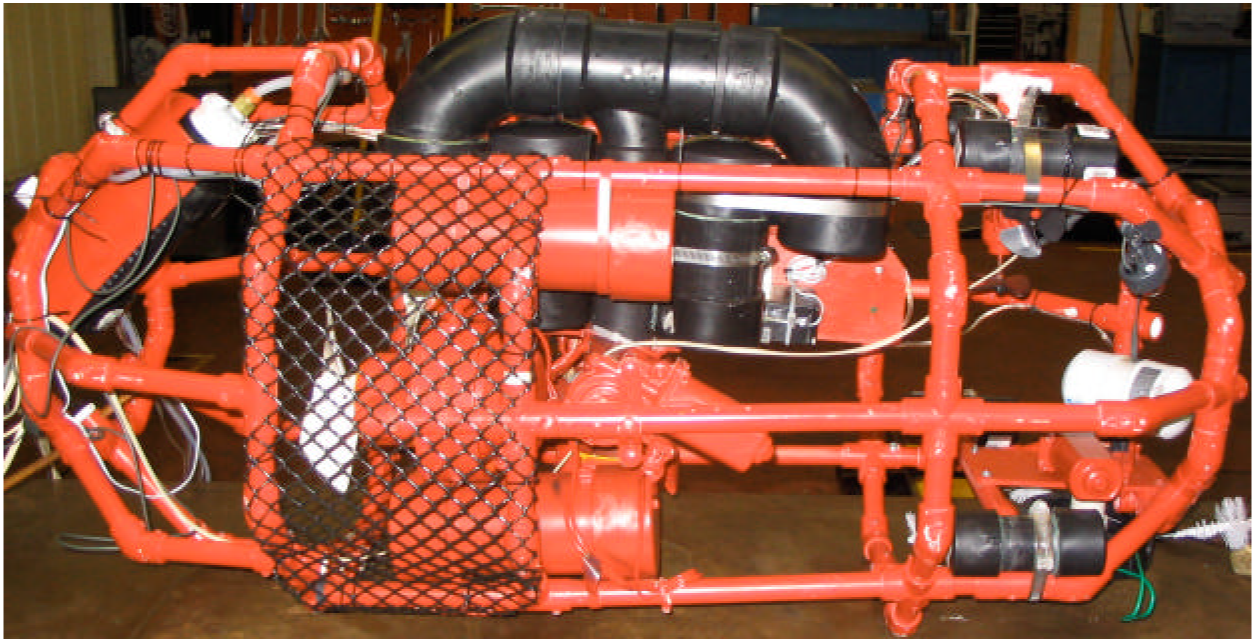
Monterey Peninsula College

presents

Team Sirius featuring the ROV *Red Dwarf*

A return mission to Europa



Monterey Peninsula College Robotics Club:

Club Members	
Jeremy Hertzberg	Gregory Kaufman
Joe Buffo	Timothy Ward
Robert Hewlett	David Gavrin
Victor Sinatra	Robert Wright
Club Advisors	
Frank Barrows	Tom Rebold
Steve Pearce	

Abstract:

When building a Remotely Operated Underwater Vehicle (ROV) one must make many design decisions. Design decisions are made based on overall cost, simplicity, feasibility, and what mission tasks are required. The Monterey Peninsula College (MPC) robotics club took these parameters into account when designing our ROV to meet the criteria of the National MATE/MTS ROV Competition being held June 16-19, 2005 at Johnson Space Center's Neutral Buoyancy Laboratory in Houston, Texas. We have taken many ideas from existing ROV designs as we built our ROV. We have also designed a new way of giving ROVs more maneuverability while still keeping a stable platform from which to work. We present these design ideas, steps taken during the build process and lessons learned in this document.

Introduction

From the first excursions across the oceans, man has pushed to discover all corners of Earth including the oceans. Our first steps into the depths of the oceans used manned diving bells and submarines. As technology has matured, we have been able to create robotic explorers to be our advance scouts and/or remove the need to send humans into dangerous habitats. With the ocean covering 71% of our planet we have explored less than 5% of the ocean [1]. The Remotely Operated Vehicles (ROV) and Autonomous Underwater Vehicles (AUV) will greatly aid us in our search to understand the unknown portions of the ocean. While there is much work to be done in Earth's oceans we have pointed our gaze to the heavens. We have plans to send our robotic vehicles into space in hopes of exploring the oceans that may exist on Europa [2][3]. These missions are the inspiration for the 2005 MATE/MTS National ROV competition, taking place in Houston, Texas at the NASA Neutral Buoyancy Laboratory.

This report details the Monterey Peninsula Robotics Club plans, design and building processes for the 2005 MATE/MTS National ROV competition. The main parts of this paper will describe our design rationale, design specifications, and challenges we faced and lessons learned along with acknowledgements to the people that made building our ROV possible.

Design Rationale

The Monterey Peninsula Robotics team brainstormed ideas for this year's ROV design. We separated into small teams to build prototypes to help us decide on the best design. We also looked to our experience from the last two years building ROVs for the MATE/MTS ROV competitions. Our initial ideas saw two possible paths to go down in building our ROV. One would lead to a highly stable ROV platform from which we would build a highly articulated tool/robot arm to reach all mission tasks. The other design would build more fixed tools with less flexibility, but the ROV would be able to position itself into many more orientations in order to complete the tasks. As we studied our strengths we realized that we were better at building highly maneuverable ROVs than building articulated robot arms. As we completed the prototype design phase it became clear to us that we could build an ROV that would combine the two paths by building on our strengths, maneuverability to place fixed tools where was needed and a provide a highly stable platform while doing the mission tasks. Our ROV design is outlined in the following system and components sections.

ROV Systems And Components

Overall Design /Construction Materials

Our final design for our ROV can be seen on the title page of this report. The final dimensions of our ROV are 100cm long, 50cm wide and 50cm high. Our ROV is able to point the front down to pass through the hole so that allowed us to set our length greater that the hole dimensions.

Our main construction material was PVC piping. The main reason for using PVC was the low cost and that it could easily be repaired and modified as we built the ROV. Originally, our frame was a rectangle, but it would allow us only four ways to pass through the ice hole since the girth was so close to size of the hole. Essentially, each corner of the ROV would have to match up with a corner of the ice hole. After some thought, we settled on an octagonal shape by removing the corners, as looking front to back. We also tapered the front and back to more easily guide the ROV through the ice hole should we make contact with sides. The design could now go through the hole in an unlimited amount of positions with ease. Our second most widely used material was ABS piping, which we used for our flotation systems since it is positively buoyant and less expensive than syntactic foam. Syntactic foam is widely used in professional ROVs for flotation.

The motor configuration uses two drive motors for forward/backward movement and turning. One lift motor for moving up and down through the water column. There are four more auxiliary motors that provide fine adjustments, operation of our tool carousel system, and to control our vectored buoyancy system (see following sections for detailed description).

Flotation

For the flotation system we chose to use ABS plastic piping as it is more readily available and cheaper than syntactic foam. To make the cylinders we glued two end caps to a pipe and held it together until the glue set up. These cylinders are positively buoyant. The only drawback that we saw was we did not know what the pressure of being at 13 meters in depth would do to the integrity of the piping. To test this we built a few prototypes, one being sealed with ABS cement and the other with Plastic Welder. We than took them to Desert Star Systems and used their pressure test chamber to make sure that they would stay sealed, which they did. We then made one of the cylinders neutrally buoyant and Robert Hewlett took it to a depth of 13 meters in salt water to see if it stayed neutrally buoyant. He observed that the cylinder was neutrally buoyant for a few seconds and then started to sink, compressing the air in the cylinder as we felt this would happen. So to counter this phenomenon we chose to make Red Dwarf positive on the surface and fight it to the bottom of the pool so we could be as close to neutrally buoyant as possible to offset this compression. Even if we end up being slightly negatively buoyant at the bottom we feel that we will be still able to overcome this with our strong motors.

Vectored Buoyancy

The design feature that has allowed us to build an ROV larger than the 60cm by 60cm ice hole we have called vectored buoyancy. To understand how vectored buoyancy differs from most ROV designs one needs to understand the principal of metacentric height (MH). Metacentric height (MH) is the distance between the center of gravity (CG) and the center of buoyancy (CB). Center of gravity is the point within an object where gravity is considered to act downward on its mass. Center of Buoyancy is the point within an object where the force of buoyancy can be considered to act in an upward direction. MH is the primary factor in determining stability and agility of a submersible. To help understand MH and stability, picture a hollow metal ball. It has the same mass as an equivalent volume of water. When placed in the water (neutrally buoyant), the ball would spin very easily since the CG and CB occupies the same spot at the center of the ball. This means that the ball has a MH of zero (0). A value of zero means that the ball has a very high amount of maneuverability/agility, but low stability. This would be seen if a mark was made on the top and the ball was spun a number of times. When the ball stopped, the mark would be positioned at different locations each time. Next, taking some of the metal from the wall of one side and adding it onto the opposite side and then spinning again, the ball will still spin fairly easily, but it will always end up with heavier side down. The MH is higher than in the first case since the center of gravity (CG) has moved away from the center of the ball. Notice that both balls have the same volume and the same weight. As we move the CG and CB farther apart this self-righting characteristic will become more apparent, while its maneuverability/agility will become more and more impaired.

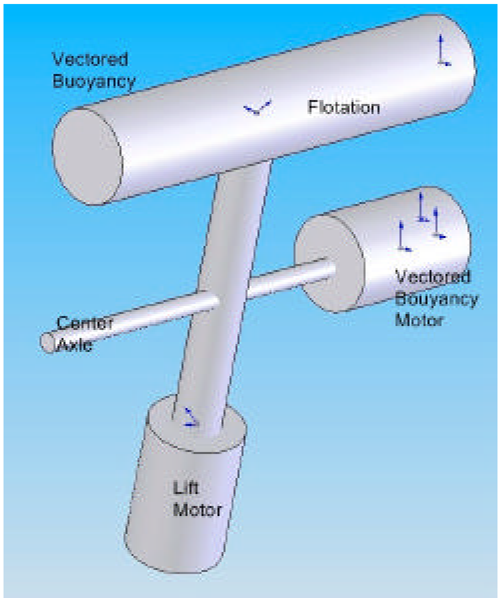


Figure 1: Vectored Buoyancy

In any submersible design, metacentric height is a major factor in determining how the vehicle will respond. Most ROVs have a high metacentric height since they place a large, fixed amount of flotation high in the frame to create a high center of buoyancy and place their weight low down in the frame to create a low center of gravity (CG). This creates a stable platform and the ability to easily right themselves in the case of turnover.

Metacentric height was pivotal in our design process that lead to vectored buoyancy. Vectored buoyancy refers to our main flotation system and the ability to rotate it within the frame of our ROV. See Figure 1. Vectored buoyancy consists of a high metacentric height by placing all the flotation and a counter weight (our lift motor) about 50cm apart. By placing an axle running through the center point between the flotation and the weight, we then mounted it to our frame by attaching it to our vectored buoyancy motor (VBM). The separation of the buoyancy and the counter weight (vertical motor) gives the VB system its incredible ability to control the orientation of the rest of the ROV's structure. With the ROV sitting in the air, the VBM will spin the vectored buoyancy around inside the frame. However, when the ROV is placed into the water the fact that the vectored buoyancy will seek out a state where the CB (flotation) is above the CG (lift motor) the frame of the ROV will rotate instead. Vectored buoyancy allows us to place the front of our ROV straight down and pass through the ice hole with 5cm to spare on either side since our width is 50cm. Since the flotation is always in the upward position like most other ROV we get our stable platform, but we have the ability to place our fixed tools wherever we need for the mission tasks.

Propulsion

When deciding on the ROV design we desired to have as much power as we could. We knew that if we had lots of power there would be more time to actually complete the tasks because we could drive from the surface faster. Our motors of choice are Bilge pump motors since require no waterproofing and for this year’s competition we were able to reuse existing

Image 1

motors. The motors that we chose to use were three Rule^{TM} 3700 GPH (gallons per Hour) motors for the drive, and lift motors and two Rule^{TM} 360 GPH bilge pumps for the fine adjustment/crawling motors. The 3700s impellers were removed and replaced with propellers donated by the U.S. NAVY in 2002 (see IMAGE 1). These propellers were from Sea Eagles and have 3 blades with a diameter of approximately 15cm. The smaller crawling motors were outfitted with 3 bladed propellers with a diameter of approximately 5cm. These motors give us excellent control of Red Dwarf and the power we desire.

Tool Carousel

One design feature of Red Dwarf is the Tool Carousel. This design came from an idea of having a Swiss Army knife-like tool kit (see IMAGE 2). The tool carousel is a set of tools mounted on a disk and then attached a motor. Throwing a switch on the surface allows the pilot to rotate the desired tool into position for each task. The tool carousel is designed to delivery the probe to the science package, open the draw and retrieve the probes.

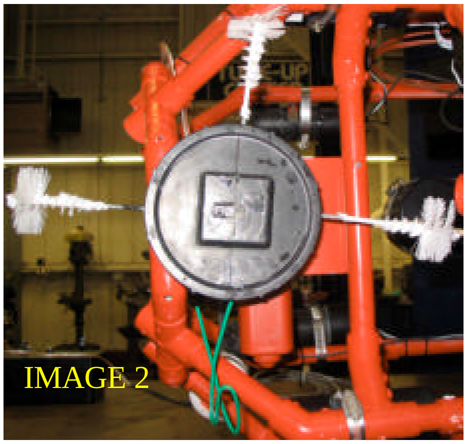


IMAGE 2

Tether Wire Selection

We decided on a tether length between 100 and 110 feet. We were able to get 14-gauge speaker wire for a good price to make our power tether, but we wanted to verify that this gauge of wire would work over our expected length of tether. What we had to be sure of was that our tether would not lose too much voltage/power over the length and therefore not provide enough to drive our motors.

Using resistance data from Handbook of Electronic Tables and Formulas for American Wire Gauge (AWG) [4] for different length wires we were able to confirm that the 14-gauge wire could be used as our power tether. From the AWG data we calculated the resistance for our 16-gauge of wire, see bold numbers in Table # 1 .

AWG	From AWG Defined Table[4]		Round Trip Cable Length Resistance – From power supply down to ROV and back to power supply.					
Wire Gauge	Ohms/ 1000ft	Ohms/ft	[Ohms] per # of [ft]					
			200ft	220ft	240ft	260ft	280ft	300ft
14	2.525	0.003	**0.505**	**0.556**	0.606	0.657	0.707	0.758
15	3.184	0.003	0.637	0.700	0.764	0.828	0.892	0.955
16	4.016	0.004	0.803	0.884	0.964	1.044	1.124	1.205
17	5.064	0.005	1.013	1.114	1.215	1.317	1.418	1.519
18	6.385	0.006	1.277	1.405	1.532	1.660	1.788	1.916

Table # 1: Calculated Resistance of Different Gauge Wire of Varying Lengths

Next, we needed to know the power draw from our power supplies at 3 Amps and 10 Amps. For a current of 3 Amps from a 12 volt battery we calculated 36 Watts of power draw. For a current of 10 Amps from a 24 volt battery we calculated 240 Watts of power draw (see Table 2). Note all numbers relating to our 3 amp system are marked in red and all our 10 amp system are marked in blue.

	Power Draw [Watts] From Power Supply @ # Amps								
Battery Voltage	**# Amps**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
12		**36W**	48	60	72	84	96	108	120
16		48	64	80	96	112	128	144	160
24		72	96	120	144	168	192	216	**240W**
36		108	144	180	216	252	288	324	360
48		144	192	240	288	336	384	432	480

Table # 2: Calculated Power Draw From Power Supply

Using Ohms laws to relate power, voltage, current and resistance we are able to calculate the power and voltage loss over the tether. We tested our motors and found that the smaller motors had a current of about 3 amperes running on 12 volts and the larger drive motors pulled about 10 amperes when running off of 24 volts. Using the formulas:

$$Power = I^2 \times R$$

$$Voltage = I \times R$$

where R = resistance(Ohms), I = current(Amps), we can calculate the power and voltage loss over the tether. Our results are listed in Table 3.

	Power Loss Of Wire @ 3 Amps		**Power Loss Of Wire @ 10 Amps**	
AWG	**200 ft**	**220 ft**	**200 ft**	**220 ft**
14	4.546	5.000	50.510	55.561
	Voltage Drop @ 3 Amps		**Voltage Drop @ 10 Amps**	
AWG	**200 ft**	**220 ft**	**200 ft**	**220 ft**
14	1.515	1.667	5.051	5.556

Table # 3: Power/Voltage Loss Over Tether

Armed with Table # 3 data we can take our two power supplies, 12V and 24V and subtract out the losses to get the remaining voltage and power supplied to our motors. We have done this in Table # 4, so that we will be running our smaller motors at about 10 volts while the larger motors will be getting about 18.5 volts.

	Remaining Power @ 3 Amps – 12V Supply		**Remaining Power @ 10 Amps – 24V Supply**	
AWG	**200 ft**	**220 ft**	**200 ft**	**220 ft**
14	31.454	31.000	189.49	184.439
	Remaining Voltage @ 3 Amps – 12V Supply		**Remaining Voltage @ 10 Amps – 24V Supply**	
AWG	**200 ft**	**220 ft**	**200 ft**	**220 ft**
14	10.485	10.333	18.949	18.444

Table # 4: Remaining Power/Voltage Through Tether

Therefore, we have proven that the 14-gauge speaker wire will work for our tether even though there will be some power/voltage loss. During pool tests we have experimental verified that our ROV still works and have also decided that the slight loss is worth living with since the most important thing is to keep our total current draw under the 40 ampere limit imposed by the competition rules. Also, we were also limited by the selection of wire and the total cost.

Control Systems

The ROV Pilot Control System consists of two control systems. The first is a computer-based piloting system (CBPS) that operates the main drive thrusters using a control stick.

The control stick that interfaces with the Pilot Control System is any USB (universal serial bus) joystick, which includes a throttle stick and rotation control. (Image 3). The motors controlled by this part of the system are the two horizontal driving (forward/reverse and turning) motors and single lifting motor for depth control.

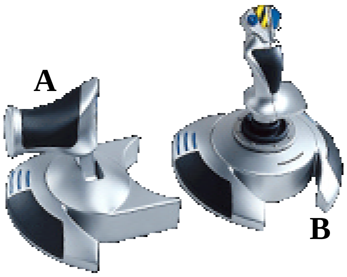


Image 3: USB Joystick

Depth rate of descent/ascent is controlled with the throttle stick (Image 3: **A**), which is a simple push/pull control stick. Pushing the throttle forward from the center position will cause the ROV to descend. As the throttle stick is brought back towards the center position, the motors will slow to a stop. Continuing to pull the throttle backwards will cause the motors to switch direction and increase speed, lifting the ROV towards the surface.

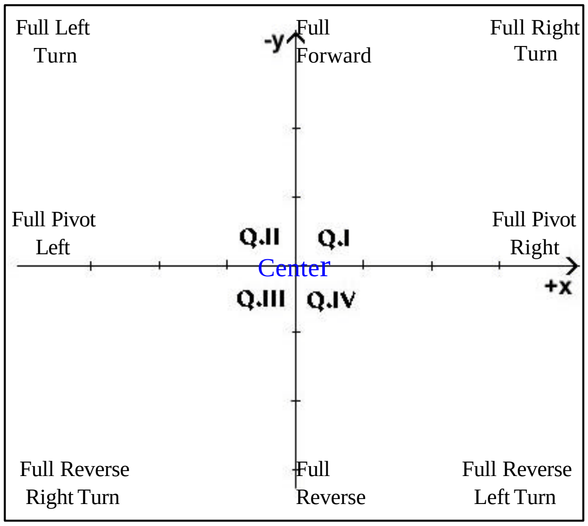


Figure 2: Joystick Coordinate System

For horizontal driving control, the joystick (Image 3: **B)** can be used in two modes. Mode one operates the ROV with forward/reverse and turning capability.

Figure 2 shows the coordinate system for the joystick. The center position holds all drive motors in the stopped position. As the joystick is pushed out in any direction from the center, the ROV motors will increase in speed from the stop position (0%) to full speed (100%). The exceptions to this are the diagonals. In these cases, one drive motor will increase in speed while the other one will remain stopped. This produces a turn about the stopped motor. Each point marked in Figure 2 (ex: Full Reverse, Full Pivot Right, etc…) defines an extreme where either motors are running at full speed or stopped position. All other points are combinations of the drive motors to produce smooth transitions as the joystick moves about the coordinate grid.

Mode two limits the ROV movement to only pivoting about the center of the drive motors. By holding down the main trigger button and rotating the joystick to either the left or right the ROV will pivot in place. Pivot speed is controlled by the amount the joystick is rotated.

The Pilot Control Software is the part of the ROV system that interacts directly with the ROV pilot. The ROV pilot uses the software to translate the joystick movements into serial data that controls the ROV motors (See Figure 3).

Select Com Port: Com Port 3

Figure 3: ROV Pilot Control System

To setup the joystick, simply plug any USB joystick, which includes a throttle stick and rotation control, into the computer. The software will automatically acquire the joystick when started up. If the joystick is not plugged in before the software is launched it can still be added. Once added clicking “Check For Joystick(s)” button will cause the software to search for the joystick. If the joystick appears to be uncalibrated (ROV should remain still when joystick is in center position) then the pilot can calibrate it by clicking the “Calibrate Joystick” button and following the instructions. Clicking the “Show Current Motor Data” button will give the pilot a numerical display of the real-time joystick data that is being transmitted down to the ROV through the com port selected. See joystick section above for more information.

The hardware piece of this control system consists of two main parts. Part one is the microcontroller and the second part is the h-bridge motor controllers. The microcontroller from Parallax Inc. is called the Basic Stamp (Figure 4). The Basic Stamp sits between our Pilot Control Software/Joystick and the motor controllers/h-bridges. It interprets the serial port signals, using the PBasic programming language, from the control software and creates the desired signals to the motor controllers to control our speed and direction. For direction control, the Basic Stamp controls a relay that switches between the forward and backward

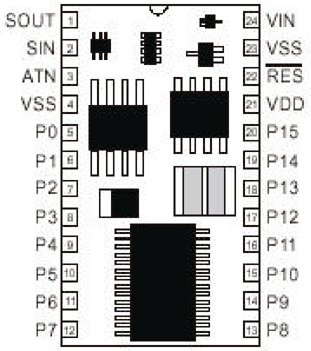


Figure 4

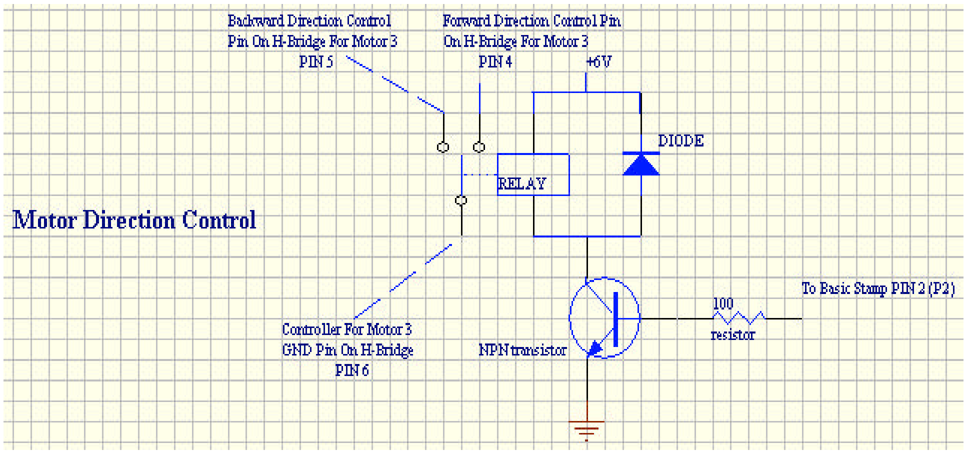


Figure 5: Motor Direction Control Electronics (one motor

direction. (Figure 5) For speed control, the Basic Stamp produces a PWM (pulse width modulation) signal. A PWM allows our Basic Stamp to produce an analog signal even though it itself is a fully digital device [5]. This analog signal is then past through our speed control electronics (see Figure 6) and into the H-Bridge control running our motors at the desired speed.

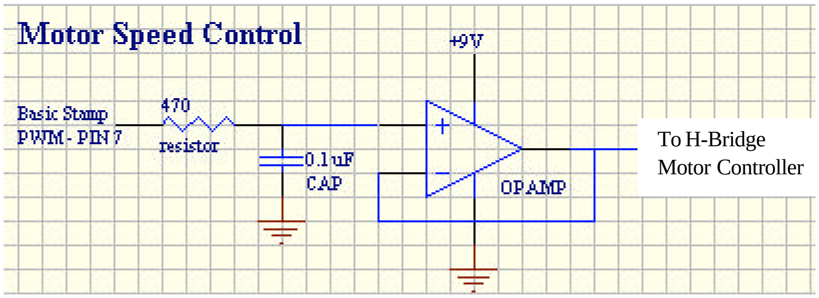


Figure 6: Motor Speed Control Electronics 1 motor

Combining the two signals (speed and direction) through an h-bridge controller we can drive a motor forward or backward and we can adjust the speed from standing still to full thrust from each motor.

The second or auxiliary control box (Image 4) places the controls for four of the smaller motors in a single right hand operation configuration. The specific contros switches are the top black switch rotates the tool carousel left or right. The middle hat switch provides fine pitch and yaw control. Finally, the lower left paddle switch controls the vectored buoyancy. Each of the switches is a double throw double pole center off (DPDT Center Off) switch configured for polarity reversal. The hat switch includes two DPDT Center Off switches configured at right angles to each other and sharing one toggle. The auxiliary power box draws its power from one 12V battery.

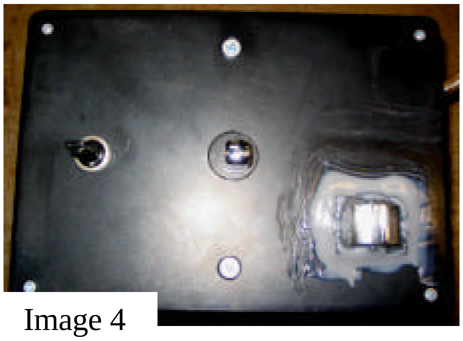


Image 4

Cameras

Image 5: Ananconda Camera

For our cameras, we settled on using X-10 Anaconda cameras (Image 5) designed for home security systems. The two reasons for using these cameras is their low cost and our experience with them from past projects. Each time we have to take each camera and seal them so that they will survive underwater. A number of methods where used to seal our cameras, but we designed a new sealing system which minimizes the time and keeps the original format of the cameras. In past years we would remove the electronics from each camera and seal it in epoxy making the need to design new mounting points. With this new technique we leave the camera in its original housing. Our process is as follows. First, focus the camera to the desired distance. Then use five-minute epoxy to seal the joint between the camera housing and the lens. Doing this will also set a constant focus. Let it cure for about five minutes. Next the two screws holding the back of the housing where removed (look under the sticker) and the housing was opened. The microphone was popped free and covered with a small piece of plastic bag before being pushed back in to its hole. Next a large batch of five-minute epoxy was mixed and spread all over the printed circuit board (PCB) till the epoxy filled up all of the area below the PCB and covered the board. Finally the back was replaced and the camera was left sitting lens down for about fifteen minutes. In our initial tests the cameras have remained watertight.

Mission Tasks

Ice Hole

Having to pass through a defined hole seriously affects the ROV design. Our very early designs limited the ROV in all dimensions to be smaller than the ice hole. As we have described in earlier sections our final design removes some of the restriction by allowing us to build a long ROV since we can rotate to a head down position using vectored buoyancy.

Science Package

Our tool carousel as described above will handle delivering the probe to the science package and retrieving the probes. We also feel that our motors will give us more than enough thrust to open the door to the science package.

Sample Fluid Return:

From the very beginning we came up with two variations of a suction system. The first idea was to run a hose up the entire length of the tether to the surface. On the surface there would be a pump system independently powered by AC power. The hose would terminate in two special reservoir setups that would separate the sample from the water. Due to complex nature of operating a system like this, this first idea was not looked upon as an ideal solution. There was simply too much chance for contamination in the sample from the ambient water.

The second concept (Figure 7) used a similar infrastructure of topside pumps but only needed one reservoir and utilized a special diaphragm within a container mounted on the front of the vehicle. To make the sample flow into the diaphragm, a special interface was made at the rear on the container. Making the system work is a very simple operation. Before a mission the diaphragm had all air removed from it and the rest of the container was flooded. Once near the target the topside pump would be activated and water would flow from the flooded portions of the container. The loss of fluid in this portion of the container caused the diaphragm to expand in turn sucking up the sample fluid. The pressure would also serve to hold the sample in its place until reverse pressure is placed on the diaphragm. Prototypes of this system were built and tested very successfully, able to suction over 700 ml of non-contaminated sample fluid.

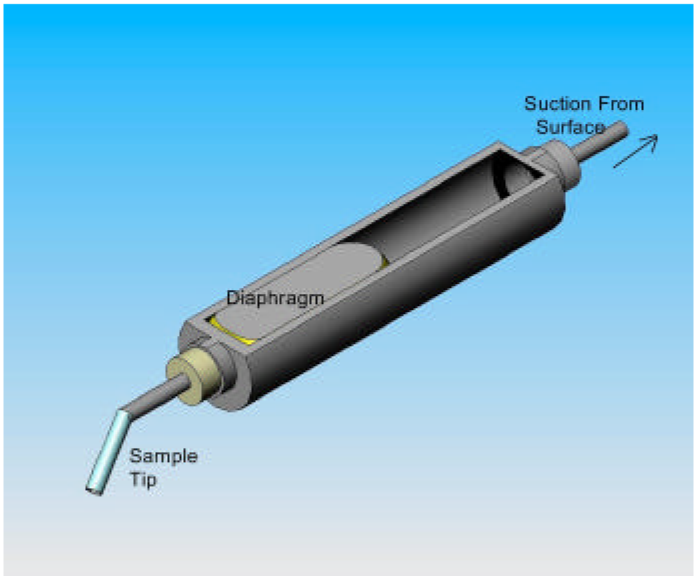


Figure 7: Cutaway View of Sample Fluid Return

Temperature Measurement

For this task, we decided to take an indoor/outdoor thermometer from Radio Shack. We took it out of the case, placed it in a waterproof container, and hooked 2 AA batteries to it. We mounted it onto the frame in a way that we could mount a camera pointing directly at it to read the digital screen. We ran into a light issue when there is a large amount of light, the view window can be highly reflective, making it impossible to see the display. Our solution was to incase the camera and the temperature display inside a box and add a controlled light source.

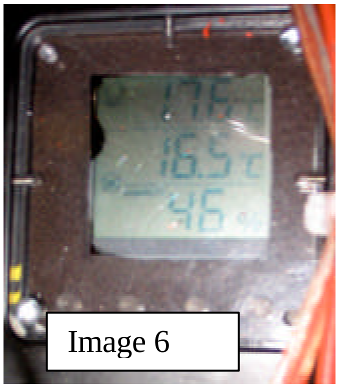


Image 6

Troubleshooting techniques

Our first tether was enormous, consisting of 14 power wires, 9 camera cables and 1 air tube. In an effort to make our overall tether more manageable we hacked the X-10 Anaconda cameras and were able to reduce the cable needs for the cameras by one-third. The Anaconda uses a very simple cable structure of six wires per cable. Upon examination of one camera cable we were able to determine the following:

Wire Color	Purpose
GREEN	GROUND
RED	POWER (12V)
YELLOW	VIDEO
WHITE	AUDIO
2 wires unused	

Using a multimeter to measure the current draw we found that each camera only used about 20mA from its 12V/80mA power supply leaving 60mA to spare. We decided we could combine three cameras together, which would have a combined current draw of 60mA and allow us to have only one cable to the surface for every three cameras. To accomplish this, we cut off the existing cables from each camera leaving about 1.5 meters and combined the three ground wires together and then the three power wires together. This meant we had one common ground wire and one wire for power. To make the video work we had to run one wire for each camera. With this configuration a single cable would leave one wire unused while the other five wires ran the three cameras. Since this ROV operates in water, the joints where the three camera cables feed into the one tether cable needed special attention. Each connection was soldered, coated with silicone glue and covered with heat shrink tubing. Then the whole joint was coated with another layer of silicone glue, paying special attention to the ends of the cable sheathe, and covered with clear heat shrink tubing. The clear heat shrink allows the joint to be inspected after assembly. At the surface the cable was split back into three connectors in order to plug into three separate TVs. Two of the connectors, however, do not need to be supplied power since that is now handled by one power supply.

Our Biggest Challenge:

One of our biggest challenges was taking all of the team's ideas and creating a final ROV design. During our first few meetings, we spent all our time brainstorming ideas, which is a very good part to designing. The brainstorming allows everyone to have input in an unbiased way; no idea is turned down. In this way, it builds synergy and inspiration among team members since ideas can easily build on others. Eventually, the brainstorming must come to an end so that a design can be finalized and the building can begin. We needed to figure out the best way to do this next step.

Several designed where offered and we decided to have a design competition where interested team members could build an ROV prototype to show how their ideas would solve the mission tasks. At the decision phase, the team was faced with three prototype designs. During our first attempt at voting on a winning design, we realized that each prototype team felt very strong and passionate about their design. With the invested feelings, it made design discussion and voting very heated. We needed a new method to help us focus on which ideas would best solve the mission tasks in a logical manner without stepping on people's feelings.

We needed a good way to easily discuss and measure the advantages and disadvantages of each ROV so that we could make our design decision. One of our mentors showed us a way that is often used in engineering for just such a decision. The method is to list out all the most important parameters that the team felt were necessary to completing the missions and building the ROV and placing each parameter into a table. Our table consisted of cost, simplicity, stability, payload space, speed and wow factor. We also gave each parameter a weight of importance in relation to each other. Then, each prototype design would be rated on a scale of one to five for each of the parameters. A five signifies that the ROV design highly satisfies the parameter and a one would signify that the design very loosely meets the parameter. Each prototype was then scored using this method. Once the table was completed each score is multiplied with the weight and each parameter is added together to get a final score for each ROV prototype. See Table# 5 below. When we finished the table the total scores were very close to each other, but because the process had focused the team to look at the important elements needed to solve the missions we made one more step and actually ended up combining designs.

ROV Design	Low Cost	W	Simplicity	W	Stability	W	Payload Space	W	Speed	W	WOW Factor	W	TOTAL SCORE
Traditional Square	4	0.5	5	0.4	5	0.4	2	0.3	2	0.3	1	0.3	7.5
Low Metacentric	3	0.5	3	0.4	3	0.4	4	0.3	4	0.3	3	0.3	7.2
Vectored Buoyancy	3	0.5	2	0.4	4	0.4	3	0.3	4	0.3	5	0.3	7.5

Ranking 0-5 - 0 least satisfies requirement, 5 most satisfies requirement
W - Weight (0.0 least important - 0.5 most important)

TABLE #5

In going through this process we discovered a very strong method to analyze design concepts or prototypes with the focus on the desired results of the final project and minimize the design based on feelings.

Other Lessons Learned

Some other lessons learned continue to be creating a plan to define project milestones and deadlines. We did create an outline of project milestones and deadlines, but we wandered away from the plan more often then hoped. We were not as efficient because of this, but the project plan did provide a way to check our progress and refocus our efforts. A second lesson is making sure that every team member is fully motivated to see the design, build and report writing to its end. As some people lost interest the burden fell to a smaller and smaller group of dedicated team members. This added stress to process, which reduced the overall effectiveness of everyone and slowed the engineering process. In fact, on two occasions we considered throwing in the towel. However, desire to travel to the competition and show off our design motivated us to continue on.

Future Improvements

One future improvement to make would be waterproofing the Vectored Buoyancy motors so that they could operate safely in salt water. Also, the addition of a waterproof *slip ring* would allow the Vectored Buoyancy (VB) to rotate an unlimited number of times while still powering our lift motor. Due to cost, our current design left slack in our lift motor wires so that we could successfully rotate the VB 2-3 times before putting too much tension on the wires. The slip ring contains two pieces that can rotate independent of each other. This is accomplished by translating each wire from one side of the slip ring to spring contacts. Each spring contact rests against a rotating disk connected to the other side of the slip ring. As each disk rotates, there remains an electrical connection with the spring contacts, allowing the lift motor to receive power without worrying about wrapping wires as we use the VB.

Mission Related Paragraph

A career that relates to Red Dwarf, and the competition is a ROV pilot or ROV technician. These pilots drive the ROV from the surface or watercraft and guide the ROV thru any tasks it must accomplish. As ROV technology advances and components come down in price pilots will be in a greater demand as ROVs replace commercial divers. Darral Jones in an article for UnderWater Magazine said this about ROV technicians, “…for a pilot is not just an operator who simply flies the vehicle. He is also a maintenance technician, a repairman, a jack-of-all-trades. The successful ROV pilot is responsible for every aspect of ROV operations on the job...”[6] According to the Marine Advanced Technology Education (MATE) Center, Entry level pilots make as little as $30,000, while with experience one could make over $100,000 a year [7]. Many skills are needed to pilot an ROV, being operating the vehicle, knowing how and why the ROV tools work the way they do and most importantly they need know the surroundings of the ROV so they don't run into something or break the tether. This is called spatial awareness. When we pilot Red Dwarf we especially need this skill because if we run the vectored buoyancy around three times than we will break the power cable to the lift motor, thus disabling Red Dwarf's capabilities.

Conclusion

Team Sirius presents Red Dwarf as our ROV design for this year’s competition. While we have introduced Vectored Buoyancy, which has increased the complexity in the frame and motor layout and the need to balance the frame, our design remains based on standard ROV engineering and science knowledge. We have designed our ROV to complete the competition missions and hopefully add a little bit of innovation into the design of existing underwater vehicles. We look forward to the competition, meetings other teams and the sharing of ideas.

2005 Budget Report

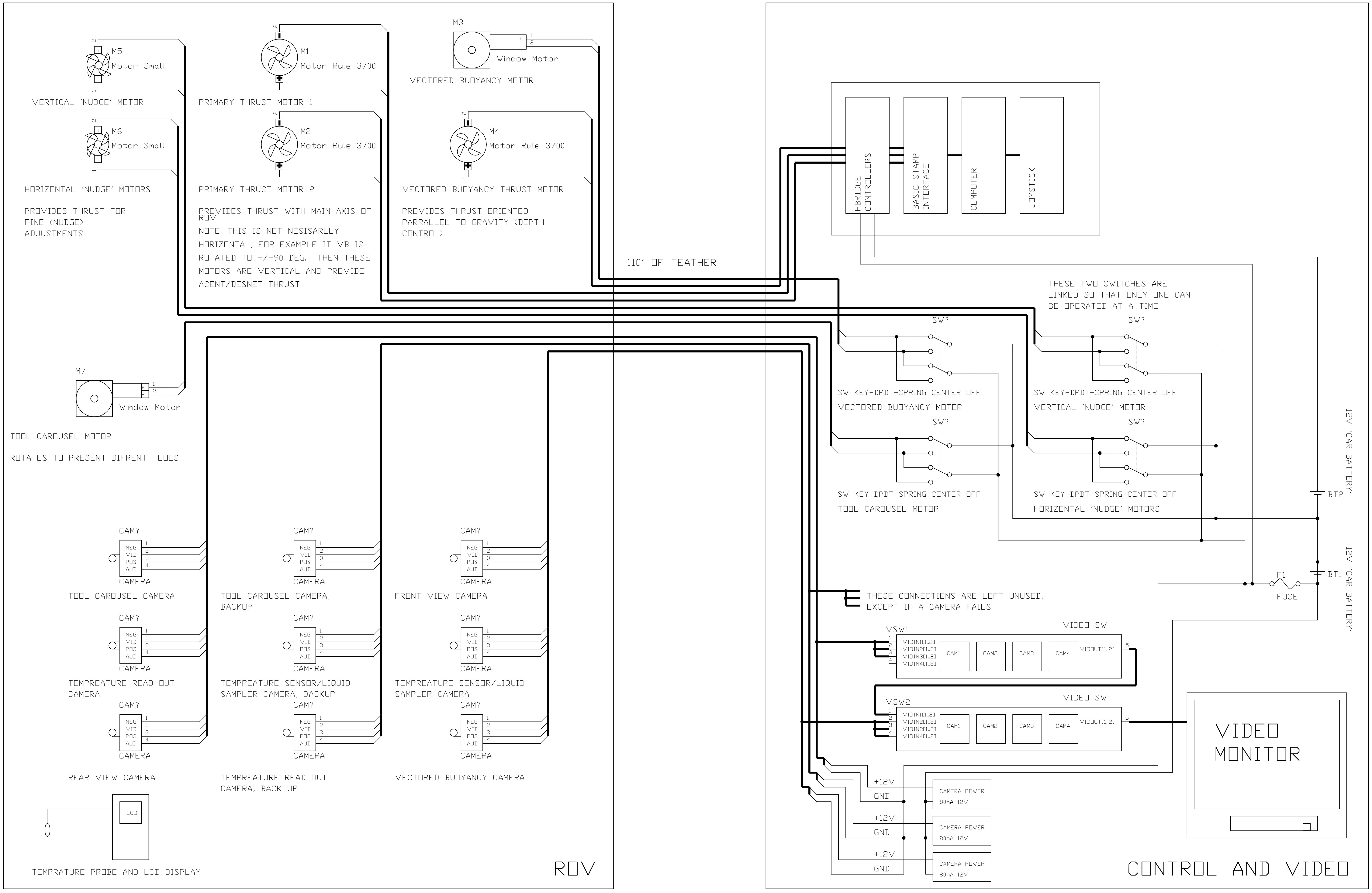
2005 Budget Report - Monterey Peninsula College Robotics Club					
	DATE	**MEMO/DESCRIPTION**	**EXPENSE**	**DEPOSIT**	**BALANCE**
1		Deferred Revenue		$926.31	$926.31
2	12/20/2004	Donation from MPC Foundation		$1,500.00	$2,426.31
3	1/14/2005	Donation from MPC Trust Fund		$100.00	$2,526.31
4	4/8/2005	*MATE Center, MPC (camera kits)*	***-$140.00***		$2,386.31
5	6/22/2005	*Victor Sinatra (liquid collection system)*	***-$42.96***		$2,343.35
6	6/22/2005	*Greg Kaufman (temperature sensor)*	***-$43.60***		$2,299.75
7	6/22/2005	*Tim Ward (screws and PVC elbows for frame)*	***-$12.25***		$2,287.50
8	6/25/2005	*Jeremy Hertzbarg (tether)*	***-$146.60***		$2,140.90
9	6/25/2005	*Rob Hewlett (mission tools)*	***-$14.06***		$2,126.84
10	5/6/2005	*Joe Buffo (camera wire, couplers)*	***-$35.49***		$2,091.35
11	5/6/2005	*Greg Kaufman (tether wrapping)*	***-$20.41***		$2,070.94
12	5/6/2005	*Rob Hewlett (epoxy, goop for cameras)*	***-$30.14***		$2,040.80
13	5/12/2005	*Rob Hewlett (camera wire)*	***-$18.00***		$2,022.80
14	5/12/2005	*Greg Kaufman (camera wire)*	***-$9.20***		$2,013.60
15	5/20/2005	*Greg Kaufman (Cameras, buoyancy)*	***-$193.32***		$1,820.28
16	5/24/2005	*Jeremy Hertzbarg (camera wire)*	***-$30.15***		$1,790.13
17	5/24/2005	*Greg Kaufman (buoyancy, cameras)*	***-$160.46***		$1,629.67
18		Travel Stipend		$1,500.00	$3,129.67
19	5/20/2005	Thomas Rebold (Travel tickets - 5 people)	-$1,996.50		$1,133.17
20		Hotel Costs	-$400.00		$733.17
21		Shipping	-$175.00		$558.17
22	5/25/2005	Donation from Marty and Janice Kaufman		$250.00	$808.17
		TOTALS	**-$3,468.14**	**$4,276.31**	**$808.17**
		New parts expenses	***-$896.64***		
		Existing parts value from previous years	-$500.00		
		Total cost of Red Dwarf ROV	**-$1,396.64**		

Acknowledgements

Team Sirius would like to thank Frank Barrows, Tom Rebold and Steve Pearce for their donations of time, energy and mentoring. Thank you to the MPC Foundation for your financial support. Thank you to Marty and Janice Kaufman for your financial donation, which helped send our finished ROV to the competition. We would also like to thank Monterey Peninsula College for the use of their Automotive Technology facilities and swimming pool. Thank you to both Desert Star Systems and Cyberware for the use of their facilities to build and test our ROV. Without your assistance we would never have been able to complete this years ROV. Thank you all so very much.

References:

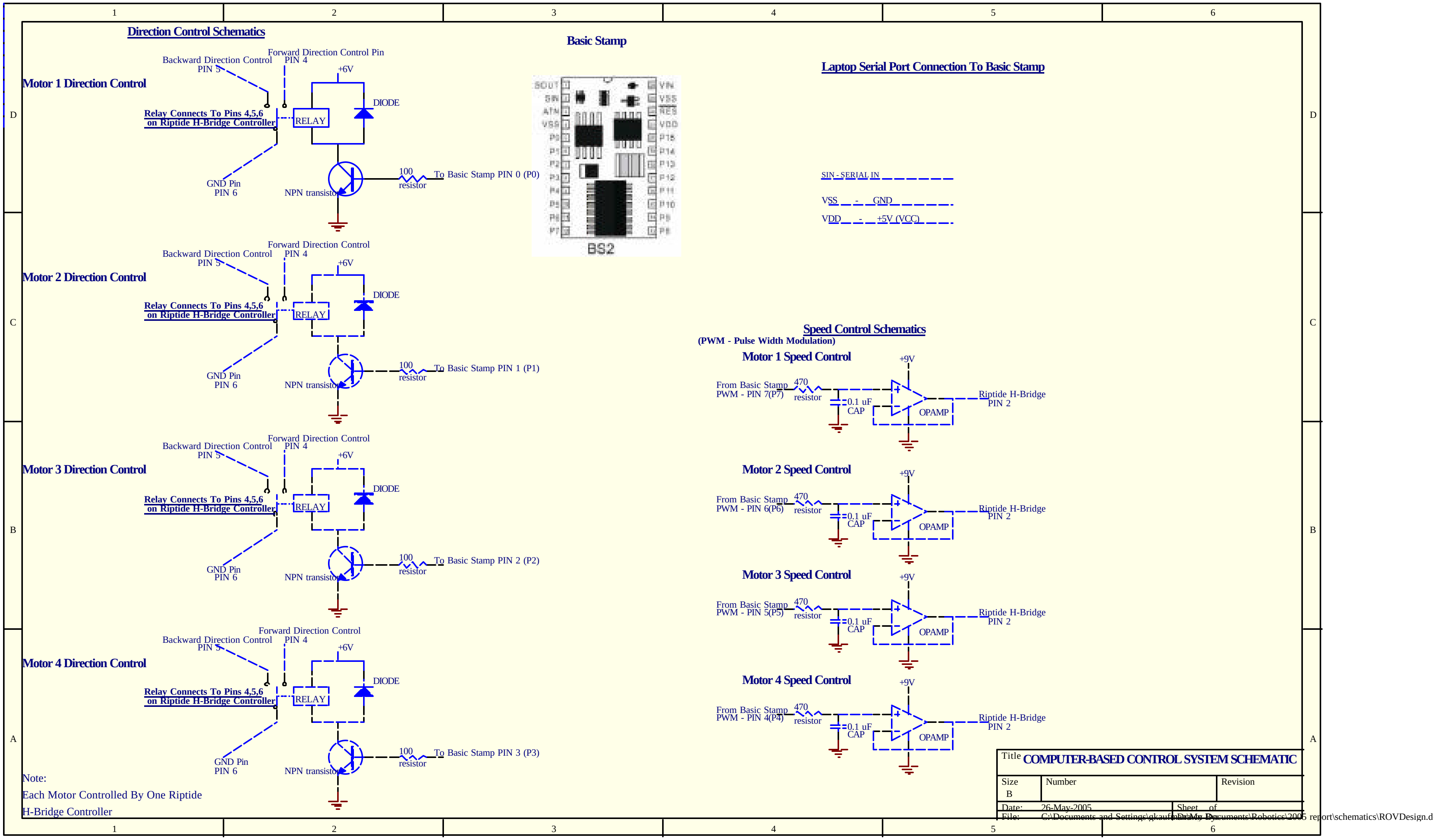
[1] Introduction to Underwater Vehicle Design, Bohm/Jensen/Moore, Marine Advanced Technology Education Center (MATE) – MATE 55 class text book
[2] http://klx.com/europa/ - Icepick: the Europa Ocean Explorer project
[3] http://www2.jpl.nasa.gov/galileo/faqeuropa.html
[4] http://www.powerstream.com/Wire_Size.htm - Handbook of Electronic Tables and Formulas for American Wire Gauge - used to calculate the power and voltage lost through power tether.
[5] Basic Stamp Manual version 2.0, Parallax Inc.,www.parallax.com
[6] http://www.diveweb.com/rovs/features/uw-su98.03.htm
[7] http://www.marinetech.org/marineworkforce/pdf/grov_tech.pdf



Title
RED DWARF-TEAM SIRIUS

Size C
Document Number NONE
Rev 3

Date: Thursday, May 26, 2005
Sheet 1 of 1


1
2
3
4
5
6
D
C
B
A
Direction Control Schematics
Motor 1 Direction Control
Backward Direction Control
PIN 5
Forward Direction Control Pin
PIN 4
+6V
DIODE
Relay Connects To Pins 4,5,6
on Riptide H-Bridge Controller
RELAY
GND Pin
PIN 6
NPN transistor
100
resistor
To Basic Stamp PIN 0 (P0)
Motor 2 Direction Control
Backward Direction Control
PIN 5
Forward Direction Control
PIN 4
+6V
DIODE
Relay Connects To Pins 4,5,6
on Riptide H-Bridge Controller
RELAY
GND Pin
PIN 6
NPN transistor
100
resistor
To Basic Stamp PIN 1 (P1)
Motor 3 Direction Control
Backward Direction Control
PIN 5
Forward Direction Control
PIN 4
+6V
DIODE
Relay Connects To Pins 4,5,6
on Riptide H-Bridge Controller
RELAY
GND Pin
PIN 6
NPN transistor
100
resistor
To Basic Stamp PIN 2 (P2)
Motor 4 Direction Control
Backward Direction Control
PIN 5
Forward Direction Control
PIN 4
+6V
DIODE
Relay Connects To Pins 4,5,6
on Riptide H-Bridge Controller
RELAY
GND Pin
PIN 6
NPN transistor
100
resistor
To Basic Stamp PIN 3 (P3)
Note:
Each Motor Controlled By One Riptide
H-Bridge Controller
Basic Stamp
SOUT
SIN
ATN
VSS
P0
P1
P2
P3
P4
P5
P6
P7
VIN
VSS
RES
VDD
P15
P14
P13
P12
P11
P10
P9
P8
BS2
Laptop Serial Port Connection To Basic Stamp
SIN - SERIAL IN
VSS - GND
VDD - +5V (VCC)
Speed Control Schematics
(PWM - Pulse Width Modulation)
Motor 1 Speed Control
+9V
From Basic Stamp
PWM - PIN 7(P7)
470
resistor
0.1 uF
CAP
OPAMP
Riptide H-Bridge
PIN 2
Motor 2 Speed Control
+9V
From Basic Stamp
PWM - PIN 6(P6)
470
resistor
0.1 uF
CAP
OPAMP
Riptide H-Bridge
PIN 2
Motor 3 Speed Control
+9V
From Basic Stamp
PWM - PIN 5(P5)
470
resistor
0.1 uF
CAP
OPAMP
Riptide H-Bridge
PIN 2
Motor 4 Speed Control
+9V
From Basic Stamp
PWM - PIN 4(P4)
470
resistor
0.1 uF
CAP
OPAMP
Riptide H-Bridge
PIN 2
Title COMPUTER-BASED CONTROL SYSTEM SCHEMATIC
Size
B
Number
Revision
Date: 26-May-2005
Sheet of
File: C:\Documents and Settings\gkaufman\My Documents\Robotics\2005 report\schematics\ROVDesign.d
Drawn By: