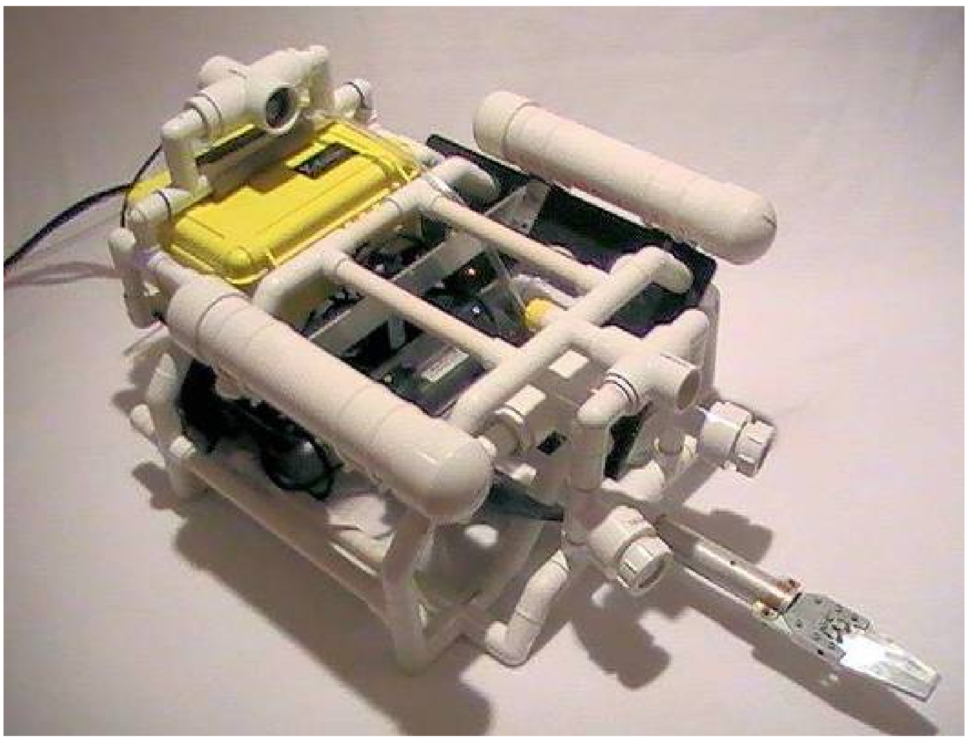
TECHNICAL REPORT
For
MATE 2007 International ROV Competition
Prepared by
Flower Mound High School ROV Team
Flower Mound, Texas

ROV "FloMo 1"



Team FloMo Members

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Luke Cragin
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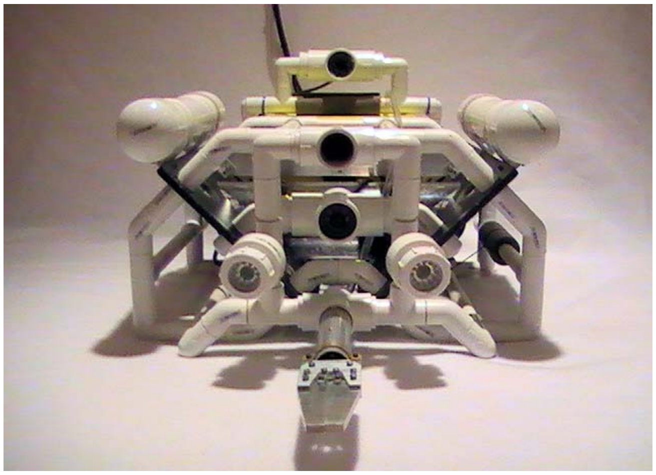
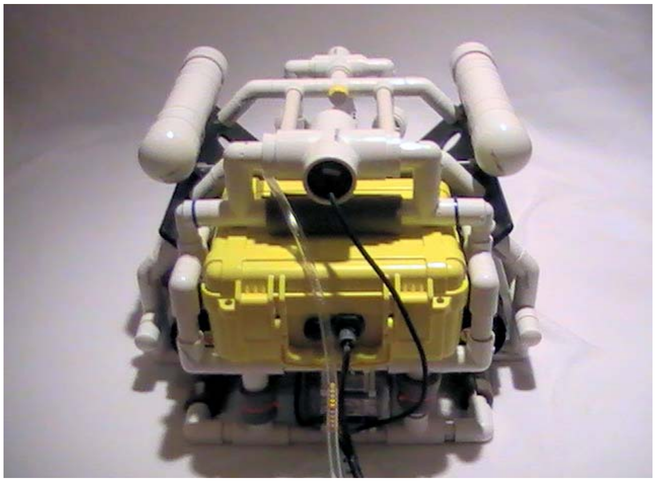
Instructors/Mentors

Ralph Szydlik – Technical Instructor, Trent Cragin – Construction Mentor, Harry Lewis – Electrical Mentor

Pictures of "FloMo 1"



Front View of "FloMo 1"



Rear View of "FloMo 1"

Table of Contents

Abstract
1. Team “FloMo” 5
2. Budget and Expense 5
3. Design Rationale 8
   3.1 Frame Construction 8
   3.2 Thrusters 9
   3.3 Lights and Cameras 10
   3.4 Control System 11
   3.5 Electrical Schematics 13
   3.6 Tether 14
   3.7 Payload and Mission Tools 15
4. Challenges 16
5. Trouble Shooting Techniques 16
6. Future Improvements 17
7. Lessons Learned/Skills Gained 17
8. Reflections 18
9. Life at the Polar Regions 19
10. Acknowledgements 20

Appendix 21

Abstract

This project was Flower Mound High School's first attempt at ROV robotics. As a first year team, our goal was to successfully build an ROV and compete in the MATE 2007 Competition. After researching ROV projects from previous MATE competitions, we came up with a design that incorporated proven and successful ROV elements from those competitions, along with our own design concepts. Using the MATE Competition mission guidelines, we designed and built a machine with the mission task in mind.

The design process for our team began with identifying all elements required to build a successful ROV. The process included selecting the number of thrusters and cameras, type of control system, selecting payload attachments and frame construction materials. Once these decisions had been made, we started the construction process. We began with hand sketches, which were eventually transformed into CAD drawings. Our original ideas were plentiful, but they were not all practical. Using CAD (2D and 3D) helped us to evaluate and visualize different design scenarios without wasting construction time and money. We could view the design quickly and make adjustments as desired.

Once our basic design had been established, we began the search for the best cameras, thrusters and electrical components available and started construction. After several months of hard work and interesting challenges, our machine was finished. Underwater testing soon followed along with mission performance evaluation. It became clear, very quickly, that mission specific attachments were key to achieving mission success. We were now ready for competition.

1. Team "FloMo"

Team "FloMo" is made up of two freshman and two juniors from Flower Mound High School in Flower Mound, Texas, a suburb of Dallas. Our interest in robotics began with our involvement in our school TSA (Technology Student Association) program. All of our team is interested in the sciences and math and want to pursue careers in engineering in the future. We are also interested in hands-on projects. Our instructor, Mr. Ralph Szydlik, passed out information of MATE 2007 to our group thinking that we might have some interest. Absolutely! We had also seen an article in "Robot Magazine" about the competition in 2006. We were hooked! The members of our team are Collin Cragin, Luke Cragin, Rachael Glockenmeier and Sung Ho Park.

2. Budget and Expense

When we started this project, we had no idea of the cost for an ROV project. After researching the MATE site archives for previous participant projects, we discovered that the cost could range between $1,500.00 and $7,000.00. Ranger Class ROVs were typically at the lower end of this range with less technology and complexity. With our limited school budget and several donations (items at half price) from individuals and companies, we established our budget of $3,000.00. At the end, we were close.

Donation/ Expense	Part Description	Usage	Quantity	Vendor	Cost
Expense	½" PVC(SCH 40) Piping	ROV Frame	10 ft.	Home Depot	$ 1.52
Expense	½" PVC Fitting – 90 Degree	ROV Frame	25	Home Depot	$ 5.75
Expense	½" PVC Fitting – 135 Degree	ROV Frame	22	Home Depot	$ 11.22
Expense	½" PVC Fitting - Tee	ROV Frame	17	Home Depot	$ 3.91
Expense	½" PVC Fitting - Cross	ROV Frame	8	Home Depot	$ 8.16
Expense	½" PVC Fitting - Spacer	ROV Frame	16	Home Depot	$ 2.72
Expense	½" PVC Fitting – End Cap	ROV Frame	6	Home Depot	$ 1.62
Expense	1 1/4" – 1/2" PVC Fitting - Reducer	ROV Frame	4	Home Depot	$ 3.72
Expense	1" – 1/2" PVC Fitting - Reducer	ROV Frame	6	Home Depot	$ 3.84
Expense	1" PVC Fitting - Cross	ROV Frame	2	Home Depot	$ 4.30
Expense	2" PVC Fitting - Cap	ROV Frame	2	Home Depot	$ 4.80

Donation/ Expense	Part Description	Usage	Quantity	Vendor	Cost
Expense	2” PVC(SCH 40) Piping	ROV Frame	10 ft.	Home Depot	$ 5.49
Expense	1 ¼” PVC Fitting - Cross	ROV Frame	2	Home Depot	$ 5.06
Expense	1 ¼” PVC Fitting – Trap Adapter	ROV Frame – Light Housing	2	Home Depot	$ 4.66
Expense	Carflex Fitting	Electronics Box Bulkhead	6	Home Depot	$ 8.94
Expense	Dive Weights	ROV Frame	2	Grapevine Scuba	$ 9.30
Expense	3/8” O.D. x ¼” I.D. Air Hose	Air Supply	75 ft.	Home Depot	$ 12.30
Expense	¼” Air Hose Barb	Air Supply	4	Home Depot	$ 6.40
Expense	L 3/4” x L 3/4” Aluminum Angle	Motor Frame	12”	Home Depot	$ 3.36
Expense	1” x 1/8” Aluminum Strip	Motor Frame	12”	Home Depot	$ 1.97
Expense	1 ½” x 1/8” Aluminum Strip	Motor Frame	18”	Home Depot	$ 3.36
Expense	9” x 15” x ¼” Cutting Board	ROV Frame	2	Target	$ 15.98
Expense	4” Dia. x 18” Clear Poly-Carbonate	ROV Frame	1	US Plastic Corporation	$ 19.82
Expense	LCA 7700C Infra-red Camera	Underwater Camera	2	Lights Camera Action	$ 450.00
Expense	XT5000	ROV Electronic Box	1	BA Products	$ 34.95
Expense	Parallax HB-25 Motor Controllers	Motor Control For Seabotix Thrusters	4	Parallax, Inc.	$ 199.80
Expense	Parallax Board of Education	ROV Interface Surface Control Board	1	Parallax, Inc.	$ 65.95
Expense	Parallax Basic Stamp	ROV Microchip	1	Parallax, Inc.	$ 49.00
Expense	Parallax APP Module Board	Surface Module Board	1	Parallax, Inc.	$ 69.95
Expense	Blue Bell Co-Processor Board	ROV Underwater Control Unit	1	Blue Bell Design	$ 264.95
Expense	Blue Bell Design Transceiver Board	ROV Underwater Control Unit	1	Blue Bell Design	$ 145.95
Expense	2 Wire x 14 GA U.L. Wire	Tether Umbilcal Power	100 Ft.	Home Depot	$ 25.69

Donation/ Expense	Part Description	Usage	Quantity	Vendor	Cost
Expense	Dayton Single Action Air Cylinder	Claw Actuator	1	Grainger	$ 18.95
Expense	22 GA Strand Wire	Data Wiring Between Surface and ROV	100 Ft.	Jameco	$ 4.65
Expense	20 GA Strand Wire	Miscellaneous Wiring	100 Ft.	Jameco	$ 7.69
Expense	18 GA Strand Wire	Motor Wiring	100 Ft.	Jameco	$ 9.65
Expense	14” Servo Extension	Motor Controller/Co-Processor Data Wiring	4	Parallax, Inc.	$ 5.16
Expense	Female 9 Pin D-Sub Connector	Joystick Connector To BOE Interface Control Board	2	Jameco	$ 1.22
Expense	Analog Joystick	ROV Control	2	EBAY	$ 10.00
Expense	12 Pole Double Row Terminal Blocks	Wiring Terminals	4	Jameco	$ 14.36
Expense	Eye Connectors 16-22 GA	Wiring Connectors	100	Radio Shack	$ 12.40
Expense	LEDRING 12	ROV LED Lighting	2	Mainland Mart	$ 49.90
Expense	1.25 O.D. x 0.058 Aluminum 6061 Tubing	Claw Housing	6 ft.	Metal Supermarkets	$ 105.65
Expense	1.125 Dia. x 12” Delrin Rod	Claw Bushing	6 ft.	Interstate Plastics	$ 135.47
Expense	Miscellaneous Stainless Steel Hardware(screws, washers, nuts)	Frame, Claw and Thruster Connections	-	Ace Hardware	$ 30.00
Expense	GE Silicone II	Waterproofing	1	Ace Hardware	$ 4.97
Expense	9/16” Dia. Rubber Faucet Washers	Waterproofing	15	Home Depot	$ 1.37
Donation	Seabotix BDT150 Thrusters	Directional Control Thrusters	4	Seabotix, Inc.	$ 1,550.00
Expense	Seabotix BDT150 Thrusters	Directional Control Thrusters	4	Seabotix, Inc.	$ 1,550.00
Donation	LCA 7700C Infra-red Camera	Underwater Camera	2	Lights Camera Action	$ 450.00

Total Project Cost (with Donation) $ 3415.88
Total Project Cost (without Donation) $ 5415.88

3. Design Rationale

Our main focus in design was to concentrate on the completion of mission objectives, while keeping in mind the competition schedule, limitations of our knowledge, the availability of materials and cost. We began our project with the desire to make all ROV components from existing available products, but ended up compromising to some degree for reasons of cost or time. At the beginning of our project we defined four areas of design where we needed to focus our concentration:

1) Maneuverability and Speed
2) Size and Weight
3) Mission Specific Tasks and Attachments
4) Simplicity

Without an ROV that could maneuver accurately and with speed, there would be no hope of completing any mission. For this reason, we chose to use a joystick type control system. This system would allow us to have proportional control and motor mixing for better efficiency. As for speed, we wanted the most powerful motors/thrusters we could build or find to overcome any potential current and minimize mission completion time.

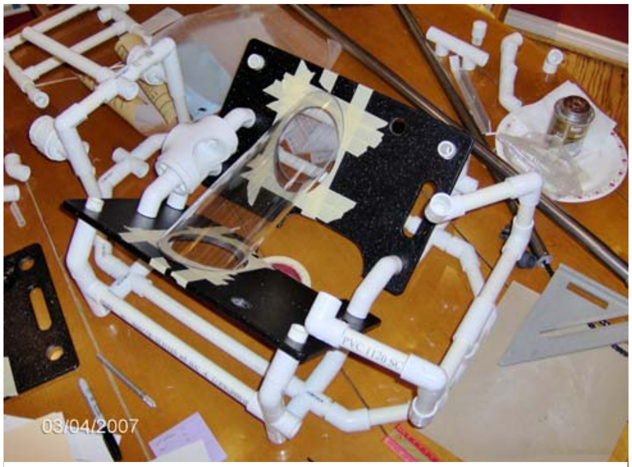
Keeping in mind the environmental parameters of all missions, with an ice insertion hole 80 cm x 80 cm, we had to keep the ROV relatively small. Keeping the machine small and light would produce other side benefits as well. A smaller profile would result in less drag and more efficiency with the thrusters. There would also be less external influence of surface waves and water current. Reducing weight, by using as many naturally buoyant elements as possible, would also help to improve thruster efficiency.

The exact placement of objects under water for all missions was a major challenge. Without the “gadget” to help ROV positioning, each mission specific task would become extremely difficult. We focused on making the robot frame adaptable for different payload attachments.

Looking at the big picture and stepping back from detail, we had to constantly remind ourselves to keep it simple. Sometimes “simple “ is the best solution.

3.1 Frame Construction

We chose to use PVC components for the frame construction because of the availability of lightweight modular connectors, ease of modification and assembly, durability and minimum cost. The variety of PVC components available on the market is enormous. The standard PVC piping also had a minimum pressure rating of 150 PSI, which far exceeded our contest requirements. Another benefit of using the PVC was the ability to run electrical wiring within the pipe sections for concealment and protection from wear. However, we soon realized that making attachments for other components to round PVC pipes was not always easy. Therefore we introduced another major frame component, the polyethylene cutting boards.



Early Stages of Frame Construction

The boards provide a flat surface to mount other ROV components (motors and cameras) as well as provide stiffness (diaphragm action) for the entire PVC frame. The orientation of the boards was determined by the decision to maximize forward and reverse motion. The boards were aligned parallel with this direction of movement to produce minimum profile. The 90-degree “V” angle between boards was set as a compromise to upward and sideways movement and to provide frame stiffness in all directions. To limit the hydrodynamic effects produced by the board surface area, we cut holes to permit water flow through as many locations as possible, without sacrificing strength. The entire frame geometry was set to meet the contest physical constraints and provide a support platform for the ROV motors, electronic module, claw, attachments and lights. Except for the vertical direction, the frame was designed to permit a clear thrust path for all motors. Reference the Appendix.

The placement of the motors, the claw and electronics box was a constant concern to us throughout the design and building phase. Our goal was to try and match the buoyancy of some elements with the weight of other elements. Ultimately, we tried to position all elements so that the center of gravity coincided with the center of buoyancy. The frame and cutting boards have net positive buoyancy. Although the PVC frame was assembled with glued joints and plugs, we injected the frame void with expanding foam sealant to prevent any additional water infiltration. This entire exercise was to prevent a changing buoyancy condition.

3.2 Thrusters

Our initial propulsion design considered the use of bilge pumps. Bilge pumps are already waterproofed and well suited to the underwater environment. We had two options with these motors:

1) Use the bilge pump unmodified with propulsion in just one direction or
2) Modify the bilge pump to accept a propeller to permit propulsion in two directions.

The use of the unmodified bilge pump was eliminated quickly because twice as many motors would be required to produce the same result as reversible motors with propellers. This was undesirable because more motors would result in more wiring, more weight, more current draw and more congestion on the ROV frame. With this in mind, we proceeded to test the Rule 1100 bilge pump with different propeller types with varying pitch, blade count and diameter. The availability of motor and prop combinations is enormous on the market today. Each motor motor/prop combination was tested for current draw and thrust. Thrust was measured using a spring scale supporting the engine in a submerged condition, simulating water load. Rule also makes a 1500 GPH bilge pump, but the larger physical size was a problem for thrust in one direction. The housing profile blocked most of the effective thrust. For this reason, we decided that the Rule 1100 GPH bilge pump would be a better fit for our project, sacrificing some thrust.

To increase the effective thrust, we added a Kort nozzle to the vertical and forward/backward motors. The nozzle provides containment and directional control of the water flow. For the sideways motion motor, we mounted the entire motor inside a clear polycarbonate tube. There is nothing significant about the tube being clear other than it made the motor look like it was just floating in water with no attachments (Very cool!). The tube eliminated any interference and loss of effectiveness from other frame obstructions and provided channel flow.

Although the exercise to evaluate off-the-shelf bilge pump motors was a good learning experience, we were concerned about our competition and mission completion within a competitive time. In our search for better motors, we discovered "Seabotix, Inc.", a commercial manufacturer of ROV robots and components. With further research, we found out that they were supplying motors to many of the MATE teams. With a half-price discount, offered to all teams, and a timely donation from one of our mentors, we purchased four motors for our machine. These motors are small and mount easily to our frame. They have a low profile in the direction of flow. They also include the Kort nozzle shroud. They were a perfect solution and would operate off of 12VDC or 24VDC. The maximum thrust of these motors is about 1.8 kg at 4.0A.

3.3 Lights and Cameras

Thinking of dimly lit water depths, we decided to add lights to our machine. Our goal was to find the brightest intensity waterproof lights available with the least amount of current draw. After some initial investigation, we decided that LED lighting (bright with low current draw) would be a good choice. We located a manufacturer of landscape and pool lighting on the internet that had many different types of light assemblies that would meet our needs. Matching their products with our PVC fittings, we came up with a light assembly that worked well with our machine. We purchased a sealed 12 LED light assembly with a 1 ¾" diameter light base. These lights operate on 12VDC and only draw .15A per unit.

After resolving the light issue, we moved on with our search for cameras. Once again, we were looking for a camera that was waterproof, small in size, had low power consumption and worked in low light levels. With a budget in mind, we began our search for a commercially available board camera (not waterproofed). We purchased several 1 ¼" square board cameras and proceeded to build waterproof housings out of PVC components and lexan lenses. We soon discovered that waterproofing the cameras was a challenge and the operation of the cameras in low light levels was unacceptable. We began our search on the internet again, this time for commercially available underwater cameras.

We found a company that specialized in underwater cameras, "Lights Camera Action" out of Mesa, Arizona. This company was also supplying many MATE teams with cameras. Using their half-price discount offered to any interested team, we purchased two cameras for our machine. These cameras were perfect for our mission. They were waterproof, had infra-red LEDs for low light conditions, small in size – 3.5 cm diameter x 10 cm long, operated on 12VDC, had a current draw of .15A and came with 100 feet of cable.

The positioning of cameras was critical to performing our mission tasks. We placed one camera in the front of the frame, looking straightforward. This camera gave us a full view for general steering, mission prop location and activation movement of the claw above. This camera could also be relocated to a lower position for Mission #3 observation below the claw. We placed a second camera on top, at the rear, to provide a view of the algae collection attachment in Mission #2. For all cameras looking straight ahead, depth perception was difficult. All camera cables were connected back to the surface, via the tether, to the "CSI ProVideo", four channel, video sequencer. Using one 13" color television monitor, we could switch between all cameras with the flip of a switch. The only problem with configuration was the bulkiness of three camera coaxial cables.

3.4 Control System

The main ROV control system is separated into two parts (1) the surface system and (2) the ROV underwater system. Our goal was to build a control system with readily available electronic components, learn PBASIC programming skills and utilize analog controllers for proportional motor control. Without the help of our mentor, Harry Lewis, we could have never made this happen.

The surface unit includes our analog joystick controllers, Parallax Board of Education (BOE) with BS2 Basic Stamp microcontroller, Parallax AppMod/Transceiver board and two 12 pole power blocks. In an effort to avoid the use of standard on-off toggle switches for motor control, we chose to use the standard analog joystick. The joystick provides much better control and allows for proportional mixing of motors for the forward, backward and turning movements. The joystick position is determined by potentiometers, or variable resistors, attached to the joystick gimbals. Varying the resistance of the potentiometer alters the electrical current and sends the analog resistance readings to the AppMod board and then to the BOE, the ROV brain. The functions of each individual component are outlined as follows:

The Parallax Board of Education (BOE) Functions:

1) Provides platform for the BS2 Basic Stamp microcontroller.
2) Provides serial connection between computer, BASIC Stamp Editor and BS2 for PBASIC programming
3) Converts the resistance readings from joystick potentiometers into servo values using RCTIME instructions (PBASIC Language) and sends this information back to the AppMod/Transceiver board.

The Parallax AppMod/Transceiver Board Functions:

1) Provides connection between joystick and BOE.
2) Receives 12VDC power from battery, powers BOE, and sends power to underwater ROV.
3) Receives signal data from BOE and transmits to underwater ROV Co-Processor board.
4) Separates serial data going to and back from the underwater Co-Processor board. This is necessary because the Co-Processor (servo controller function) requires separate wires for the data in each direction, but allows us to use one data wire to limit tether size.

The ROV underwater system includes our Blue Bell Design Transceiver/Driver board, Blue Bell Design Co-Processor board, Parallax HB-25 motor controllers and two 14 pole power blocks. All electronic components of the ROV are placed within a BA Products XT5000 watertight box (rated to 30 m).

Transceiver/Driver Board Functions:

1) Receives serial data coming from the AppMod surface unit and sends data to Co-Processor board.
2) Separates serial data going to and back from Co-Processor board.
3) Drives reset to Co-Processor which stops the servo signals to motor drivers.

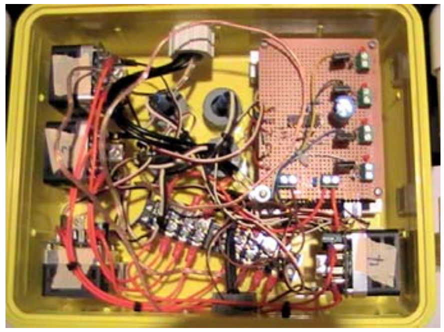
C0-Processor Board Functions:

1) Receives commands from the BOE, through Transceiver/Driver Board, and converts them to servo pulses to the motor drivers. The Co-Processor chip coverts serial data signal into a high level pulse from 1 to 2 ms in length. Servo pulses repeat every 20 ms. A1.5 ms pulse will cause a motor driver to stop. A 1 ms pulse will cause the motor to go full speed in one direction. A 2 ms pulse will cause the motor to go full speed in the opposite direction.
2) The board also has other features not used, like bumper sensors, voltage measurement and timers.

Motor Driver Functions:

1) The Parallax HB-25 motor controller is rated to 25A (maximum peak) and operates on 12VDC power. Our motors do not exceed 5A each.

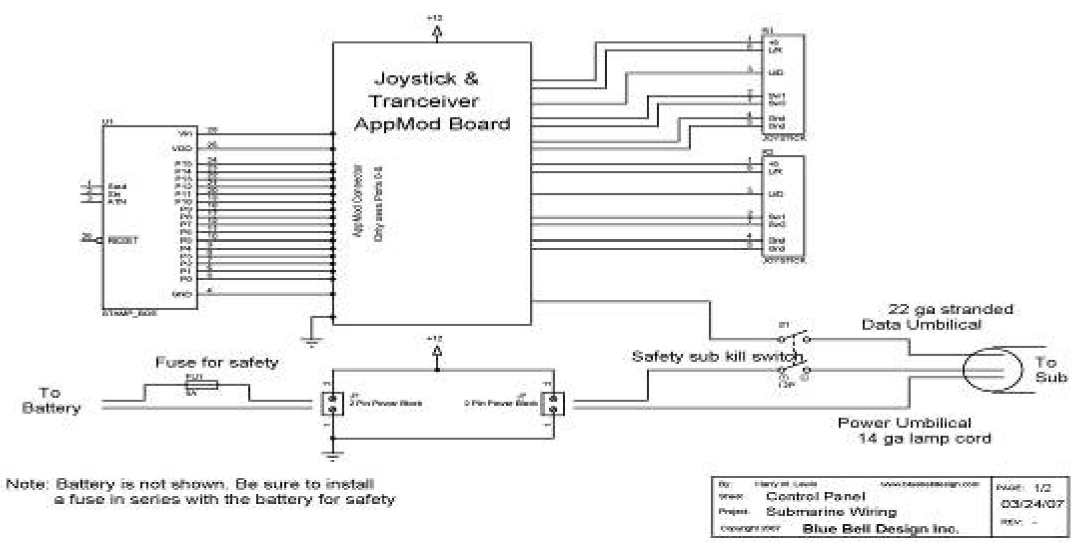
2) A signal servo wire is connected from the Co-Processor board servo port to each motor controller. Power to each motor controller is supplied directly from the power block in the electronics module.
3) Uses Pulse Width Modulation (PWM) to control motor speed.

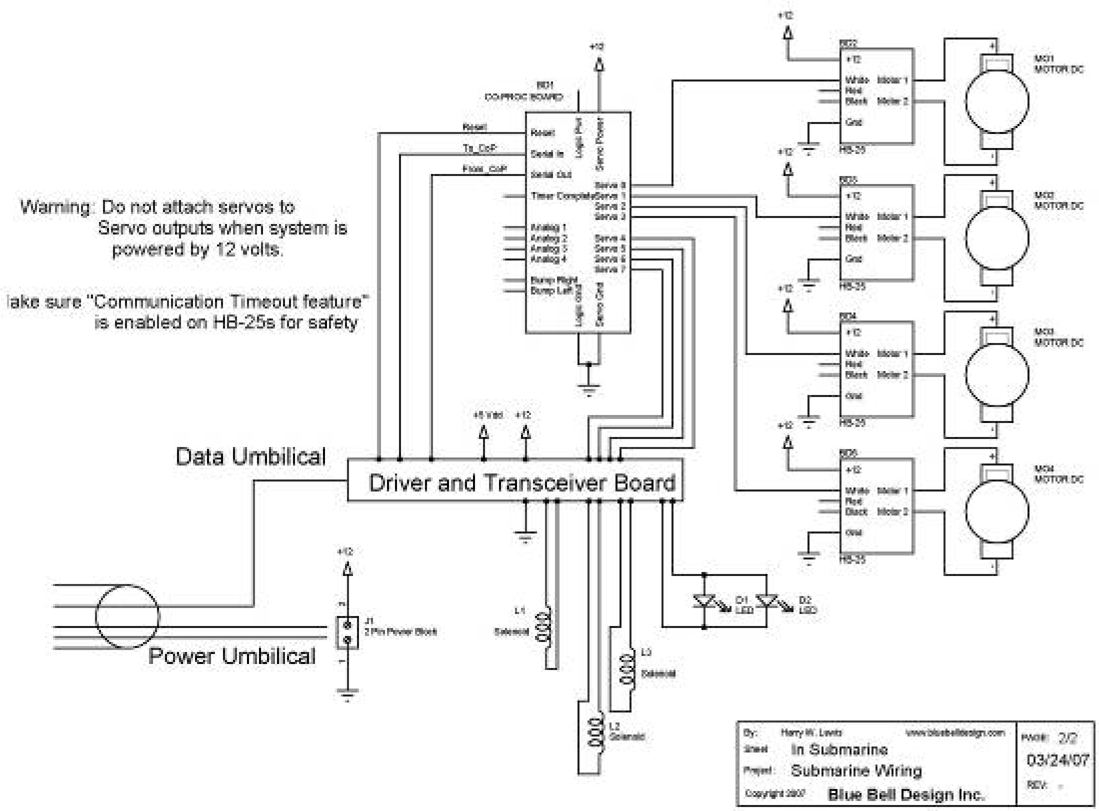


The ROV's Waterproof Electronic Box

Our biggest challenge for the ROV electronics box (the XT5000 box) was to maintain water tightness with multiple penetrations. Our box has a total of six penetrations, four motor wires, two LED light wires and one tether with multiple wires (see Tether). Using plastic electrical ½" and ¾" Carflex bulkhead fittings, double neoprene water faucet washers and GE Silicone II, we were able to make each penetration watertight. As an added measure of safety, we elevated all of the electronic components ½" above the bottom of the box to provide some additional protection (assuming water collects slowly in the bottom) and time to check for leaks between missions.

3.5 Electrical Schematics





3.6 Tether

Our goal for tether construction was to eliminate as many conductors as possible. We realized that a thick and stiff tether would add drag and weight. Our tether consisted of the following elements:

1) 1- 2 wire 14 GA insulated wire for ROV power
2) Three video camera cables
3) 1 – 22 GA signal wire
4) 1 – ¼" ID/3/8" OD plastic hose air supply
5) 1-25 A fuse

This length of the cable was chosen based upon the maximum vertical and horizontal distance to the mission prop location (4m down and 10m out from the wall). This gave us a total length of 14 m. We added another 30% for maneuvering around the prop. The total length of the tether was 18.28 m. The combined tether umbilical had negative buoyancy characteristics, so we added foam flotation segments about every four feet to provide neutral buoyancy. The positioning and length of foam flotation was by trial and error. The foam used was HVAC coolant line insulting foam. This works great until you go to deeper depths. This foam eventually losses its buoyancy with greater pressure.

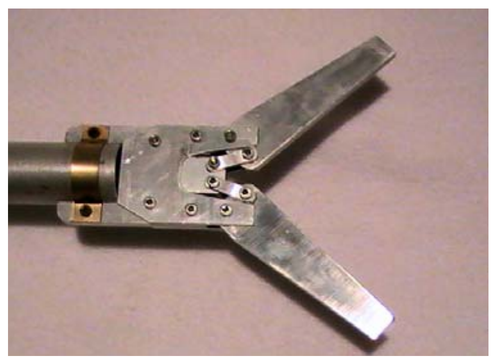
3.7 Payload and Mission Tools

The ROV is very maneuverable, but placement of objects at a precise point in space requires extremely sensitive controls, mission specific tools and a good driver. After our ROV had been completed, we started to practice each mission task. We discovered very quickly that the control of our machine for precise positioning was difficult and we needed additional help to complete several missions.

The claw was great for general holding and retrieval. All tasks in Mission #1 are easily completed with the basic claw configuration. In Mission #2, the task of grabbing the benthic jellyfish is also easily accomplished with the basic claw. However, the Mission #3 task of positioning the hot stab into the well head requires that the claw hold the hot stab at an angle of 45 degrees from the horizontal claw arm. Our claw blades were modified to achieve this (not shown). We also made a special arm/hook assembly for the well head cap removal and gasket insertion task.

Claw Mechanism - Closed

Our original claw design was based upon the use of an electric motor with planetary gears and linear drive screw, mounted internally in an aluminum tube. We chose this form of drive mechanism because the clamping force from the motor torque was significant. All claw parts were designed by our team on CAD and made with shop tools.



Claw Mechanism - Open

However, we had several challenges to overcome with the claw design:

1) Waterproofing the geared electric motor
2) Setting travel limits for the drive screw
3) Finding available parts for bushings and seals to fit within the aluminum tube

We successfully resolved challenges (1) and (3), but did not have time to work out the problem of travel limit control before Regional Competition. Until this time, we had avoided using air pressure and running an additional tether line to avoid tether thickness and stiffness, but we decided to go back to the air actuated piston driven claw.

The air piston we used was a single-action piston with spring return. The claw opens with pressure and closes with spring return. The only problem with this power system is that the clamping force is relatively weak with the spring return. Fortunately, clamping force is not a critical component of any mission task this year. We could improve the clamping force with the use of a double-action piston and solenoid valve switch.

A special attachment was also designed for mission #2, task #2. The collection of the algae (ping pong ball) proved to be very difficult in practice and regional competition, even with a smooth flexile ice fabric surface. The task will probably be more difficult with real ice since the underside surface may be more irregular.

4. Challenges

During the course of this project, our team encountered many challenges and learning opportunities. We approached every challenge as a team and resolved some issues quickly and others with more deliberate thought. Our most significant challenges were:

1) Developing an electronics control system, learn PBASIC programming
2) Waterproofing the electronics box (see Control Systems)
3) Developing a claw mechanism (see Payload and Mission Tools)

With the help of Mr. Harry Lewis, our electrical mentor, we learned how to bring together several components, made by different manufacturers, to make a complete control system. Mr. Lewis created our first joystick program and helped us learn PBASIC programming. Our team organized and installed all of the wiring and component placement for “FloMo 1”.

5. Trouble Shooting Techniques

During the course of the project we developed several trouble shooting techniques. Most of our challenges were related to electrical problems, the claw mechanism and buoyancy. Some examples of these problems and solutions are as follows:

1) Problem - There is no power to an electrical component.
   Solution - Starting from the battery and ending at the ROV, check every connection with a volt meter to determine if there is power. Repair the connection or rearrange the wiring until there is a reading on the meter.

2) Problem - The air actuated claw will not close or return completely.
   Solution - Provide rubber bands around the base of the claw blades to help the internal return spring. Oil the internal piston chamber frequently to lubricate the o-ring now operating in a water environment.

3) Problem - The tether sinks creating drag on the ROV.
   Solution - Add small pieces of insulating foam to the tether line at equal intervals to establish neutral buoyancy. Add air lines for pneumatics for additional buoyancy.

4) Problem - The ROV buoyancy changes with extended time in the water.
Solution - The ROV PVC frame had some leaks. Expanding foam was sprayed inside all frame PVC pipes to prevent water infiltration. The void was filled and consistent buoyancy was achieved.

5) Problem - Adding foam insulation around PVC pipe frame adds only limited buoyancy.
Solution - This type foam crushes at shallow depths and loses buoyancy at some point. Only use syntactic foam (very dense) or sealed hard-shell PVC components.

6. Future Improvements

With more time, investigation and money, we could definitely make improvements with our current ROV. Since this was our first year to compete in MATE, it was our goal to design and build a machine that could meet the basic requirements for the competition and keep the cost as low as possible. Our goals for next year will be to improve the following:

1) Replace the current control system joysticks with either a PS2 controller or commercial grade precision joystick.
2) Add an additional vertical thruster. Provide vertical tube nozzle to add Kort effects.
3) Replace coaxial camera cable and signal wires with fiber optics.
4) Replace claw power system with electric geared motor and screw drive or double action air pistons.
5) Relocate electronic module to center of machine frame for better buoyancy balance. Eliminate adding any weight.
6) Add variable ballast system to allow for payload weight.
7) Add more cameras.
8) Refine mission specific payload attachments.
9) Make use of impulse connectors for all electronic box penetrations to reduce chance of water leaks and allow for wet connections.

Our list of improvements was created from our experience gained this year and observing our competition.

7. Lessons Learned/Skills Gained

We began this project not knowing anything about electronics and computer programming. We now have a much better understanding of electronic components, circuitry, program code (PBASIC) and how they can be combined to make complete control systems. Although we do not completely understand all PBASIC language, we have become familiar enough with our own ROV programming to make small adjustments to the code. Our goal for next year is to be totally independent and develop our own ROV program with more functions and features for a more advanced robot.

With the aid of the internet, we also discovered a large network of electronic products and suppliers. This opened our eyes to even more possibilities for system design.

We found that the use of CAD (Computer Aided Drafting) was a tremendous help in the development of our ROV design. Making the ROV out of standard PVC parts and knowing the physical dimensions of all attached equipment, made it easy to create a model, change and manipulate our design without any actual construction. Time and material were saved. This is a great engineering tool. Our CAD skills improved immensely.

As this project developed we discovered that we had to be creative in the selection of off-the-shelf components that we could bring together to build a complete project. Finding “things” that fit into other “things” or that could be modified easily became our driving objective. What would we do without Home Depot? Building the frame involved the use of many shop power tools. We learned what tools worked better than others for specific tasks and developed hands-on skills. Working with your hands and your mind is extremely rewarding.

Team organization and scheduling are essential to a successful project. Without a schedule for task completion, we would have never been ready for the competition. We established a schedule early in the project, which was followed with very little deviation. Dividing project tasks among team members helped distribute the workload. Research is a key component of success. Many hours were spent on the internet by all, looking up related links for materials and ideas.

8. Reflections

The 2007 MATE Regional Competition has been an exhilarating learning experience for our entire team. From the beginning stages of the design process, to the regional competition at the Neutral Buoyancy Lab at NASA, we gained invaluable knowledge of ROV operations and their use in the scientific and research communities. The training pool facilities at NASA, along with a complete submerged space station, were simply unbelievable.

The MATE competition itself, with each different mission challenge, was extremely interesting. The fact that these missions incorporated real life undersea tasks made our experience seem even more important. Relating to this year’s theme of “The International Polar Year”, we can see how the use of the unmanned ROV can help with the scientific exploration, under the ice, in extreme environmental conditions. Eliminating the need for manned submarines, requiring human conditioning, will help make exploration much more economical and safe.

9. Life at the Polar Regions

From the first settlers, to the people that will inhabit the poles hundreds of years from now, they have a common bond. This bond is the need to adapt to their environment. They must adapt to many things in their climate such as the temperature, lack of rainfall, and harsh terrain, all of which are ever-changing aspects of life at the poles.

Both poles are considered polar deserts, a term for a region that receives very little rainfall and has extreme cold. This climate along with the rugged terrain is a driving force for humans to adapt to the area. One way people have adapted is living in close proximity to others in order to utilize the same amenities and resources. Other things that people have had to adapt to are different modes of transportation, how to collect and hunt for new foods, new types of shelter, keeping warm, and different methods of employment. In many ways they have had to depend on each other more than we depend on each other because of the unavailability of alternative solutions.

Adaptation will need to continue in these ever changing areas that are new and unexplored. Outcomes of exploration in the area possibly involving robots could bring changes in economy and population. Global warming is a large factor in the constant changing of the land, and people have to continue to adapt. They will have to face warmer temperatures which will melt parts of the ice layer causing changes in animal and plant populations and the shoreline. The increased amount of methane released from thawing permafrost will also greatly affect Polar Regions. Results from studies collected during the International Polar Years (IPY) may bring insight into the dramatic changes to the Polar Regions. This insight may prepare people for the changes coming and offer options to alter undesirable changes.

Changes in adaptation are part of evolution and are occurring everywhere. The extremes of climate, location and limited previous exploration have made the poles regions that have required great adaptation. The future with global warming, international interest spurred by events such as IPY, will demand continued adaptation on the part of people in the polar region and in the World.

Chilean Antarctic Base
(Source: http://epsc.wustl.edu/seismology/SEPA/photos/prat.jpg)

This image shows an Antarctic base and living shelters at a coastal site.

Works Cited

Science from the poles- http://www.exploratorium.edu/poles
Windows to the Universe – http://www.windows.ucar.edu/tour

10. Acknowledgements

We would like to thank the following people and companies for their help, support and donations:

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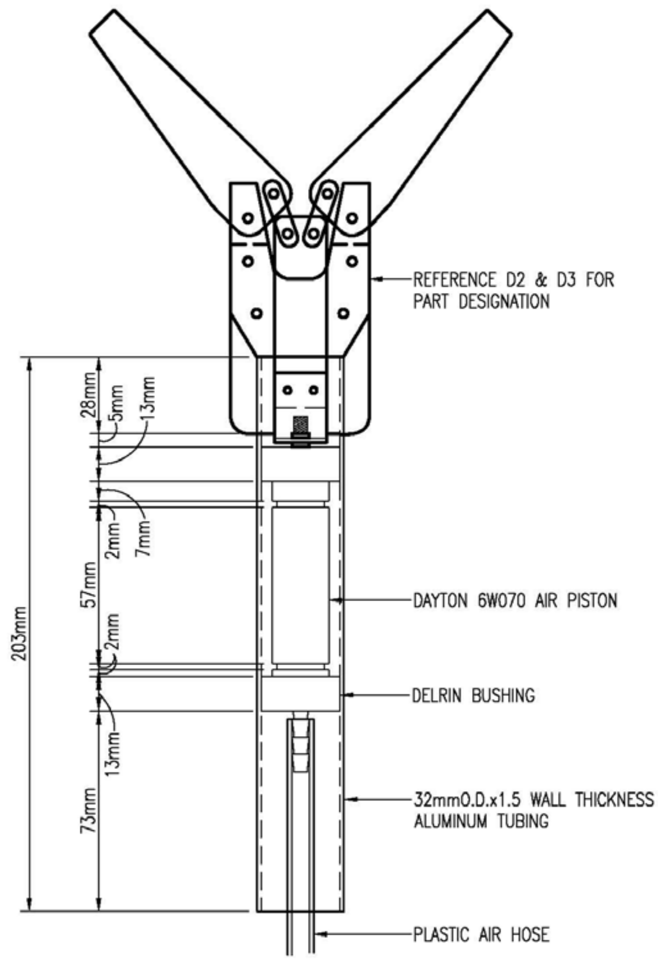
Halsey Engineering
Lewisville Independent School District
Flower Mound High School
NASA Neutral Buoyancy Lab
Oceaneering, Inc.
Lockheed Martin Aerospace

Without this group, this project would not have been possible. Our instructors and mentors were incredible.

Appendix A

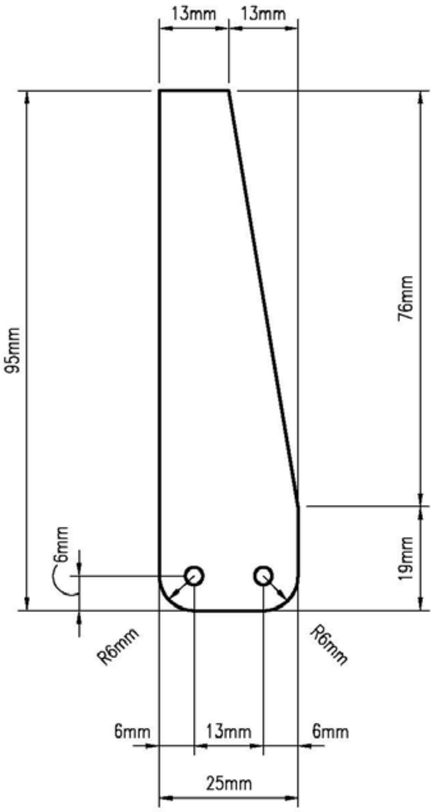
Drawing D1 - Complete Claw Assembly
Drawing D2 - Claw Parts
Drawing D3 - Claw Parts
Drawing D4 - Claw Parts
Drawing D5 - Claw Bushing
Drawing D6 - Polyethylene Frame Board
Drawing D7 - ROV Frame
Drawing D8 - ROV Frame

APPENDIX A

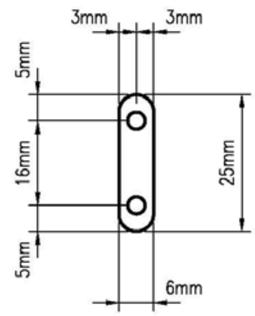


TITLE:	AIR ACTUATED CLAW ASSEMBLY	**SHEET NO.**
PROJECT:	FLOMO 1, FLOWER MOUND HIGH SCHOOL, FLOWER MOUND, TEXAS	**D1**
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	

APPENDIX A



PART "A"



PART "E"

NOTE: ALL MATERIAL 6mm THICK ALLUMINUM

TITLE:	PART "A" & "E" – CLAW	**SHEET NO.**
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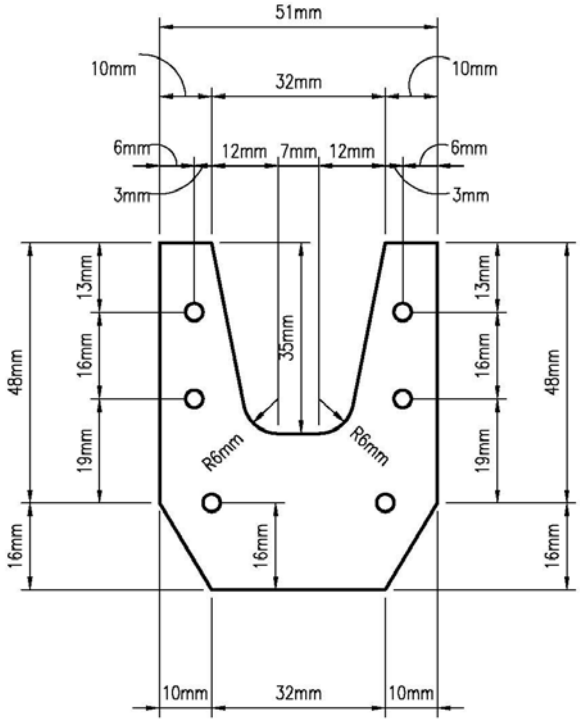
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	

APPENDIX A



PART "B"

NOTE: ALL MATERIAL 3mm THICK ALLUMINUM

TITLE:	PART "B" – CLAW	**SHEET NO.**
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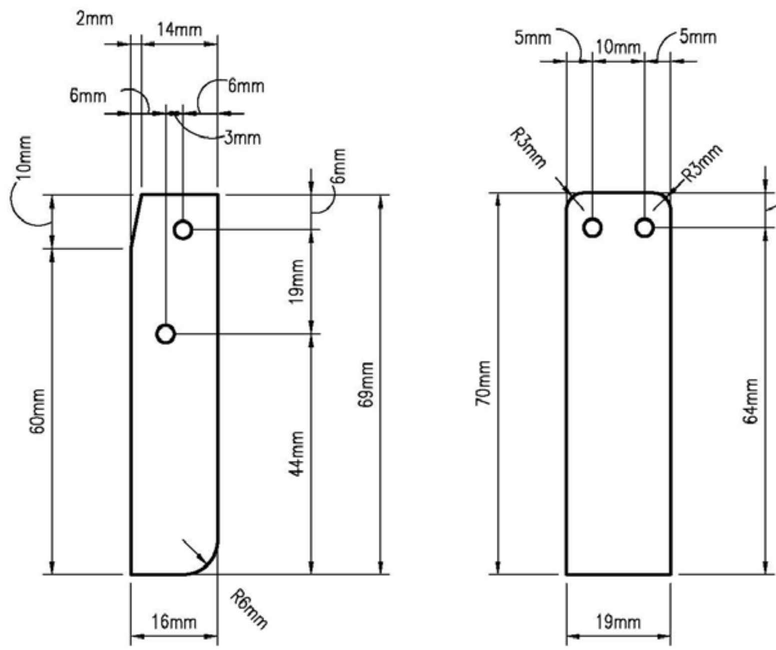
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	

APPENDIX A



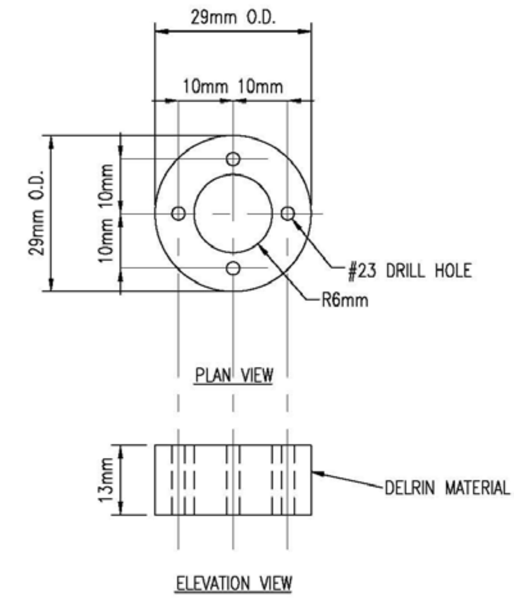
PART "C"

PART "D"

NOTE: ALL MATERIAL 6mm THICK ALLUMINUM

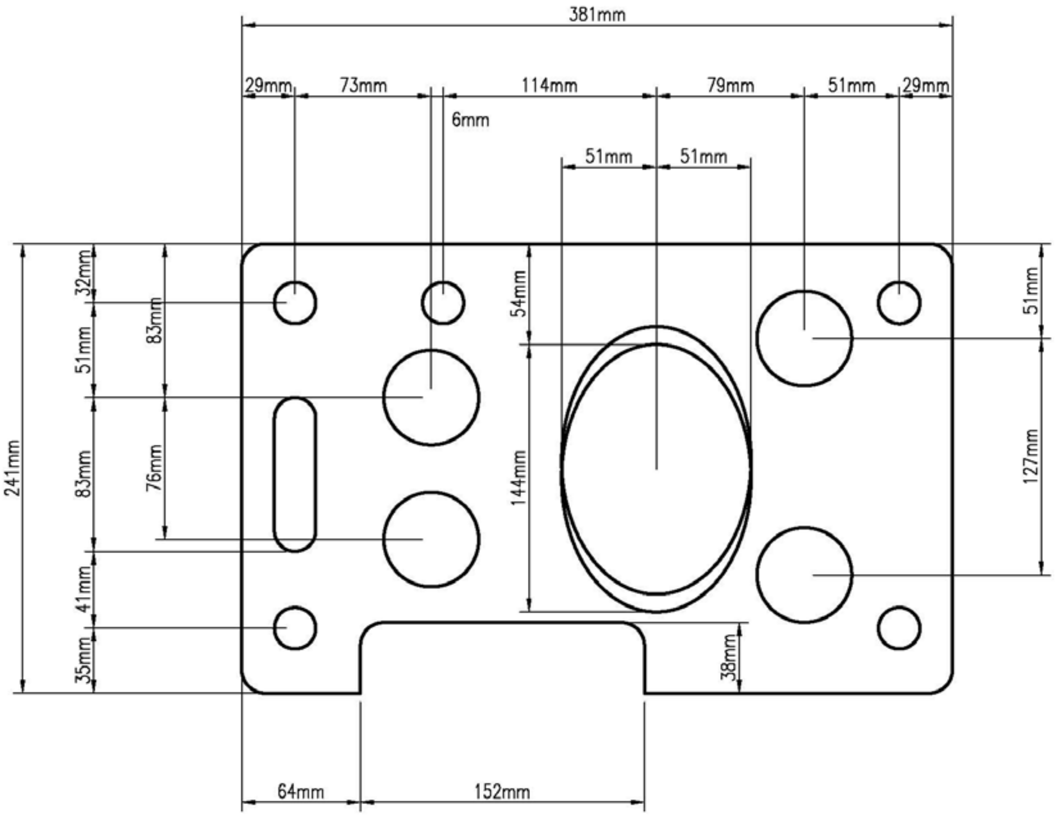
TITLE:	PART "C" & "D" – CLAW	**SHEET NO.**
PROJECT:	FLOMO 1, FLOWER MOUND HIGH SCHOOL, FLOWER MOUND, TEXAS	**D4**
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	

APPENDIX A



TITLE:	CLAW BUSHING	**SHEET NO.**
PROJECT:	FLOMO 1, FLOWER MOUND HIGH SCHOOL, FLOWER MOUND, TEXAS	**D5**
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	

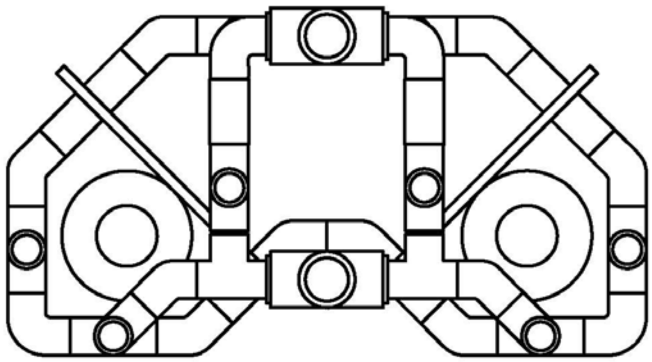
APPENDIX A



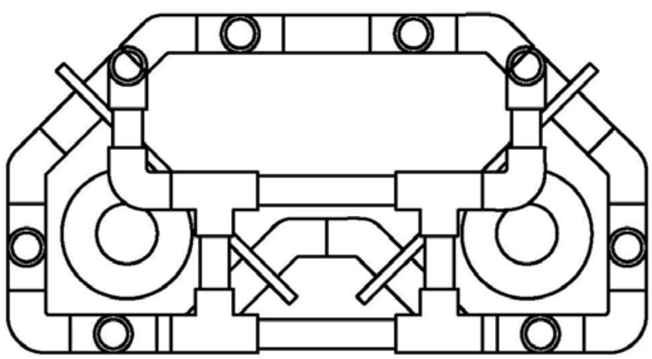
NOTE: POLYETHYLENE FRAME BOARD THICKNESS = 8mm

TITLE:	POLYETHYLENE FRAME BOARD	**SHEET NO.**
PROJECT:	FLOMO 1, FLOWER MOUND HIGH SCHOOL, FLOWER MOUND, TEXAS	**D6**
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	

ADDENDUM A



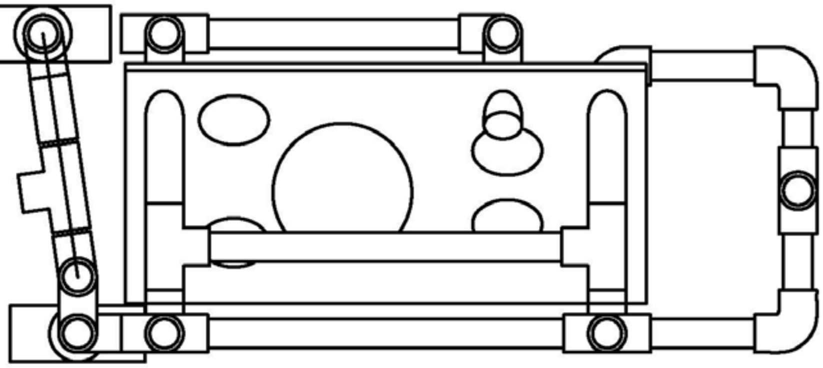
FRONT VIEW



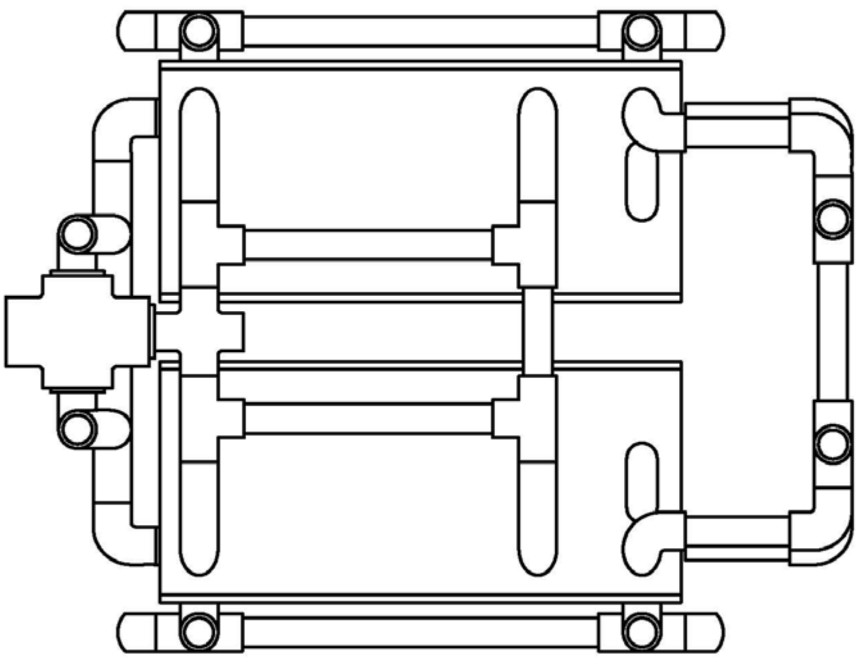
REAR VIEW

TITLE:	ROV FRAME	**SHEET NO.**
PROJECT:	FLOMO 1, FLOWER MOUND HIGH SCHOOL, FLOWER MOUND, TEXAS	**D7**
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	

ADDENDUM A



SIDE VIEW



TOP VIEW

TITLE:	ROV FRAME	**SHEET NO.**
PROJECT:	FLOMO 1, FLOWER MOUND HIGH SCHOOL, FLOWER MOUND, TEXAS	**D8**
DATE:	MAY 1, 2007	
SCALE:	NO SCALE	