Team constructed a ROV in a manner to allow modifications and alterations to accommodate attachments and apparatus to accomplish the set forth mission. The team goals included designing a lightweight, stable vehicle as simple as possible that could perform the assigned tasks.



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Challenges

The Cape Fear Community College team faced many challenges during the design and construction of the Sea Devil 3. The challenges included but were not limited to time, scheduling conflicts, and the difficult nature of the individual tasks. The Team recognized the competition would not be as rewarding if it was easy and welcomed the challenges.

The largest obstacle the team faced was time. In one semester (sixteen weeks) a working ROV capable of completing the seven difficult mission tasks had to be designed and constructed. This task would be difficult for industry to accomplish with people working full-time on the project, while our team only had a couple hours a day. To ensure a quality design, many weeks were spent discussing design ideas and constructing three dimensional assembly drawings. The team constructed a complete 3D Inventor model of the ROV including ballast system, frame, motor system, and electrical. Due to the length of time needed to manufacture some of the parts, it was extremely important the team worked out most of the design problems in the models. A design mistake could be detrimental since we may not have time to manufacture a replacement part.

Another major challenge the CFCC Team faced was scheduling conflicts. It seemed impossible for all team members to meet at the school at the same time, although some team members were much worse with attendance than others. This became very important when one individual team member was working on a part that was relative to a different part. If the first student doesn't make it in for a couple of days, she/he is holding up several parts during the design process. On several occasions this resulted in parts taking much longer to design then they should.

The nature of the individual tasks the ROV is expected to perform seemed very challenging. One example is the fluid sample device that requires us to design an apparatus to remove a fluid from a barrel underwater without contaminating the fluid with seawater. This task required many hours of thought and discussion, but we are confidant in the outcome. Other difficult design challenges included measuring distance of the wreck and implementing a hydrophone to find the pinger.

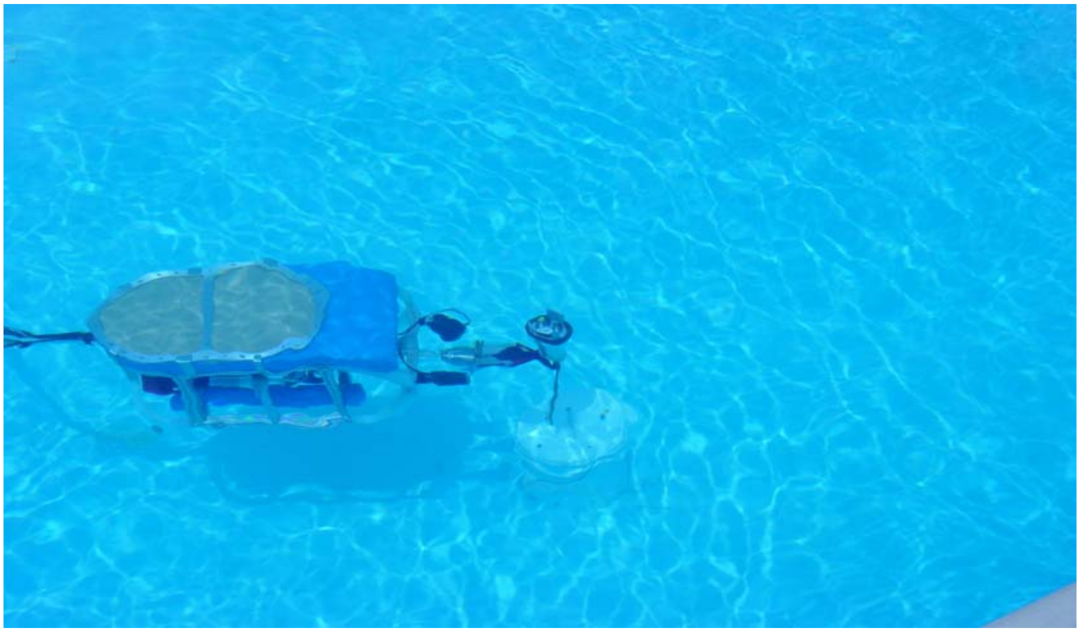
Troubleshooting

During an initial dry run in the classroom it was discovered that one of the motor controllers was not working properly. While taking a closer look it was apparent that both controllers seemed to have problems. After employing various trouble shooting techniques and contacting the manufacturer it was concluded the best solution was to send them back for repair. The Sea Devil Team then hardwired toggle switches to temporarily replace the controllers so testing could continue while the controllers were being repaired. The SD-3 was now ready for a wet test.

The first pool test was strictly to test the flotation and ballast system. Although we carefully calculated the amount of flotation needed, we realized it was near impossible to consider all variables. The result was the ROV was slightly buoyant which was a welcomed outcome. By applying some weight in the lower area the SD-3 hovered in the water perfectly. The onboard air ballasting system was still available if extra lift or adjusting is needed.

A second pool test did not go as smoothly. During the second wet test we realized the fluid sampler was not retrieving. A trigger adjustment was needed. Problems were also apparent with docking during wreck measurement and fluid sampling. Some of the docking problems may be resolved when we reinstall the motor controllers and joysticks, but engineering some additional guides proved to be advantageous. The SD-3 also spun a propeller due to the fact that Loctite does not work very well on stainless steel. A primer offered by Loctite was applied to the stainless steel shaft before applying the adhesive to resolve the problem. One of the most troubling problems is the failure of two monitors. The best theories for the failures were either a low voltage condition or the heat created by having the displays in direct sunlight during Wilmington’s summer weather.

The third pool test was to confirm the motor controllers were working properly and to test the trigger mechanism. Piloting the ROV was not very realistic to competition conditions due to the lack of monitors but still provided the ability to test the other systems one more time.



Lessons Learned

The lessons learned were extensive. The biggest lessons learned were probably along the lines of working with other students, instructors, mentors, and vendors. Working on a team requires a different process than an individual design where there is relative design freedom. The feedback and direction from instructors and mentors was at times frustrating but in the end very valuable. Many students held the belief that there was a "best" way to solve most tasks and design problems. The reality is there many different directions that can be adapted and successful. Learning to accept and learn from criticism was more difficult than any other class experience probably due to the added pressure and larger scope of designing the ROV for a competition. Once the process of presenting a design and then modifying it due to feedback was familiar, the team meshed better and learned to compromise more. Looking back this seemed to be the first big hurdle the design team needed to overcome.

Future Improvements

The ROV that CFCC produced this year was a step forward from previous years. The goal for the next version is to incorporate on-board power to allow a much smaller and more flexible tether. The use of a fuel cell to power the ROV has also been forwarded and discussed. In addition a new type of gripper (electronic) will, again, allow for a smaller and more flexible tether with the loss of the airlines of the current pneumatic gripper. The last main improvement to the ROV would be the design of a composite or lightweight metal propeller.

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How ROVs Are Currently Being Used in National Marine Sanctuaries

Remotely Operated Vehicles (ROVs) are underwater robots that can perform various tasks. Oceanographers use ROVs in their studies of marine sanctuaries.

In 2002, an exciting exploration of National Marine Sanctuaries (NMS) began. The three-phase study, *Sanctuary Quest West Coast Expedition 2002*, ran from March 1 through September 16, 2002. The National Marine Sanctuary (NMS) Program conducts this study. Expedition Coordinator, John McDonough, states there are three primary goals, " One: To learn a little more about habitat. This is in the depth of the sanctuary that is below SCUBA depth. Two: To learn a little bit more about some of the perhaps human use of the sanctuaries themselves. Three: To continue on with some of the ongoing monitoring efforts that have been occurring in the sanctuary." [i] The ROV serves as the primary tool for McDonogh's team.

Daniel J. Basta, director of the NMS Program discuss the concept, "Our scientist will compare these relatively undisturbed underwater areas with those that have been altered by human activity. These results will have direct application to management issues and will contribute to the ongoing research and data collection within the sanctuary program. We will also investigate ship wrecks as cultural resources and for their potential impact on the marine environment."[ii]

Sanctuary Quest West Coast Expedition 2002 phases:

- **Phase I**
    - **West Coast Monitoring Mission**

Figure 1. Marine Sanctuaries of the U.S. Pacific Coast
Obtained from NMS website. www.sactuaries.nos.noaa.gov/oms/oms.html

- **Phase II**
    - **Channel Islands National Marine Sanctuary**
    - **Monterey Bay National Marine Sanctuary**
    - **Gulf of the Farallones National Marine Sanctuary**
    - **Cordell Bank National Marine Sanctuary**
    - **Olympic Coast National Marine Sanctuary**
- **Phase III**
    - **Alaska and Canada Monitoring Transit**
    - **Olympic Coast National Marine Sanctuary**

Much of the data collection effort includes using the U.S. Navy's sophisticated ROV. Equity the ROV with a high quality video camera provides excellent underwater video footage not only for the scientist but also "1 to 3 minute video displays for aquariums and other venues."[iii] Images of the fish communities and invertebrates stimulate public awareness and provide scientists a baseline reference for future studies of these communities.

The ROV must complete many tasks. During research of habitats, the ROV visually verifies data represented by sonar equipment. A reconnaissance dive by the ROV samples the sediment surrounding the shipwreck of the *Pac Baroness* whose cargo contained powdered copper. A second shipwreck will be inspected, the *Jacob Luckenbach*, for possible oil recovery missions. Samples and videos of undisturbed sponge fields and deep-water coral can be collected. Archaeologists use the ROV to search for evidence of human habitation along ancient submerged shorelines. This ROV gives the researchers a helping hand as it logs many dives during this quest.

* Note: All references and endnotes for this section appear at the end of the report.

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Acknowledgements

Cape Fear Community College would like to give a special thanks to the **Hilton Riverside** in Downtown Wilmington for allowing us to test and practice in their pool.

We wish to express our appreciation and thanks to the following for their commitment and resources:

- CFCC Machining Technology's students and instructors

  Randy Johnson – Lead Instructor
  Ben Bowie – Instructor
  Jason Cole – Student
  Steve Shearin – Student
  Bobby Grossnickle – Student
  Patrick Arnold – Student
  Matt Arnold – Student
  Greg Edens – Student
  Marcus Simpson – Student
  Janis McNeal – Student
- Seaward International – Flotation material
- Slickfish Enterprise – Shipping crate
- Aqua-Vu – Discounted camera

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[i] NOAA Ocean Explorer: Sanctuary Quest 2002. Interview with John McDonough, Expedition Coordinator.
http://www.oceanexplorer.noasa.gov/explorations/02quest/backgroud/plan/media/02quest_.html
[ii] National Marine Sanctuary News, NOAA 02-040, April 23, 2002
http://www.sanctuaries.nos.noaa.gov/news/pressreleases/pressrelease04_23_02.html
[iii] NOAA Ocean Explorer: Sanctuary Quest, Mission Plan. revised May 2, 2003,
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