CCC TECHNICAL REPORT

Explorer Class

DAB

(a.k.a. Das Ausgefallene Boot)

ROV Team 2009

Clatsop Community College (CCC)
Astoria, Oregon

Team Members

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Instructors/Mentors

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Abstract

The initial phase of the *DAB*, a.k.a. Das Ausgefallene Boot, project centered on building an ROV that could move forward and backward as well as descend and ascend on a tether. Once preliminary work was completed, design and construction were refined to enable *DAB* to complete the four tasks required by the 2009 MATE ROV Competition. Tasks include: (1) locating the damage points on a submarine; (2) docking with the emergency escape skirt; (3) opening the ventilation hatch, inserting the air hose into the ventilation shaft, turning on the air for 10 seconds, turning off the air, and removing the hose from the ventilation shaft; and (4) opening the life support hatch, placing five pods inside, and closing the life support hatch. The team used four Johnson 1250 GPH bilge pump motors for propulsion. *DAB* currently uses three underwater cameras for visibility but an additional camera will be added and mounting locations changed to optimize the view for the operator. Two electromechanical arms/claws, powered by four 9 volt linear motors, will also be added to the final configuration. The 21 meter tether currently installed carries the video signal from the underwater cameras and supplies the four propulsion motors with 12 volt power via four double pole double throw switches. The final design will include a tether that has been shortened to 16 meters and modified to carry 9 volt power, via four double pole double throw switches, to the linear motors powering the arms/claws.

ROV Drawings/Photographs

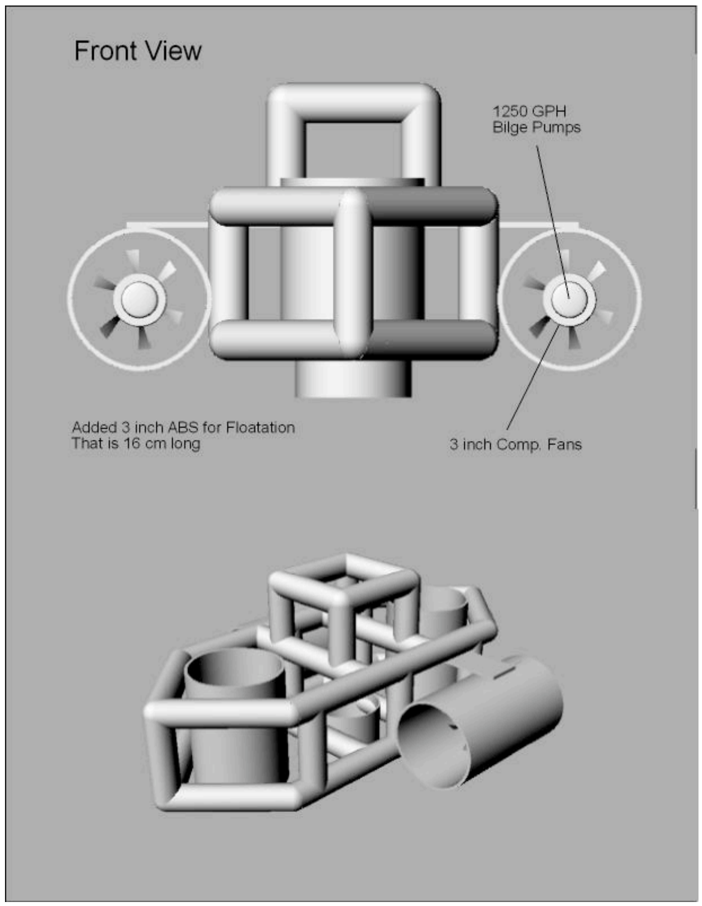

Figure 1 - Front & Oblique View of *DAB* Sans Arms/Claws

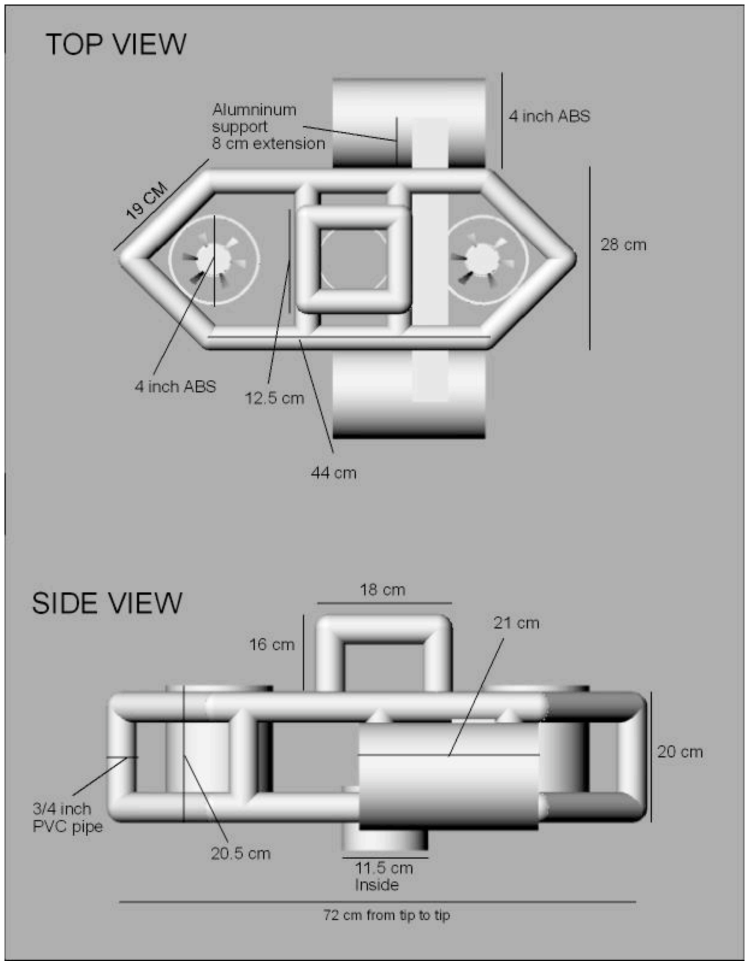

Figure 2 - Top & Side View of *DAB* Sans Arms/Claws

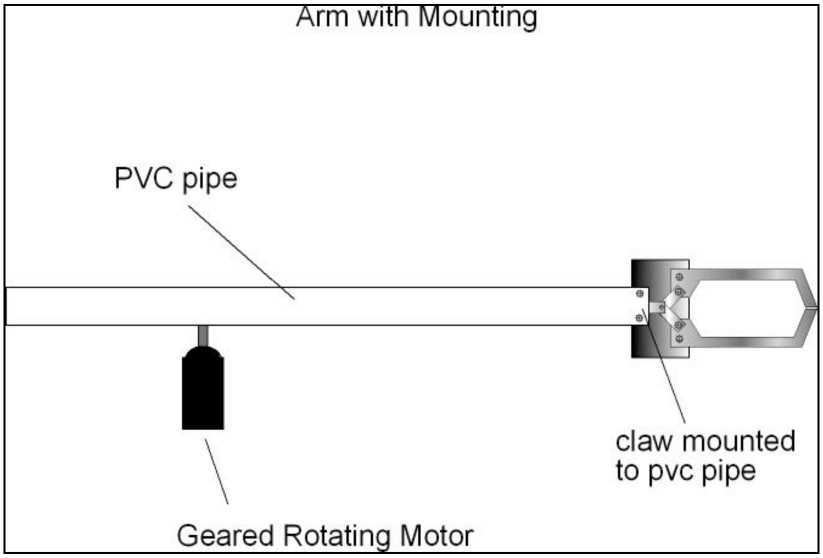

Figure 3 - *DAB* Arm/Claw

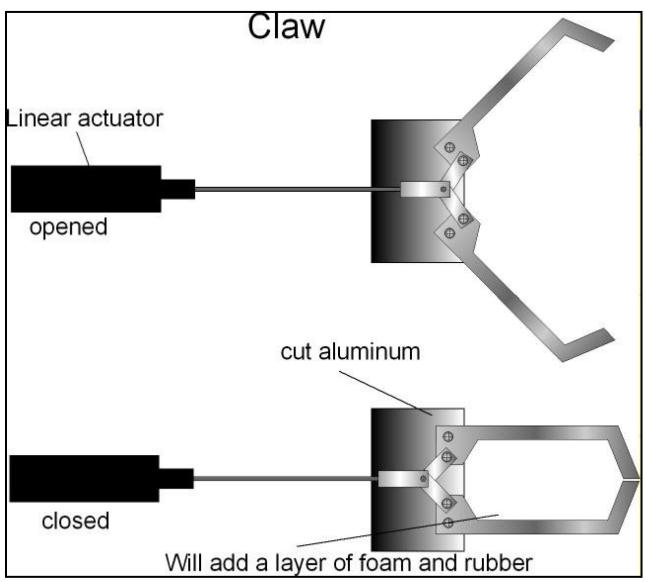

Figure 4 - *DAB* Claw

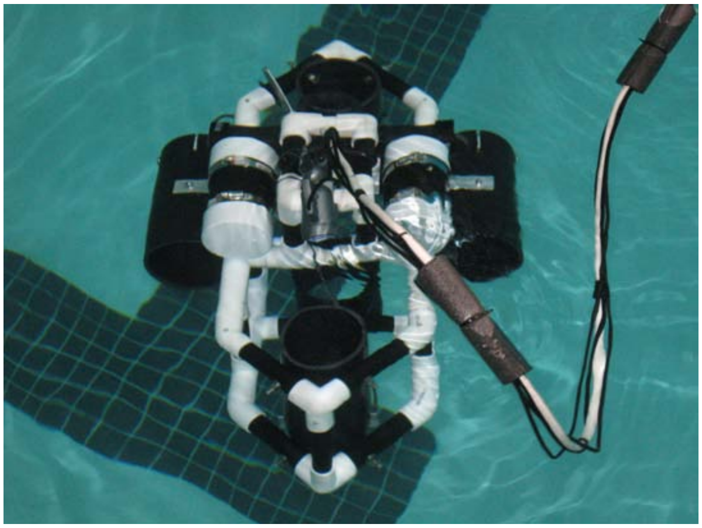

Figure 5 - *DAB* Awaiting Tests

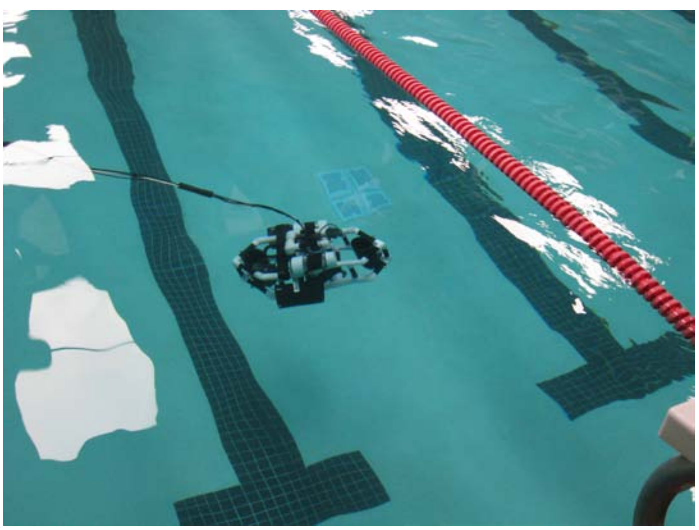

Figure 6 - *DAB* Powers to the Surface

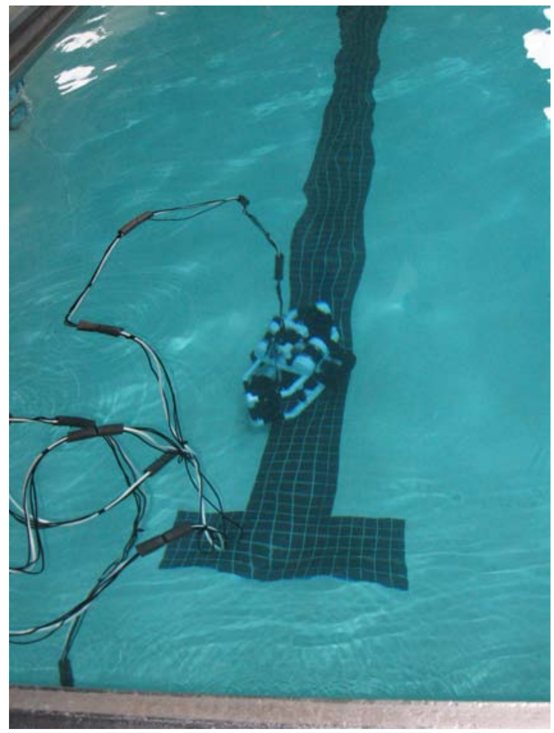

Figure 7 - *DAB* Navigating Bottom of Pool

Budget/Expenses

Budget

Source	Amount
CCC Science Department (School Funds)	$201.39
Columbia Pacific Maritime (Cash Donation)	$300.00
Englund Marine (Cash Donation)	$100.00
Rochester Trust (Cash Donation)	$400.00
Total Available Budget	$1,001.39

Actual Expenditures (Materials)

Item	Quantity	Unit Price	Total
3/4 inch PVC 3 part elbow	8	$0.65	$5.20
3/4 inch PVC 45 degree elbow	8	$0.65	$5.20
3/4 inch PVC T shaped elbow	24	$0.55	$13.20
3 meters of 3/4 inch PVC	1	$1.50	$1.50
3.7 meters of 4 inch ABS	1	$11.89	$11.89
3.7 meters of plumbing foam wrap	1	$2.50	$2.50
1250 GPH bilge pumps	4	$39.00	$156.00
3 meters of 1 ½ inch aluminum strip	1	$4.00	$4.00
5 inch steel bolts	2	$0.95	$1.90
		Total Actual Expenditures (Materials)	$201.39

Anticipated Expenditures (Non-material)

Item	Quantity	Unit Price	Total
Mileage (per mile)	190	$0.51	$95.95
Airfare (per person)	3	$327.39	$982.17
Lodging (per night)	8	$20.00	$160.00
Rental Car (per day)	4	$77.00	$308.00
Airport Parking (per day)	5	$10.00	$50.00
Excess Baggage (per bag)	2	$25.00	$50.00
		Total Anticipated Expenditures (Non-material)	$1,646.12

Budget Shortfall

Source	Amount
Total Available Budget	$1,001.39
Total Expenditures (Materials)	-$201.39
Total Anticipated Expenditures (Non-material)	-$1,646.12
Total Budget Shortfall (see Note 1 on page 9)	**-$846.12**

Donations (Cash)

Source	Amount
Columbia Pacific Maritime	$300.00
Englund Marine	$100.00
Rochester Trust	$400.00
Total Cash Donations	$800.00

Donations (Materials)

Item	Source	Quantity	Est Value
Heat Shrink	Wadsworth Electric	1	$1.00
21 meters, 9 piece Beldon Cable	Wadsworth Electric	1	$50.00
9 Volt geared motors	Andrew Jobe	2	$10.00
Linear actuator	Andrew Jobe	2	$7.60
Stainless steel nuts	William Krieger	32	$3.20
30 1 1/2 inch bolts	William Krieger	30	$30.00
Lock Washers	William Krieger	20	$2.00
Flat black paint	William Krieger	1	$4.00
Computer fans	CCC Computer Services	4	$4.00
		Total Donations (Materials)	$111.80

Recycled Materials (from 2008 ROV)

Items	Quantity
Brass couplings	4
Cameras	4
3 inch PVC floatation chamber	2
21 meter Cat 5 Cable	2
Switches	4

Note 1: As outlined on page 8, the team is still $846.12 short of the funds necessary to send three members to the competition. Alternative sources are still being explored, e.g. MATE Travel Assistance. It is anticipated that adequate funding will be obtained in time for the team to travel to the competition.

Electrical Schematic

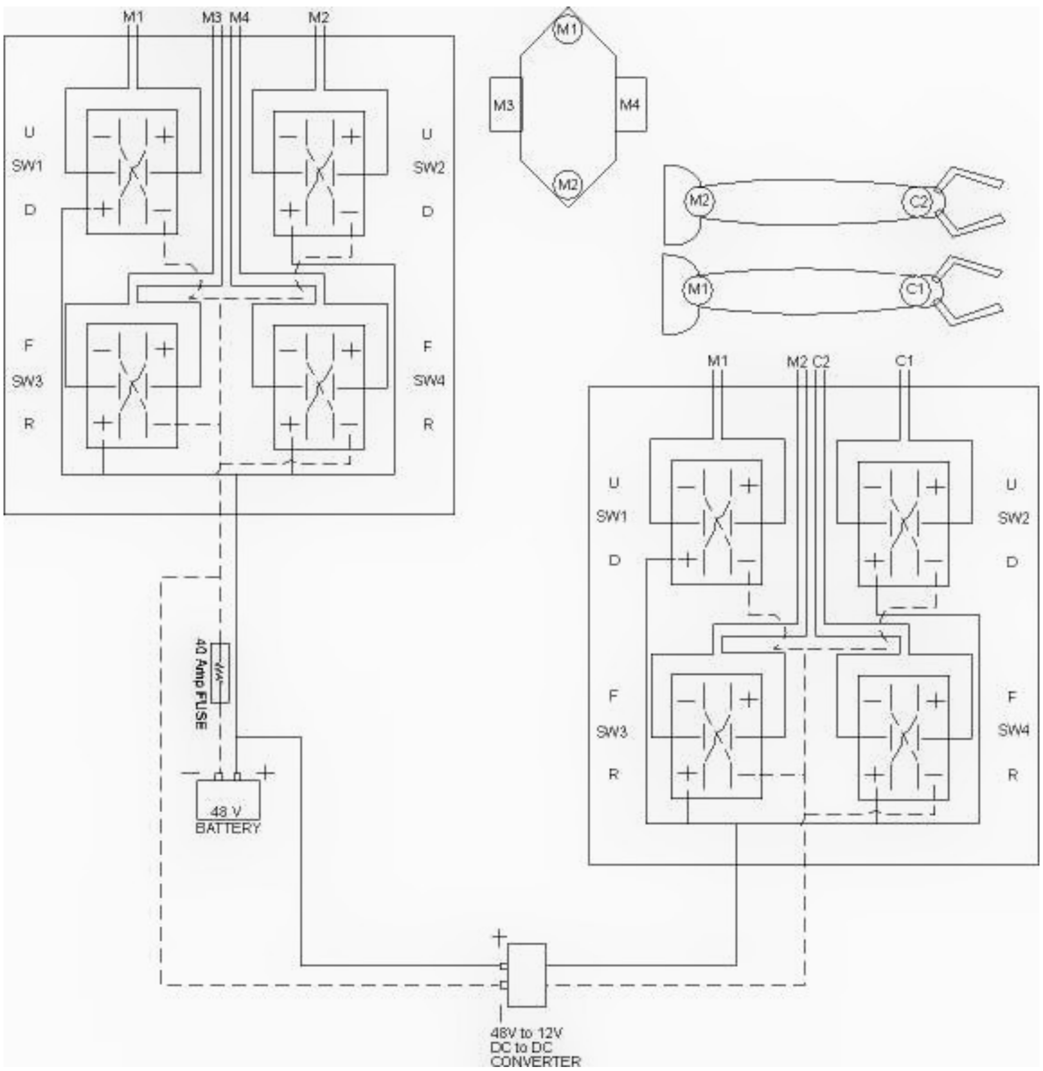

Figure 8 - *DAB* Electrical Schematic

Design Rationale

The overall design strategies followed throughout development of *DAB* were simplicity, ease of operation, and low cost.

Rhino 3D was used to design *DAB*. This enabled the team to model several different configurations before settling on the optimal design. The team chose the smallest, most compact vehicle that offered the best maneuverability and had the fewest abrupt angles so as to minimize entanglement surfaces.

The team chose 1250 GPH bilge pumps to provide propulsion because they offered the most thrust for their size. In addition, these pumps proved to be more watertight than the next largest size available.

DAB was initially designed to use computer fans as propellers because they were free and readily available from CCC Computer Services.

4 inch ABS propulsion housings were used because they were the smallest size available that could house and protect *DAB's* motors and propellers. Aluminum strips were used to mount the ABS housings to the frame because they were strong, light weight, and could be easily removed/adjusted to maintain optimal vehicle balance.

Electrical power is transferred via Beldon Cable to control *DAB's* propulsion system. Paired wires are connected to each motor to minimize the generation of heat and avoid the risk of a short circuit.

Cat 5 cables will be used to provide power and control to the arms/claws.

Cabling was secured using butt splices that were heat shrinked. This process was used because it was inexpensive, waterproof, and allowed for quick removal/replacement of the motors.

The team decided that motors would be controlled by double pole double throw switches. These were recycled from the 2008 ROV because they were a proven system that was available at no cost. The switches proved to be easy to setup and operate. In addition, because they are relatively simple, there's less that can go wrong with them and they don't require any programming.

Challenges

One of the first technical challenges faced was in discovering the cause of and correcting for a thrust differential caused by *DAB's* right motor which ran slower than the one on the left. While this situation could be compensated for by constantly changing directions, doing so slowed *DAB's* forward and aft progress. Since all of the recycled motors were the same, there shouldn't have been any thrust discrepancies between them. In order to determine the cause of the asymmetric thrust, the team removed and disassembled the right motor. Examination revealed that it had experienced water intrusion that resulted in significant rusting inside the motor. Not wanting to run the risk of this happening to the other motors, the team replaced all four of them with new ones.

One of the biggest nontechnical challenges in doing a project of this type was in coordinating the disparate schedules for various team members. Despite this reality, the majority of the work for this project was done by various team members outside of class.

Troubleshooting

As with any technical endeavor, the *DAB* team had to investigate and solve problems that arose as well as identify areas for improvement and implement necessary changes. One of the areas identified for improvement was vehicle speed. The computer fan propellers, although they did propel the vehicle, didn't provide enough thrust. To increase *DAB's* speed, the team resorted to the time-tested troubleshooting technique of observing the effectiveness of different propeller installations. First, the team placed *DAB* in the pool and ran in to figure out how much thrust the original computer fan propellers produced, i.e., they each generated 7 newtons. Team members then replaced the propellers on the left and right side motors, adding a modified 3 ½ inch four bladed model airplane propeller on one side and a regular 2 inch two bladed remote controlled (RC) boat propeller on the other. *DAB* was maneuvered around the pool again and it was determined that, even though the propellers were quite different, they produced 12 newtons each. However, since the RC boat propeller was a stock item and half the size of the modified plane propeller, it was determined to be a more suitable replacement for the computer fan propellers.

Lessons Learned/Skills Gained

Use of Rhino 3D as the design tool for *DAB* proved to be most advantageous. The team used the program to quickly draw four different vehicle configurations. Using the team's design criteria, members were able to rapidly identify the model that best suited their needs. An unexpected benefit of using Rhino 3D was the precise measurements it rendered. This enabled the team to build *DAB* without making mistakes, i.e., there were no oversized or undersized components. Not only did this allow the team to build the vehicle quickly, but it also eliminated potentially expensive waste.

Payload Tools

Payload tools on *DAB* will include two electromechanical arms/claws that will be used to move the pods and complete the other competition manipulation tasks. An alternative tool for lifting the pods could have been a simple hook. However, a hook would have made completion of the other tasks virtually impossible. Electromechanical arms/claws, on the other hand, enable the operator to ensure maximum control when manipulating a hatch, hose, valve, etc.

Future Improvements

The team plans to do a number of improvements to *DAB*. The most obvious is building and installing the arms/claws with their attendant motors, power supply, and control systems. The configuration of the underwater video cameras will also be changed and an additional forward camera installed to provide the operator with a panoramic view. A further modification will be to the tether, reducing its length from 21 to 16 meters to minimize voltage drop. Finally, the team plans to install 3-3 ½ inch RC boat propellers to generate even more thrust, significantly increasing vehicle speed.

Submarine Rescue Systems

In the early days of submarines, most Submariners probably knew they were unlikely to survive a deepwater mishap that involved the rapid sinking of their vessel. This was evidenced by the fact that from 1929 thru 1939 the US Navy lost 700 men from 20 subs. The genesis to reverse this trend began in 1925. Lieutenant Commander Charles "Swede" Momsen, USN, was involved in an unsuccessful search and rescue operation for a submarine that had sunk following a collision with a surface vessel in September 1925. Momsen, moved by the loss of life, decided to focus on devising ways to rescue stranded Submariners. He went on to develop a number of rescue devices including a diving bell specially modified for submarine rescue (Swede). The diving bell was successfully deployed in 1939 to rescue 33 men trapped aboard the sub *USS Squalus* (Rescue).

In 1963 the US Navy lost the submarine *USS Thresher* and its entire crew at a depth greater than could be reached by rescue vehicles in use at the time. This event prompted the development of the Deep Submergence Rescue Vehicle (DSRV) program which led to the completion of the first of two DSRVs, i.e., DSRV-1, in 1970. DSRV-1 could be transported via various means, including by air, to the site of a downed submarine and operate with a mother ship or sub. These self propelled vehicles, operated by two pilots and two crew, could descend, search with sonar, and attach itself to the escape hatch of a stricken sub. It could then transport 24 evacuees at a time to the surface. In addition, the DSRV used an arm with a gripper that was able to lift 1000 pounds so it could clear debris away from hatches. The arm also included a cable cutter (Deep).

Figure 9 - *Mystic* (DSRV-1)
US Navy Photo

The US Navy's submarine rescue capability underwent a significant evolutionary step in 2008 with the implementation of the Submarine Rescue Diving and Recompression System (SRDRS). SRDRS is actually a collection of components that, like the DRSV it replaces, can be deployed by air or other form of transport to any location in the world with the goal being to be at the site of a stricken sub and beginning rescue operations within 72 hours of being notified. Elements of SRDRS include: Atmospheric Diving Suit, i.e., a pressurized hard diving suit with a diver inside, used to inspect a stricken sub and clear debris away from hatches; a remote controlled Pressurized Rescue Module (PRM); and, scheduled to be delivered in 2012, a Submarine Decompression System (SDS). The PRM can be deployed from military or commercial ships (New). The vehicle, attached to a control/power tether, is remotely directed by a "pilot" located in a special van aboard a surface ship. The pilot directs the PRM using information provided by video cameras and sonar attached to the vehicle. A major design feature of the PRM is the skirt used to attach to a stricken sub. The skirt can be rotated up to 45 degrees and still be attached securely to the hull of a submarine. Once the skirt is properly positioned and sealed, two attendants inside the PRM can evacuate up to 16 survivors at a time (Gibson and English).

Figure 10 - US Navy PRM
US Navy Photo (MCS2 A. Riveracorrea)

Reflections

Team members were able to see the fruits of their labor in an operational vehicle. This was especially significant because, with the exception of two members, no one had ever done anything like this project before. Of course, members of the team were rightly proud of the fact that *DAB* was designed, built, and successfully operated in a relatively short period of time.

Teamwork

The team began the project by meeting to brainstorm various ideas. This not only proved highly effective but ensured members had significant input on how *DAB* should be designed, built, and operated. Meetings continued throughout the process to discuss design revisions as well as to make modifications, conduct tests, review documentation, etc. Since it wasn't possible for each member of the team to be at every meeting, the team also relied extensively on email and cellphones. Email proved to be particularly vital. While used throughout the project, email helped make members aware of corrections that needed to be made to the draft technical report. Those responsible for making the changes were able to do so and email them for inclusion in the final report.

References

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Riveracorrea, Alexia M. "DSU Tests New Submarine Rescue System with Chilean Submarine." NAVY.mil. 1 October 2008. 20 May 2009. <http://www.navy.mil/search/display.asp?story_id=40097>.

"Swede Momsen: Diving & Rescue - Early Interest." Office of Naval Research. 20 May 2009. <http://www.onr.navy.mil/focus/blowballast/momsen/momsen2.htm>.

Acknowledgements

The team is very appreciative of the guidance and support provide by Pat Keefe and Julie Brown. We are also very grateful for the financial support provided by the CCC Science Department, Columbia Pacific Maritime, Englund Marine, and Rochester Trust. In addition, we are thankful for the donation of material by Wadsworth Electric, Andrew Jobe, William Krieger, and CCC Computer Services. Finally, we extend our appreciation to the Astoria Aquatic Center as well as the Sunset Empire Parks and Recreation District for use of their pools.

Team Photographs

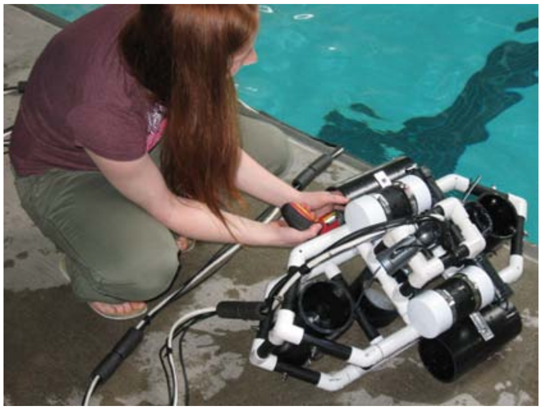

Figure 11 - Victoria Replaces Propeller

Figure 12 - Paul and Justin Evaluate Propulsion

Figure 13 - ROV Team
Back Row (L-R): Justin Krieger, David Moberg, Pat Keefe (Instructor/Mentor), Julie Brown (Instructor/Mentor), and Jerry Howe
Front Row (L-R): April Nicholas, Victoria Lagerquist, John Bowie Jr., and Ken Thysell
(Not Pictured: Blake Higgins, Andrew Jobe, Paul Lenz, and Alesia McDonald)