Pasadena Memorial
High School

"Scorpion 2"

H_2O

Underwater Robot Diving Team

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Shara "The Evil Burner" Reisewitz – Team Captain/ Ulric "The Man…Oh, Yeah" Ibanez – Team Co-Captain
Randall "The Redneck" Ross – Team Co-Captain / Winnie "The Omniscient" Lung – President
Sara Freeman – Vice-President / Nicholas Festeu-Treasurer / Michael Stinson -Historian
Ramiro Castillo-Mr. Helpful / Steven "Frenchy" Cepeda – First in Tether Command
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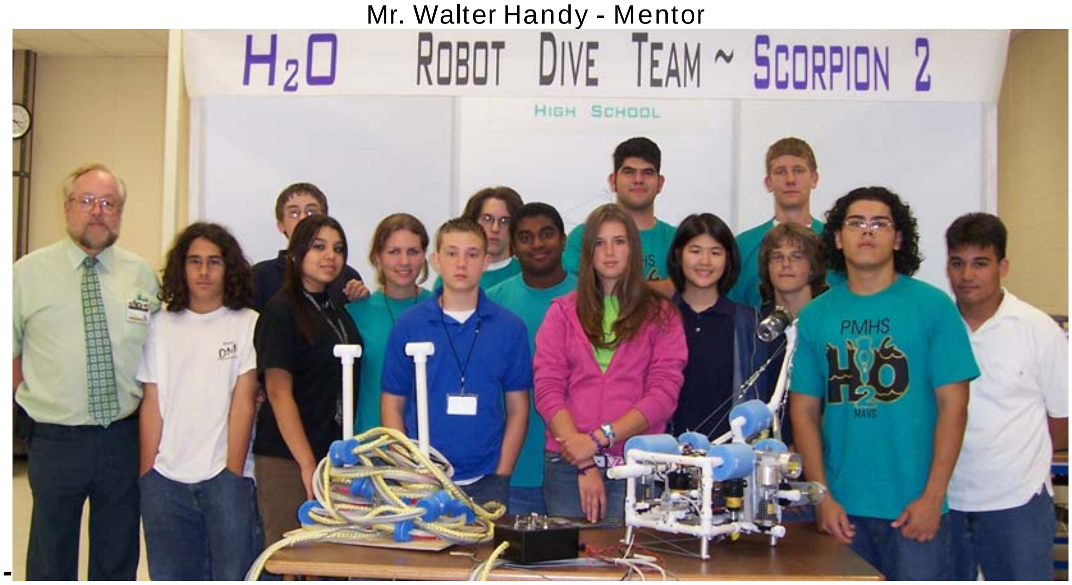
Dustin Estry / Charles Long / Joshua Vasquez / Chet Haywod / Chistopher Sims

Mr. Kim Page – Teacher & Sponsor
Mr. Walter Handy - Mentor



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2004-2005
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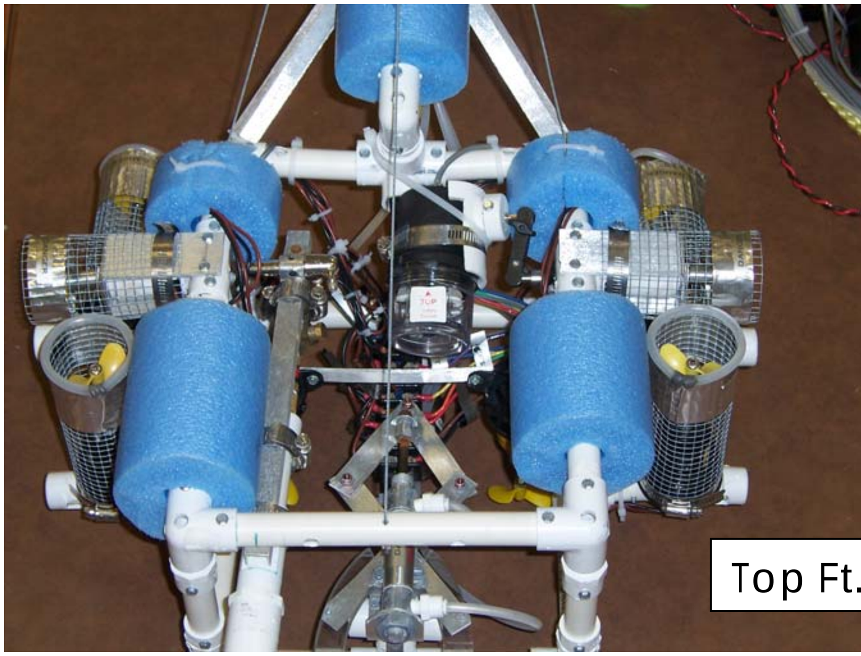
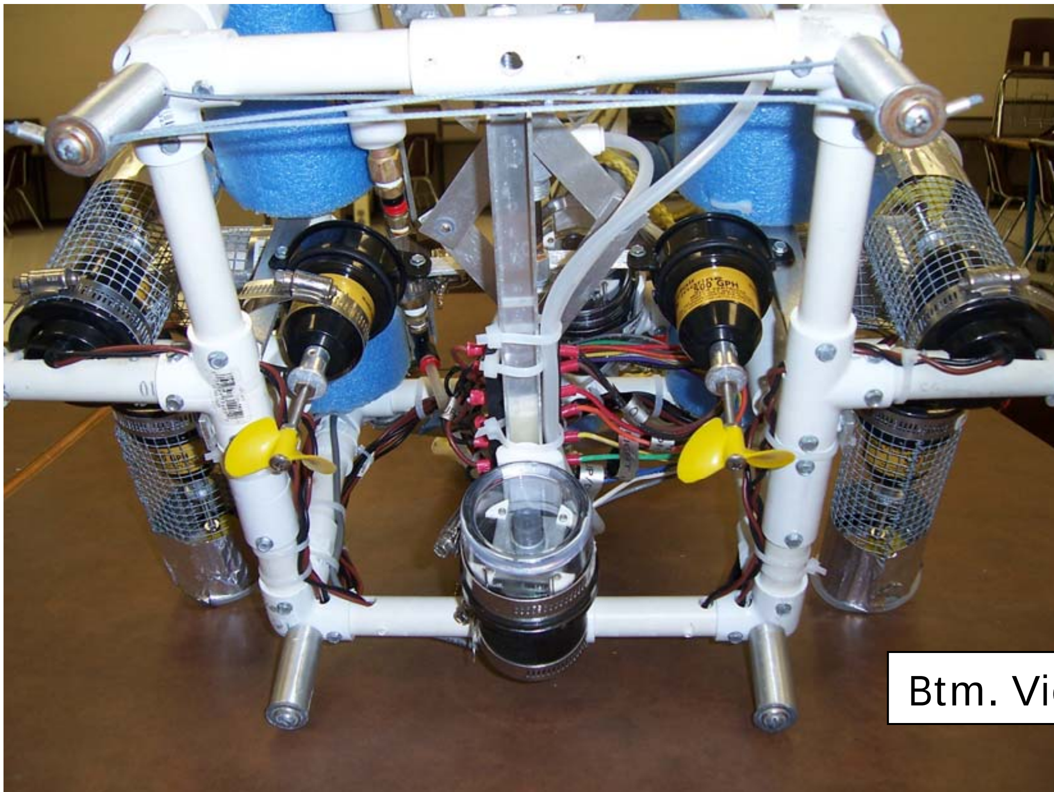
Abstract

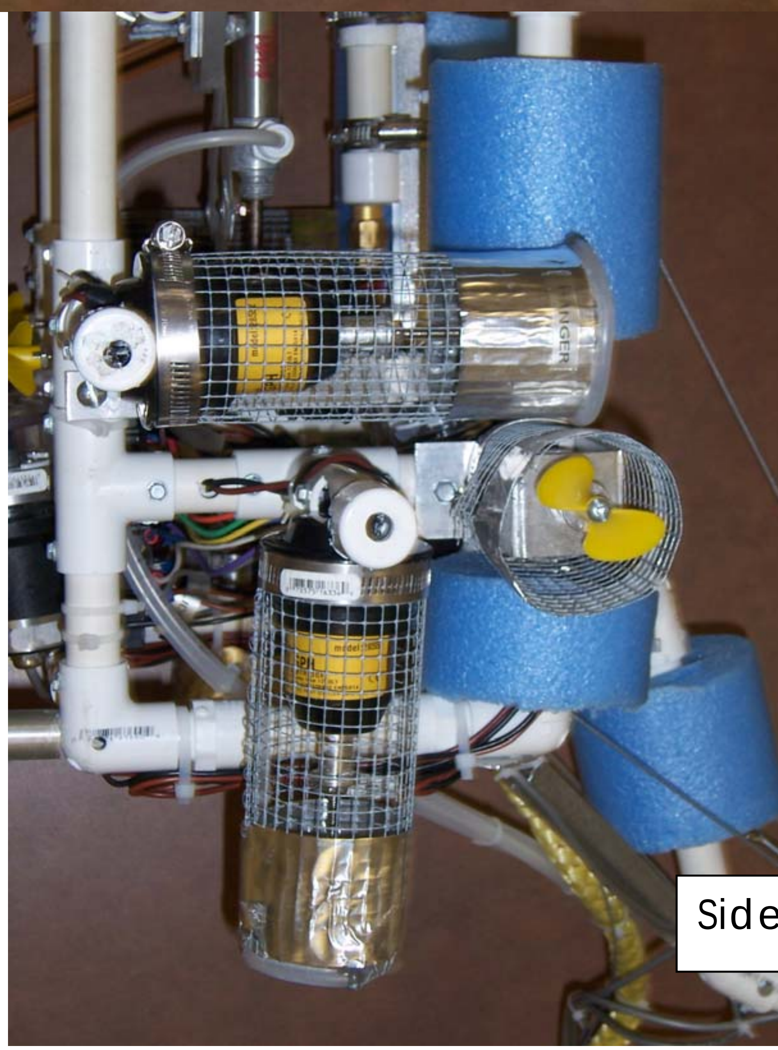
We constructed the ROV from PVC, aluminum, and Lexan glass. It is light, weighing in at 6899.2 grams or 15.4 pounds, small, pleasing to the eye, and most important it's functional. It successfully completes its task and does so in excellent time. The only weakness of the ROV would be the buoyancy we are using foam floatation. This will no longer be a problem as soon as we can test it once more this week. We are currently programming a Play Station 2 controller to work with our motors, which will improve our handling and maneuverability. It will also allow us to control the speed of our motors to go from very fast to very slow. All electrical wires are neatly run, wired, and are protected from water with electrical tape or liquid electrical tape. The propulsion comes from 6- 500 GPH motors and 2- 250 gph motors. The propellers are protected with galvanized ¼" wire mesh. Our sensors include 3 water tight CCD cameras, a x-crossing wire rope to act as a target cross-hairs, to give us a feel of where we are. We are confident that the ROV we built will be a success at the national level contest. Building this ROV has been one of the most fascinating learning activities we have ever experienced, and has really inspired us to follow science and engineering fields.



Top Ft. View



Btm. View



Side Motor Config.

Structure

We constructed the ROV from PVC, aluminum, and Lexan glass. It is light, weighing in at 6899.2 grams or 15.4 pounds, small, pleasing to the eye, and most important it's functional. It successfully completes its task and does so in excellent time. The only weakness of the ROV would be the buoyancy we are using foam floatation. This will no longer be a problem as soon as we can test it once more this week. We are currently programming a Play Station 2 controller to work with our motors, which will improve our handling and maneuverability. It will also allow us to control the speed of our motors to go from very fast to very slow. All electrical wires are neatly run, wired, and are protected from water with electrical tape or liquid electrical tape. The propulsion comes from 6- 500 GPH motors and 2- 250 gph motors. The propellers are protected with galvanized ¼" wire mesh. Our sensors include 3 water tight CCD cameras, a x-crossing wire rope to act as a target cross-hairs, to give us a feel of where we are. We are confident that the ROV we built will be a success at the national level contest. Building this ROV has been one of the most fascinating learning activities we have ever experienced, and has really inspired us to follow science and engineering fields.

Structure Questions

- We choose our materials keeping in mind that we wished for the ROV to be small and light for maneuverability and speed and also to we needed the materials to relatively inexpensive, so we used PVC pipe and aluminum to build our structure.
- The depth rating of our ROV is 15 feet; we tested to this depth in the first underwater competition.
- Yes, we purchased an air tank to which we attached a 12 volt compressor to help top it off the tank as we used air. We then mounted it under our control cart for steady air pressure to the pneumatic claw and air cannon.
- We did not use o-rings in the traditional sense. We used them to make an air tight seal in our air cannon.

- To make the vehicle, it cost around $2200.
- The ROV weighs around 15.4lbs or 6899.2grams.

Control Systems

- We use a box holding all of our switches to control the motors and a box holding our pneumatics box which we can disconnect for easy transportation.
- In our scheme, we have 10 different colored conductors in a nylon rope. Each set of these wires controls either one or a set of motors. These leads are each controlled by a double throw reverse polarization switch.
- There are ten conductors in our tether and three CCD camera wires attached to the outside.
- We have a separate box to control our pneumatics which hold a on off air flow switch for the air cannon and a FIRST double throw air in and air to atmosphere switch.
- We either wrapped all connections in tape or heat shrink or both. We also used liquid electrical tape on the buss bar to prevent amp bleed.

Propulsion

- Our ROV has 8 motors to which 2 of them hover left and right, 2 motors to go forward and reverse, and 4 to elevate and to descend in action.
- We estimate that our thrusters produce 3.2lbs of thrust
- Our thruster uses an estimated 2.7 watts at full rpm at full load.
- Our thruster pulls an estimated max of 3 amps under full load.

Ballast System

- We used foam to make our ROV neutrally buoyant at about five feet below the surface.
- We have all of our weight low, towards the bottom of the ROV; in terms of the bulk of our floatation, on the ROV in order to keep our robot from turning over. This keeps our robot stable in the water.
- It is important to consider stability so that you can accurately control your ROV with out it turning in direction the driver doesn’t expect.

Sensors

- We use three **CCD** cameras with a high camera seeing the whole ROV. a camera focused on the probe target and a camera focused on the claw's target
- A CCD camera is a small piece of silicon which has many electron receptor called photosites these each represent a pixel when displayed as an image. The camera can make a picture based on the amount of light it senses on each photosite.
- We put a wire cross-hair on the bow of our vehicle in order to have a feel of where the vehicle is in relation to the target and drop pipe. It detects when we are in position to drop the probes.

Payload Tools

- The payload tools we designed to accomplish the tasks are a claw and air cannon because they are effective and the best idea that we came up with, after many trial and error experiments.
- The claw uses an air cylinder to open and close a scissor mechanism which in turn, opens and closes a custom-fit claw. Our payload tool that delivers the probe is an air cannon which upon attaching it to the Velcro we blow it off and fly away.

Resources

- We economized and produced a functional and robust vehicle that is able to function appropriately to produce desired results.
- PVC pipe, fitting, hex head screws, solder, cameras, motors, First air fittings and air switch, power tools, manual tools, and everything else that might have been needed were bought by Mr. Page, our instructor in exception to the FIRST air switch and air fittings graciously lent to us by FIRST team High voltage 231.
- Since there was no set budget, we assume that our spending was within the bounds of what was acceptable. The school set up and built 14 prototype robots and had a swim off at an area pool. WE then took the five remaining teams to our regional where one of them won second place.

System Design

- Our safety systems include wire mesh, danger labels, PVC pipe frame, and a fuse which all work.
- Our only weakness is our buoyancy.
- The strengths of our design are the air powered claw and cannon which allow us to use powerful force to grab and release, the small design which makes for better maneuverability, and multiple motors which allow the vehicle to go in many directions.
- The vehicle has demonstrated the ability to be able to do the tasks in excellent time.

Originality

- The air cannon was made out of PVC pipe and a couple of customized o-rings.
- The cannon works efficiently and effectively.
- The tail-end camera is positioned in such a way that it is easier to see the body of the vehicle as well as the surrounding targets.

Workmanship

- The vehicle looks pleasing and has a practical functionality because we used PVC pipe and some aluminum which is strong, light, and pleasing to the eye. It resembles a scorpion with the back view camera high looking like the tail of a scorpion.
- The tether is neatly bundled with tie wraps and is protected by a nylon rope.
- There are warning labels and guards posted on potentially hazardous components such as propellers, air cannon, and the pinch point of the claw.
- In terms of access our open structure makes components it is easy to access most parts for maintenance, but some parts require longer tools. Such as the camera in the belly of the robot.
- The electrical systems are neatly run and wired in order to make it easier to understand where the wires lead. They are tied down with tie wraps and labeled as to what motor they lead to. The under water connections are insulted with either tape or liquid electrical tape.

- We strived to make every part as good as possible. For instance we have remade many parts after realizing flaws in our prototypes. There was much time spent on it by the students; no physical work, or ideas came from our instructor, only encouragement. All ideas were from the students, as well as all the work done.

Design Rationale

We chose a simple rectangular prism for the structure. This was because if we had used a more complex intricate design we would've been required to use more PVC pipe fittings and the weight would increase. So to keep it simple, light, and small which was our goal, We built it large enough to fit six motors (now eight), three cameras, and two air actuated devices (a claw, and an air cannon), but small enough to maneuver effortlessly where required.

The design we used for the claw is sequence of successively larger scissor pairs. The scissor is open and closed by an air cylinder which is mounted in the middle. We used this design because the claw gets a lot if motion for 1in of throw from the cylinder. Also this design gets a great amount of power as the claw closes. This design we use allow the probe to drop unobstructed from the claw.

When we started designing the claw we decided to use air power for a number of reasons. The best thing about air power is that it is a quick renewable source of power. It gives the ROV a quick bit of energy. An air powered device gives you immediate results, and you can get many cycles out of one pressurized air tank. Also, air power is relatively cheap. We already had the air cylinder that we used, but a new one of that size would only be around $125. Also, you encounter no real problems when putting air devices underwater because an air cylinder is already airtight and requires no further waterproofing. The materials we used to build were aluminum and Lexan glass. We used these materials because they are light and relatively cheap. A strip of aluminum is only $6.00 and a 1/8 sheet of Lexan is only $20.00. The claw is activated b y a 12 volt double throw FIRST air switch that was graciously lent to us by FIRST team 231, High voltage.

To build the air cannon we originally did not have it in mind as an air cannon. What we wanted to do was to design a claw that would barely hold onto the pipe so that when we attached to the Velcro we could just back off once the probe was securely stuck. We stayed with that idea going through various o-rings of different sizes and materials. All these materials were relatively cheap. PVC pipe is extremely cheap and easy to find and the o-rings were a little more expensive but with in our range.

We added air when after we decide to use it on our claw. We had the capability so we decide to add it on. We found that a standard air fitting could put in a ½ in piece of pipe with just a little bit of coaxing. We then used silicon to fill in the gap and make it air tight. So we easily made it an air cannon by using a reducer to attach the coupling that held the o-rings. The switch is operated by a simple on off air flow switch.

Challenges of an air cannon

The Hubble instrument module would not release when placed on the Velcro target, so to solve this problem one of our team members came up with the idea of having an air cannon. The instrument would be placed in the cannon and be blown out when in place. The prototype was made by Alex Boehm with a small amount of ¾" PVC pipe, a couple of corresponding fittings, o-rings, and an air fitting. Unfortunately, it did not work as good as expected. With his instructions and permission I went ahead and constructed one of my own. The problem with the prototype was that it wouldn't release the device easily enough even when lubricated. Having that in mind, I sanded the o-rings very cautiously to get them to the precise size needed to release the object with enough pressure and ease. When I put all the parts together it worked beautifully just as Alex would say.

Trouble shooting: How to size rubber o-ring equally and accurately

Our originally design was to have snap rings trapped in a 3/4 in coupling by short pieces of ¾ in thin wall PVC pipe. We were unable to find snap rings in accurate enough sizes so we sought for alternatives. We settled on o-rings. We first found o-rings in the right sizes in foam so we prototyped with them. They seemed to work but at further inspection I could see that they would tangle upon themselves after the pipe went in a few times. We then tried rubber o-rings. I had a bit of trouble getting the o-rings to fit the pipe. To do this I put them on a ½ in piece of pipe and then put a slightly smaller rod through this pipe. I then sanded the o-rings on a belt sander. This spun the pipe taking off the same amount of rubber all the way around off all off the o-rings at the same time. I could then fine tune the rings by sanding them a little at a time. Doing this I got the rings to fit in the pipe perfectly. When would put the pipe together it worked perfectly with a little petroleum jelly. This design has proven itself to be effective every time we used it.

Relating the game theme

In the Hubble task we deliver the paddle probe by driving our ROV to the target, aligning ourselves, and driving forward until the probe is firmly attached. We then push our selves off leaving the probe attached. This is similar to what a space ROV could do to deliver a electronics package to another part of the space station with out having to endanger the life of an astronaut.

In the DSL line task we deliver the probe by driving our ROV to the target, align ourselves, and move down to deliver the probe. We then drive backwards, out of the way of the attached wire, and up to the surface. This is similar to what ROV do under the ocean to connect lines of DSL deep in the ocean where divers cannot go.

In the oil well task we drive the ROV over to the valve, align ourselves, and push the valve forward. This is similar to what ROV do in the Gulf of Mexico to shut off oil valves and turn them on at depth and danger where it not safe to send humans.

Gaming Strategies

To win this task we have 4 up and down motors to get up and down fast. When dropped in the water we are neutrally buoyant 3 or 4 feet down. Once in the water we drive down to the task we are going to accomplish. On the paddle probe task we drive to the target and use the camera that is focused directly on the target to align our self at 3 or feet away. We have learned that if we try to align our self close up we can never hit the target straight on, from distance it is easy to make small adjustments as needed. Once aligned we drive up and get the probe firmly stuck to the target. We then activate the air cannon and drive off the target. Once free we fly to the surface as soon as possible.

On the DSL task we drive over to the target and get the pipe we need to drop the probe in our site with the appropriate camera and line up our wire crosshair with the pipe. Once we know were in the right place we drop the probe fly back and up to the surface as fast as possible.

For the oil well task once down in the water we drive over to the valve and get it in our sites using the crosshair camera. We then drive at the valve and use the legs on our ROV to push it closed. We then drive up and away.

Once clear of the task area we drive to the edge of the pool as fast as our ROV will go and haul it out of the water.

Engineering Process

Identify problem

*Need to deliver two items, one vertical, and one horizontal and turn a valve:

- Ranger Mission One: Turn ½ " ball valve ¼ turn
- Ranger Mission Two: Drop vertically ½ " dia. Com Probe into 4 cm PVC coupling
- Ranger Mission Three: Attach horizontally 10 cm dia. Instrument Module onto a Velcro target

Brainstorming

Deciding on ways to deliver the packages:

All team members joined together and everyone suggested possible ways to complete this mission.

Each member sketched out three or more ideas

Each member made their best idea out of cardboard.

Everyone joined together and tested each other's ideas.

Everyone unanimously decided on ideas that are proved successful.

- Ideas for arm: Accordion with X-frame with stationary claw
- Ideas for hand: Shovel, Scoop, Claw.

Analyzing and Evaluating Design

-After testing different possibilities with cardboard prototypes, we searched for problems in prototypes.
-The prototype with the least number of problems was made out of wood and cardboard.
-After testing the wood/cardboard prototype, we evaluated problems.
1st Problem: The string opens claw but doesn't close it.

- Make it open with accordion x-frame.
- Use electric solenoids one to open one to close.
- Redesign the string path.
- Use air cylinder with the x-frame.

2nd problem: motors and propellers are not protected.

- Mount motors inside ROV frame
- Construct a cage/frame surrounding the exterior motors
- Install ¼" galvanized wire mesh around the motor itself.
- Make the motor fit in a big enough pipe to protect it.

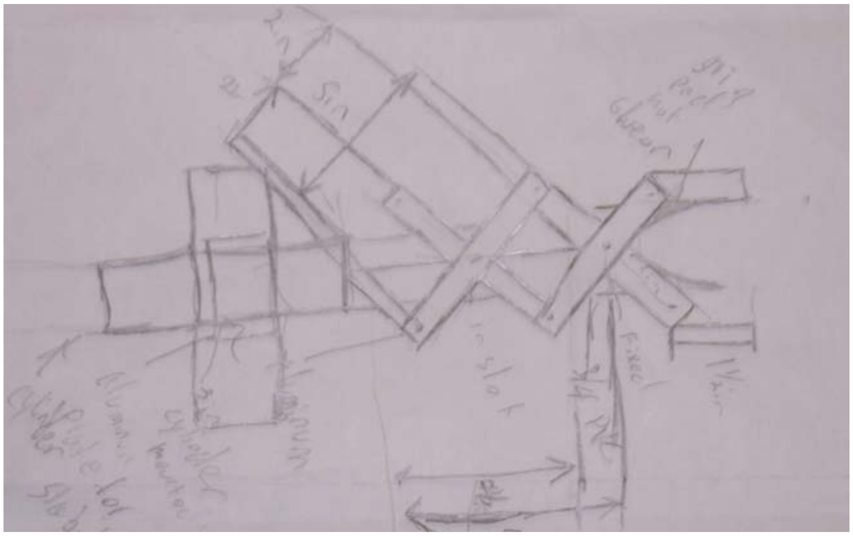
3rd Problem: can't see if the legs turn the valve or not.

- Add cross-hair wire rope to the two front legs for depth and height perception.
- Move bottom camera back farther to see the legs.

4th problem: the ROV doesn't move left to right as needed.

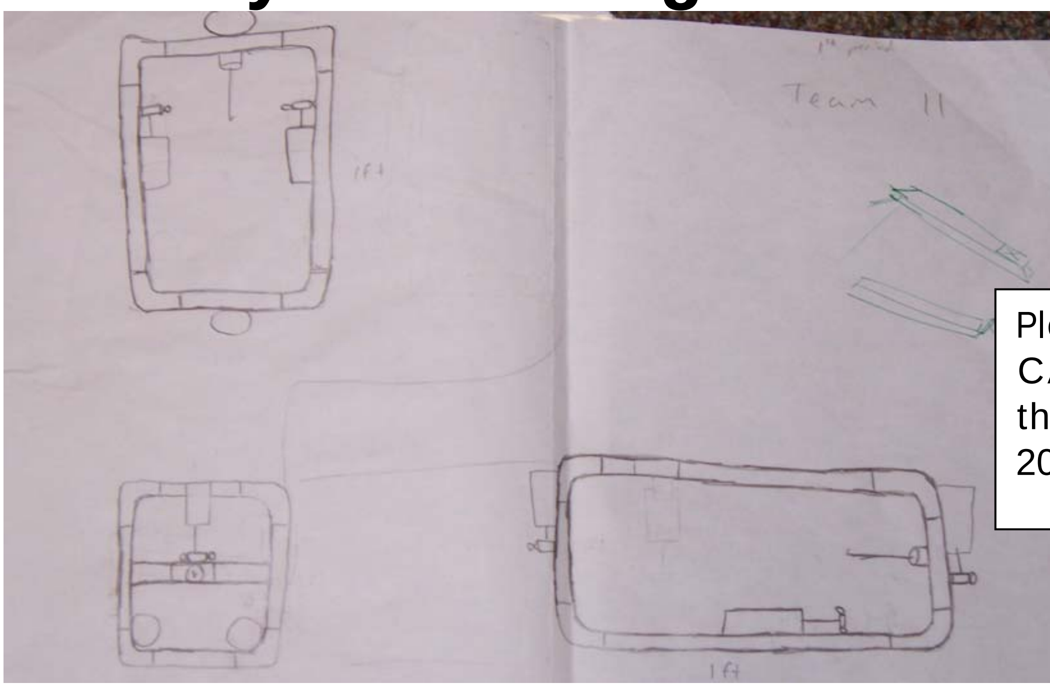
- Add shift motors on right and left sides.
- Reposition the existing motors to work for two different movements.

The Prototype claw

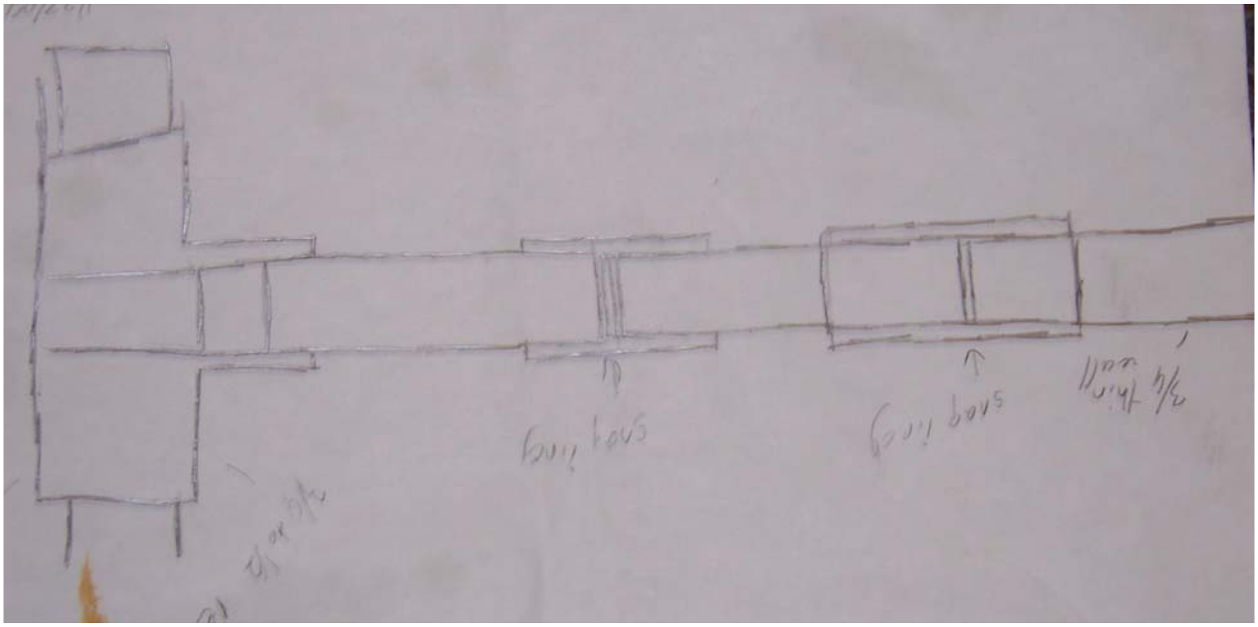
First Claw Plan

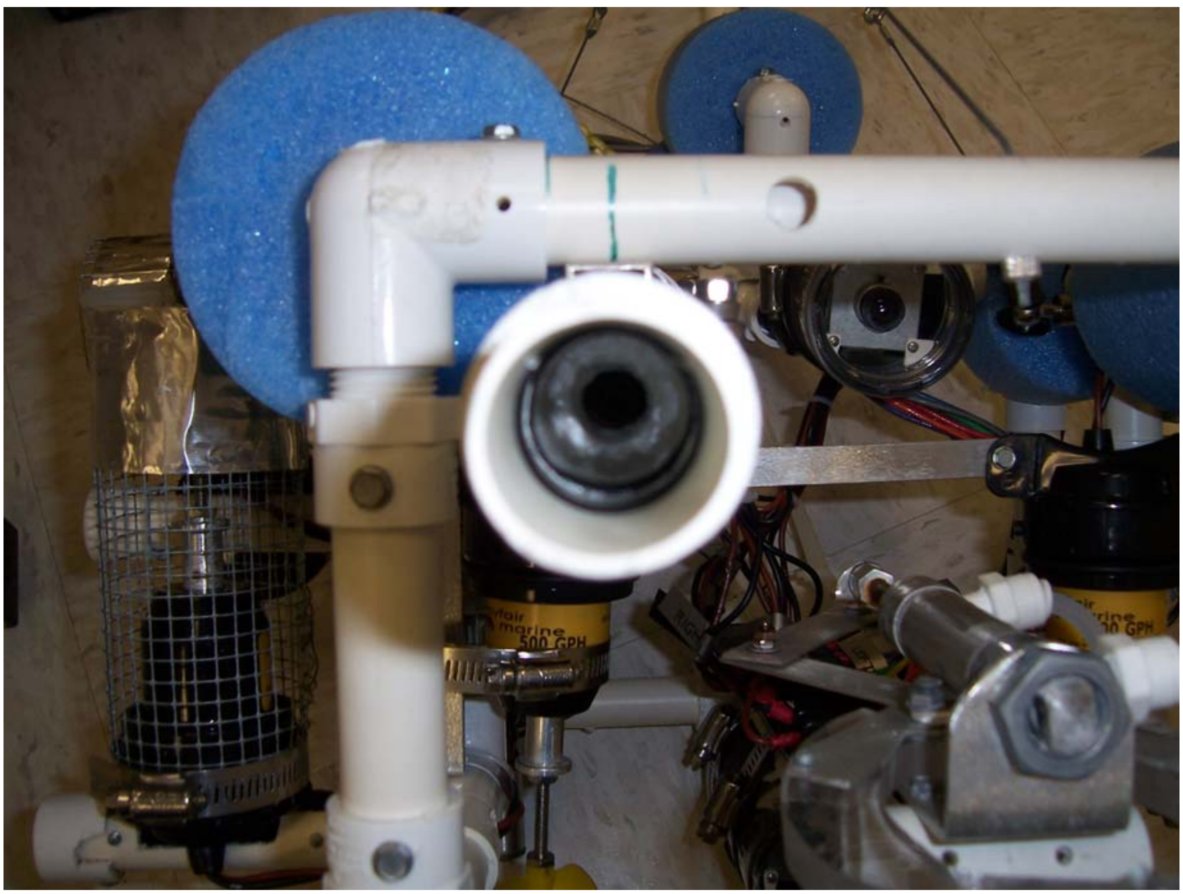
An early frame design



Please See Our CAD Drawing of the ROV as our 20th page

The first sketch of the air cannon



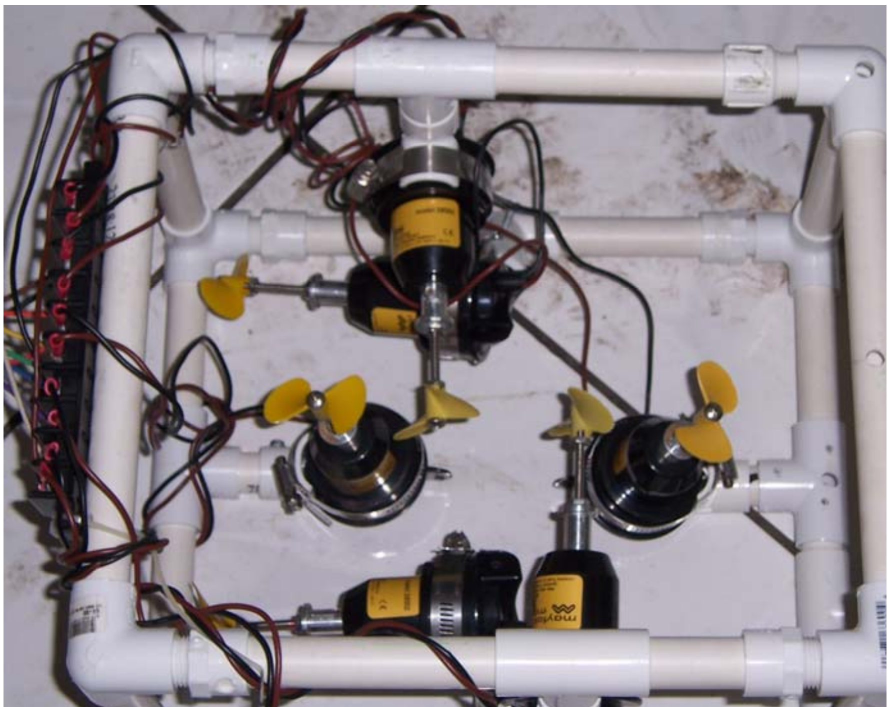


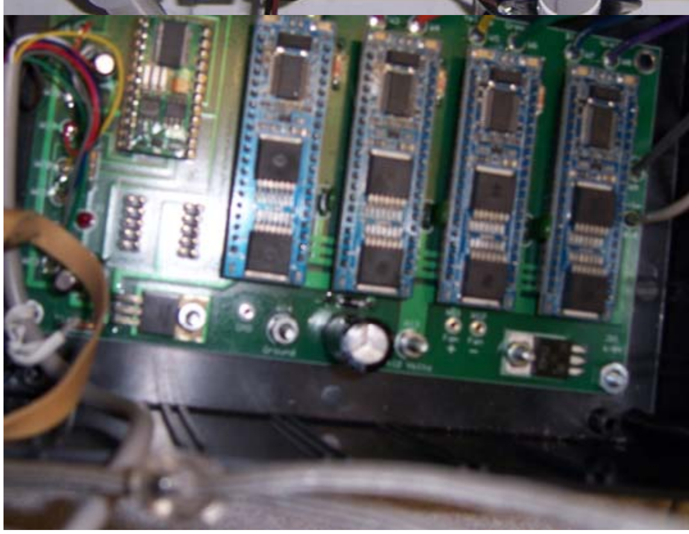
Looking into finished Air Cannon

On Going & Future Improvements

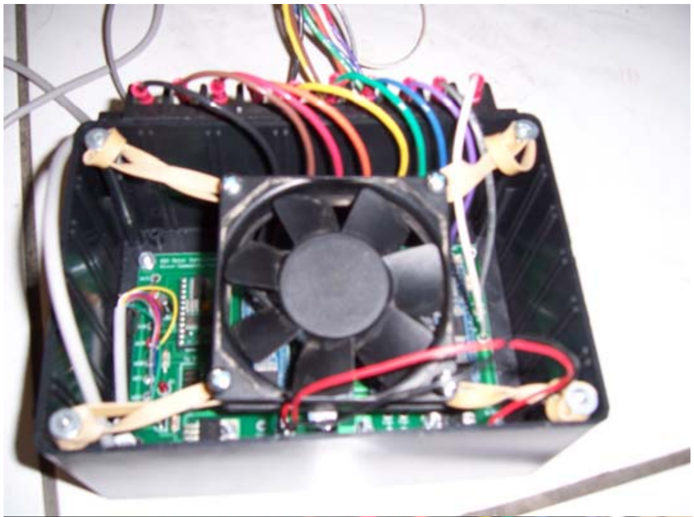
We are using a PS2 controller that was given to us by Alvin Com College an are trying to write software to work with our Robot. We have built a test robot with similar motor configuration. It appears at this time that our student programs may be ready in a few days.

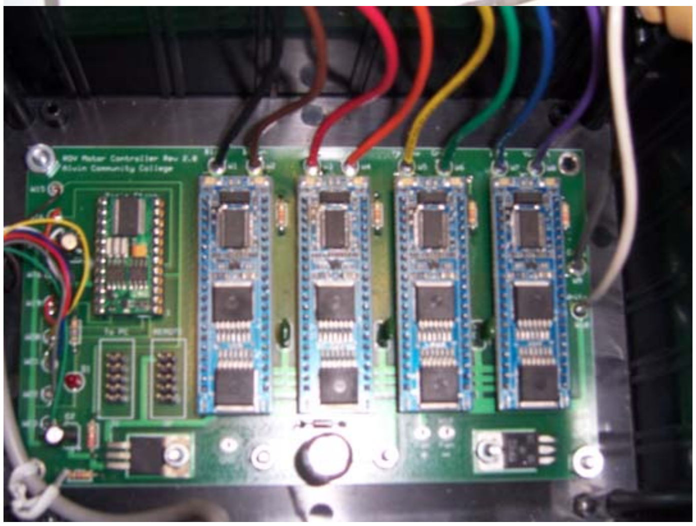
The Test ROV





The Basic Stamp Box





The Controller

Careers:

We are al interested in doing more robot building. Many of us want to stay with ROVs an since we are in the Houston area feel that the Oil Industry will be close for us. At A&M University at Galveston they offer a degree in Marine Engineering with ROVs.

Others of us are interested in Industrial and/or combat robots and are looking for education paths in that direction. When we went to the nationals in "First" robotics several Universities were there and a couple of the team is interested in that direction.

Being less than 6 miles from the NBL our visits there have inspired many of us to seek a career with Oceaneering.

Acknowledgements:

We wish to thank Mr. K. Page, our teacher, for providing all the tools and materials to make this ROV possible.

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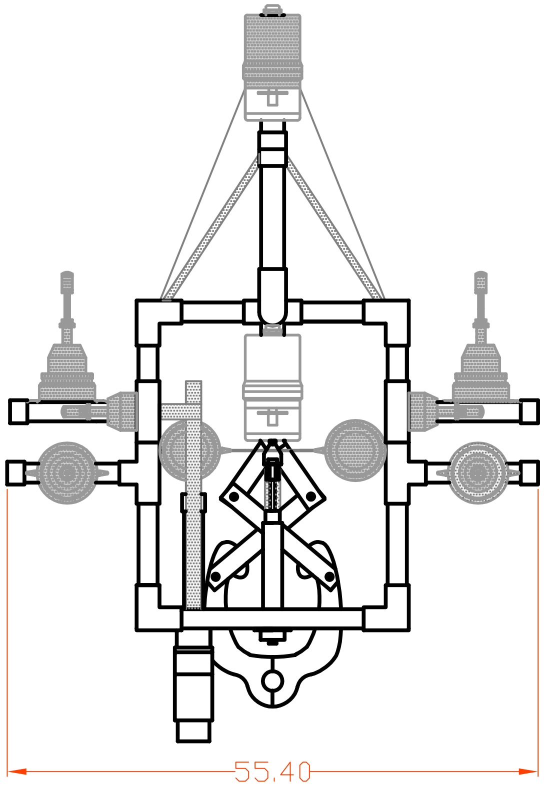
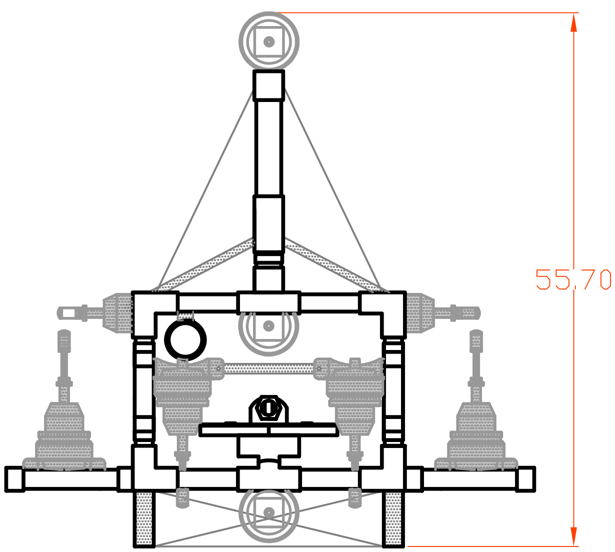
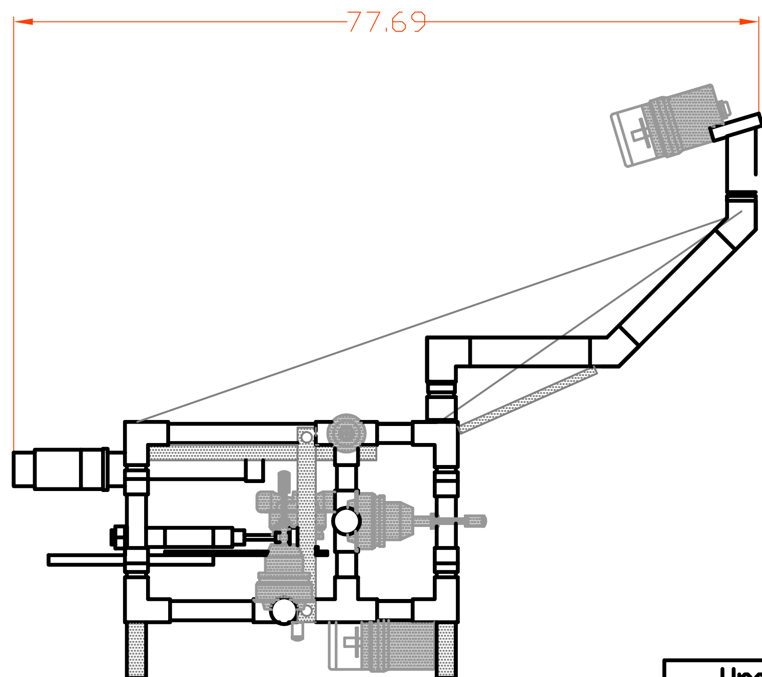
H_2O ~ Scorpion 2

Underwater Robot Dive Team







Underwater Robot			
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