The Sound School Senior ROV Team presents

ROVeNGeR

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Mentored by David Low

Abstract

ROVeNGeR, the Sound School's third attempt at the MATE ROV Competition's Explorer class, was designed and built by the Senior Marine Engineering and Physics class. The team is made up of ten seniors who took the prerequisite class last year and chose to pursue engineering. Taking us, a bunch of students with limited knowledge of electronics and physics, and basically putting us in charge of our own engineering project was a test of all of our team's abilities. We had to be able to overcome the various hurdles that come with the territory of a large project like this.

The design was created around the size requirement of the hole in the ice. We wanted to be able to fit through the small hole but still carry a large amount of instruments. By being able to carry all the tools required on one frame we would require few or no trips back and forth to the surface. We used the large Minnkota trolling motor as our primary vertical thrust so that we could make the lengthy trip from top to bottom as swiftly as possible, allowing more time to complete the mission tasks. The design process for the ROV began before Christmas break when the class began work on smaller mid-term ROVs. The class used these ROVs as a place to test different thrust configurations and frame designs to form an idea of what would work most efficiently on our competition ROV.

Budget/Expense Sheet

School Name: The Sound School

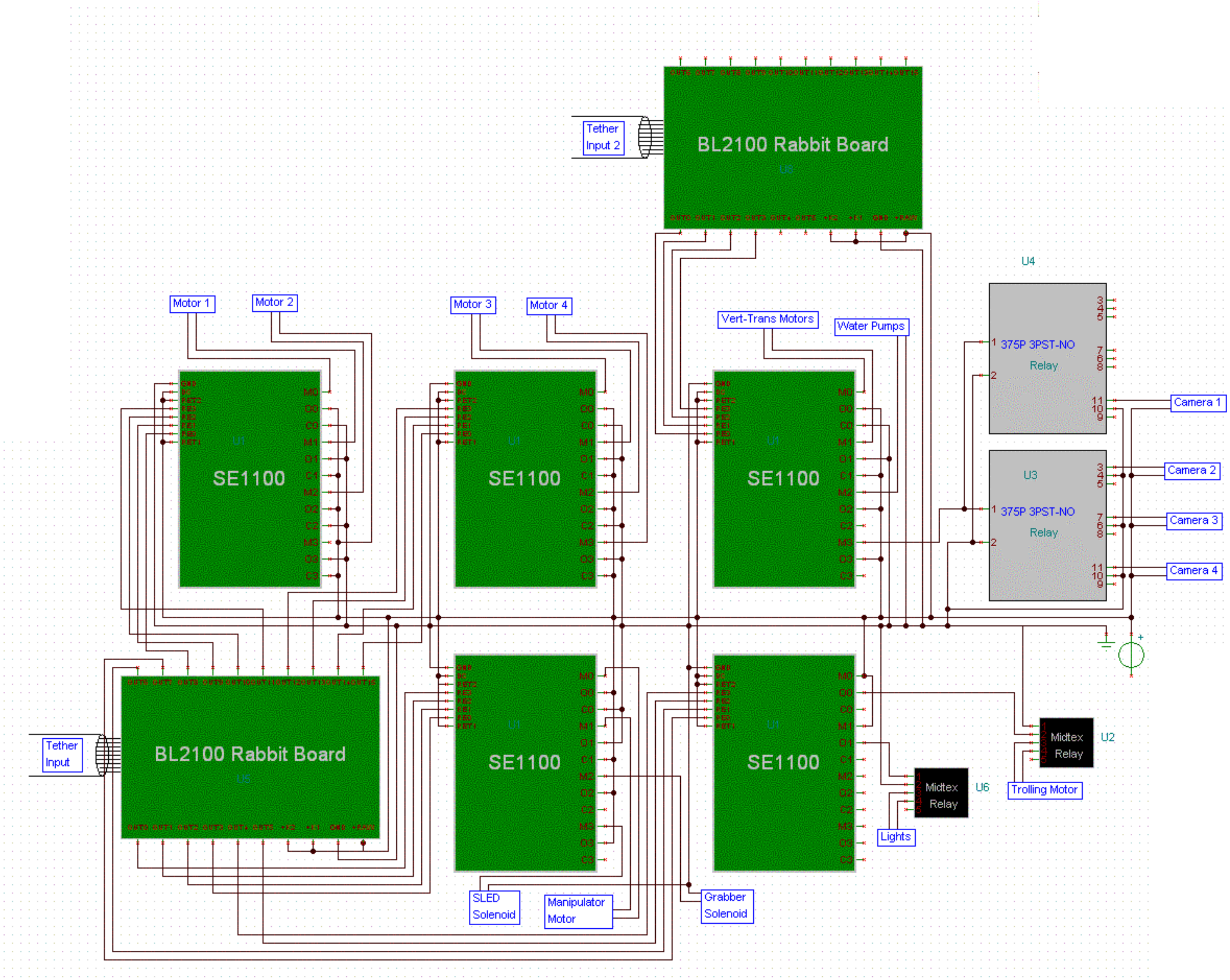
Instructor/ Sponsor: Dave Low

From:

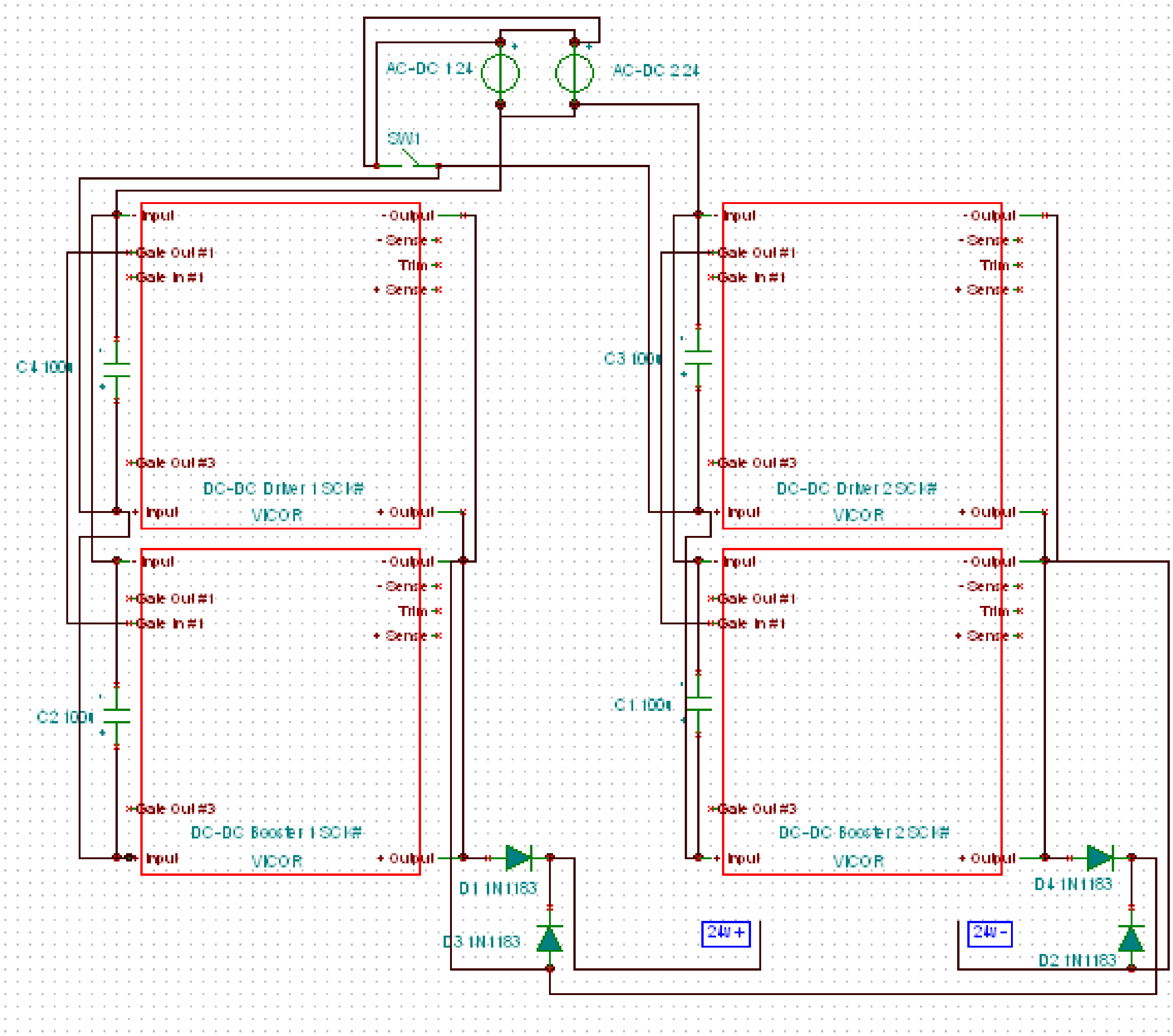
To:

Funds

Date	Description	Qty	Amount	Balance
4/25/2005	BDL-HOU 6/16-6/20 US Air (Through Phil) (Purchased)	10	$ 297.30	$ 2,973.00
5/4/2005	Van Rental from Thrifty (Purchased)	1	$ 456.88	$ 456.88
5/18/2005	Hotel Rooms (for 4 nights $79 per night)(Purchased)	2	$ 316.00	$ 632.00
3/18/2005	Food (Projected)	10	$ 40.00	$ 400.00
3/18/2005	Shipping To Houston (Projected)	1	$ 500.00	$ 500.00
3/29/2005	1/2" Threaded/Socket PVC True Union Ball Check Valve (Purchased)	1	$ 23.51	$ 23.51
3/29/2005	12VDC Mini Water Pump (Purchased)	2	$ 3.75	$ 7.50
3/29/2005	Shipping from All Electronics (Purchased)	1	$ 6.00	$ 6.00
3/23/2005	3-ft plastic Tubing, 1/2 inch outer, 7/16 inner (Purchased)	1	$ 1.50	$ 1.50
3/29/2005	PVC 45 Elbow - SxS - 3/4" (Purchased)	8	$ 0.47	$ 3.76
3/29/2005	PVC Side-Outlet 90 - SxSxS - 3/4" (Purchased)	8	$ 1.34	$ 10.72
3/29/2005	Shipping from Plumbing Supply (Purchased)	1	$ 5.91	$ 5.91
4/28/2005	Blue Funnels 5' Diameter, 4.5' tall (Donation from Drew)	2	$ -	$ -
4/28/2005	Scotchcast 2130 (Purchased)	1	$ 21.92	$ 21.92
5/5/2005	Polyurethane Foam 2 cubic foot kit (Purchased)	2	$ 28.00	$ 56.00
5/5/2005	Shipping for foam	1	$ 11.00	$ 11.00
5/16/2005	Hobo Temperature Sensor (Donation)	1	$ -	$ -
5/17/2005	Diode Units for Power Bottle (Purchased)	2	$ 62.50	$ 125.00
5/17/2005	Shipping from Digi-Key (Purchased)	1	$ 10.62	$ 10.62
5/17/2005	USB-to-Serial Converter (Purchased)	1	$ 36.99	$ 36.99
5/17/2005	12 VDC Gearhead Motor (Right-Hand Version) (Purchased)	1	$ 16.95	$ 16.95
5/17/2005	12 VDC Gearhead Motor (Left-Hand Version) (Purchased)	1	$ 16.95	$ 16.95
5/17/2005	24 VDC Solenoid w/ Spring-Return Mechanism (Purchased)	2	$ 4.00	$ 8.00
5/17/2005	7 Position Dual - Row Terminal Strip (Purchased)	2	$ 1.60	$ 3.20
5/17/2005	Set of 5 Gears and Bushings (Purchased)	2	$ 2.75	$ 5.50
5/17/2005	Mating Nylon Gears (Purchased)	3	$ 1.50	$ 4.50
5/17/2005	Rotary Solenoid (Purchased)	2	$ 3.90	$ 7.80
5/17/2005	12 VDC Solenoid (Purchased)	2	$ 3.50	$ 7.00
			Subtotal	$ 32.21
			TOTAL	$ 32.21



Control Systems Electrical Schematics



Vicor MegaMod and MegaMod Boosters Schematics

Design Rationale

Propulsion - For our propulsion we decided to use a Minnkota trolling motor and two small Johnson motors for our vertical motion. For the forward and reverse motion we used four of the same Johnson motors.

We chose the trolling motor because it has speed control. That way we are able to maneuver down the ice tunnel and reach the bottom very quickly, but not so fast that we will crash into the bottom of the pool. The Johnson motors are mounted transversely because it allows for small adjustments of our position. We can use them to strafe and to hover above a given point. We use the smaller motors instead of the trolling motor because they are capable of finer, more controlled thrusts.

We chose to use four of the Johnson motors because they were the most efficient motors available to the team that were still powerful enough for what we needed. We decided to place one at each corner of the ROV because of the benefits of maneuverability that this offers us. For example by moving the forward on the top two motors and moving backwards on the bottom two motors we are able to pitch the ROV forward. It is an excellent feature to have and by pitching the ROV we can get a different camera angle on an object if we need to.

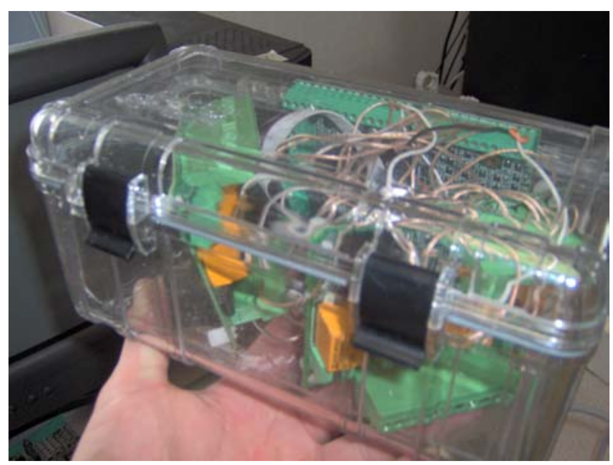
Frame - We chose a tall, square based design for our frame based on the mission tasks we have to accomplish. We made the base small and square so that we could fit through the 60x60cm hole in the “ice.” The frame is tall so that we can fit all the instruments necessary for the rest of the mission tasks. We made the frame twice as high as it is wide to keep it stable in the water when the flotation and ballast is set up properly. The ROV has to hold our bulky power bottle and an even larger trolling motor. We sealed the top half of the PVC frame to add extra flotation and to keep the center of flotation high for added stability. The base of the ROV is 42x42cm so that the pilot has a lot of room to maneuver down the “ice” hole. We chose PVC because it is a cheap but durable frame option that was easy to modify if/when complications in our building process arose.

Early construction on the frame.

Configuring attachments to the frame.

Control systems - To control the ROV, we are going to be using a Rabbit Microprocessor chip mounted on top of a BL2100 circuit board. We decided to use this chip to control it because it utilizes a program called Dynamic C, which is very similar to the C programming language. This programming language has the ability to control multiple inputs and outputs at high speeds, and can perform multitasking very well. Using this, we can turn motors and other devices on and off using almost anything. (For example, we can use a keystroke to go forward.)

The method of "driving" the ROV that we will be using is through an arcade joy pad that plugs into the computer. This unit, called the HotRod, has two joysticks, and 18 buttons. It plugs into the keyboard port on the computer, and when something is pushed, it responds like a keyboard, by giving a character or something like Alt or Shift. This unit will be used mainly for the fact that it has so many buttons, so we can control more functions. We would have used other joysticks that had even more buttons than this, but they were USB joysticks, and Dynamic C can't read USB input.



The program itself that runs the Rabbit processor takes the numerical code that is received from the keyboard (or in this case, the HotRod) when a key is pressed, matches it up with a list of codes, and then turns on a specific relay depending on what code it read. This way, if we need to map a key last minute to do another function, we can easily do so. This also allows for easy troubleshooting if an issue were to come up.

The Rabbit Processor has a ten pin serial port on the outside of it for communications with the computer. To cover the communications between the processor and the computer, we will be using a 65-foot CAT-5 cable, and cut the serial cable down the middle, so as to make the original serial connection longer than it would normally be. The CAT-5 cable, a standard broadband cable, contains 8 copper wires inside of a standard wire insulation. Testing has been done on it, and it is able to carry the electronic signals down the 20 meters (~65 feet) of cable that will be used.

Camera and lights - The ROV consists of four cameras and one light. The purpose for the camera placed at the bottom of the ROV is for it to be able to provide us with a view of the hole as we descend into the pool. It also provides the team with a view of the fluid vent. The purpose of the camera placed at the top of the ROV is for it to provide us with a view of the hole as we rise to the surface. Both cameras are equipped with LED's therefore they have no need for a light. The camera placed in the inner right side of the ROV is relatively close to the extraction device and the manipulator. This way we are able to see if both devices are functioning correctly. The light is placed on the opposite side of the camera facing inside of the ROV so that we are able to illuminate the devices because the camera is not equipped with internal LED's. Finally, the camera that is placed over the Power Bottle is the only color camera and is equipped with LED's. Therefore it can also adjust to the changes of light. Its main purpose is to give us as full and detailed view of the mission task locations as possible.

Two of our Mini SM50 cameras.

Challenge Description

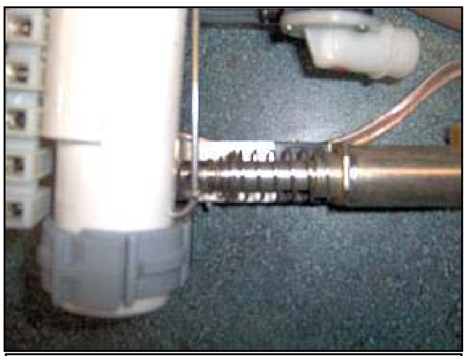
The biggest challenge we faced in making this ROV was working together as a team. The problem wasn't caused by any differences in the team; there was just a lack of organization and cooperation. In the beginning of the year we stressed the objectives that needed to be completed and their due dates, but the year flew by us and before we knew it the last month before the competition rolled around and we weren't even close to being done. We had spent a lot of time hypothesizing and testing, which is good unless you spend half the year doing it. When May came we had only a basic frame and some motors attached to it; all of the other parts of the ROV were still in the process of being completed. Looking back on what we had done wrong we realized that a lot of time was spent arguing with each other and goofing around, something that, while acceptable in it's time and place, had caused us to neglect our tasks.

Another mistake we made was that we didn't communicate well between different sub-groups. There was little communication between the motor people and the control systems people, so when the deadline came there was a scramble to assemble the information needed from other groups, adding to the chaos of the already hectic project. It was very hard towards the deadline because we had to talk more than ever, but in the last week when the tech report was due on Friday everyone took responsibility for their part and we came together as a team and accomplished our goal.

Nick fooling around with our team mascot, a rubber duck we found in a box, and Eric laying down the law. (Scripted event)

Troubleshooting Technique

The first phase of developing the device to extract liquid was coming up with a general idea as to how the extraction was going to occur. At one of our early team meetings we brainstormed how we could successfully complete each of the tasks. There were two main ideas being tossed around at first; using a hydraulic cylinder to activate a syringe, or using a funnel to guide a tube hooked up to hydraulic pumps. The question really came down to how the device was going to get inside the PVC tube to extract the liquid. We finally settled on a system that would use a funnel to guide the PVC pipe from on top of the barrel containing the liquid sample into the focus of our pumps extraction hose.



This is the solenoid that pulls the pin that releases the pipe that shoots out the funnel that directs the needle that sucks the

The problem was how this extraction device would insert into the barrel. The linear motion at fist was going to be caused by gravity, but gravity has little effect underwater. We were going to have washers with the rigid airline tubing in the inner hole and PVC pipe connected to the funnel on the outside. This would allow for the airline tubing with the washers to slide down the tubing into the barrel.

We tested this method and found that the density wasn't great enough to move the extraction device at a practical speed. We troubleshot this problem by using our knowledge of physics and practical testing to discover that a spring-loaded extraction device would work most effectively.

Lesson Learned

At the beginning of the project we set several goals for ourselves. The main thing we decided on was that we wanted to get a finished ROV out the door early. This way we would have plenty of time to test it and fine-tune it long before the competition rolled around. Unfortunately we didn't follow the series of schedules and deadlines we set for the project and when the final days began to roll around we were far from finished. As we rushed to complete our ROV we began to make mistakes that ate up more of our precious time. We began to realize that if we had set a plan at the beginning and kept to it instead of winging it like we did. By winging it we spent more time talking about what needed to be done that actually doing any of it. Because of this we didn't feel we had accomplished as good a job as we might have if we planned better. The ROV will be completed but everyone involved has learned valuable lessons the hard way, about life and organization that each will carry with him or her forever.

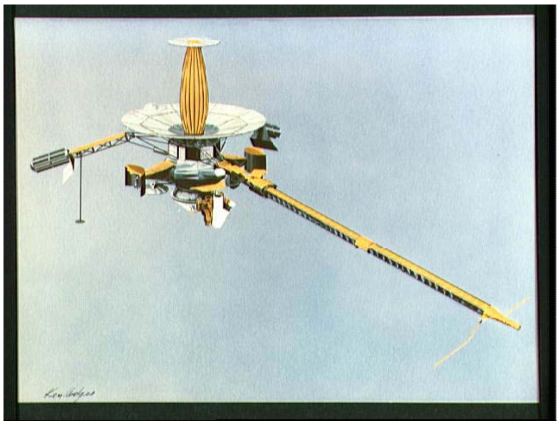
Future Improvements

If we were to create an ROV in the future trying to accomplish the same objectives there would be several things we would do differently. We would make the frame smaller to allow for more maneuverability and to ease the construction process. We wouldn't use the trolling motor because it drew 32 amps and was far too bulky. It took up more space than was practical for it's use. We would also put more thought and testing into our motor placement, using different types of motors and props to maximize thrust and maneuverability. As a frame choice, PVC worked for a few reasons this year, but in some ways it didn't. Because we were rushed for time and were forced to make several modification of our frame on quick notice PVC was an optimal choice for this use, but if we had the ability to plan far ahead and complete testing and prototyping we would choose a frame material that didn't warp and bend as much as PVC does. We had problems pouring the floatation onto the top of the frame because the expanding foam pushed the PVC out of place. All the connections on our ROV would be sealed properly so that the wires would have no risk of shorting out.

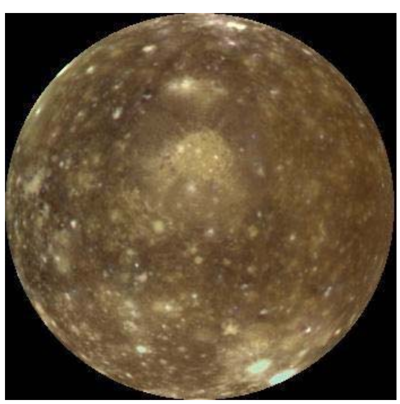
Technology Used to Explore Europa

The human race has always contemplated the heavens, creating stories, making observations, and generally wondering about that vast unknown space that has always existed above our heads. It was in 1609 that Galileo constructed the first telescope and turned its eye to the heavens, giving us our first detailed look at that celestial realm. Since then mankind has created more and more powerful telescopes to explore the mysteries of space. We have launched satellites that travel far from our planet and become our eyes and ears. The Galileo Orbiter and the Galileo Probe were two of these satellites.

In 1989 NASA launched the Galileo Orbiter from the Kennedy Space Center. The probe's eight-year mission was to travel to our solar system's gas giant, Jupiter, and take detailed readings on the planet, as well as its moons. The Galileo Orbiter's cameras, when focused on Jupiter's moons, made several important discoveries. It discovered the probable presence of an ocean underneath Europa's icy skin, the magnetic field around Callisto probably caused by an internal ocean, and active volcanoes on Io's surface.



The Galileo Spacecraft has been hailed as "Arguably the greatest engineering achievement of the 20th Century, a Modern Wonder of the World, a science Colossus." During the peak of its performance it was operating on obsolete computer technology from twenty years ago. It suffered from constant technological hiccups that put its mission in peril and every time it pulled through, accomplishing its mission through the sheer resilience and ingenuity of the NASA engineers responsible for its care. The mission was so successful and raised that NASA is planning another trip to the Jovian system to further explore the possible ocean on Europa. Several features of the ocean lead scientists to believe that there is the possibility of life existing in the oceans of this Jovian satellite.



"[This] ... data lend[s] support to the hypothesis that Europa is warm and active today and potentially characterized by a global subsurface water layer or ocean. Europa, like Mars and the Saturn moon Titan, is a laboratory for the study of conditions that might have led to the formation and evolution of life.

The combination of interior heat, liquid water, and infall of organic material from comets and meteorites means that Europa has the key ingredients for life, and it represents an exciting environment that is worthy of further detailed exploration."

-James Head, Brown University professor of geological sciences.

The proposed return mission to Jupiter and its moons will involve transporting a larger vehicle, capable of carrying the necessary instruments and possibly an ROV. To provide enough thrust to carry this extra load to Jupiter NASA is looking into using a more modern form of propulsion than conventional rockets. NASA plans to use an ion propulsion system. This system won't use huge amounts of fuel like the conventional rocket engines do. These engines tend to be extremely powerful but have a short life. An ion propulsion system uses electrical fields instead of a massive chemical reaction to propel. This system tends to be far less powerful but so much more efficient that it can run for years before running out of fuel.

Sources used:

- Life on Europa - http://www.resa.net/nasa/europa_life.htm
- MSN Encarta entry on the Galileo (spacecraft) - http://encarta.msn.com/encyclopedia_761580672/Galileo_(spacecraft).html
- SSE: Galileo Legacy Site - http://galileo.jpl.nasa.gov/

Photo Album

Testing the motors in our converted fish tank.

Pouring the foam into the top of the ROV.

Final countdown.

Romy with black, flame retardant adhesive hardening all over her fingers.