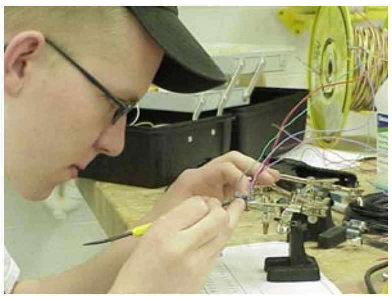
# Parkland High School Engineering Club

# RED OCTOBER

## Parkland High School
## Splashcam Everest VIT Parkland Engineering Club



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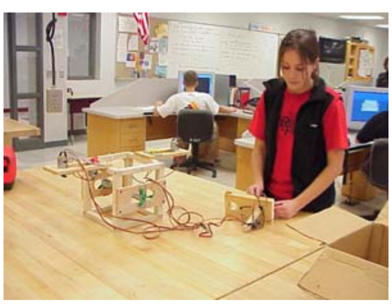


**2005 MATE ROV Competition**

Parkland High School
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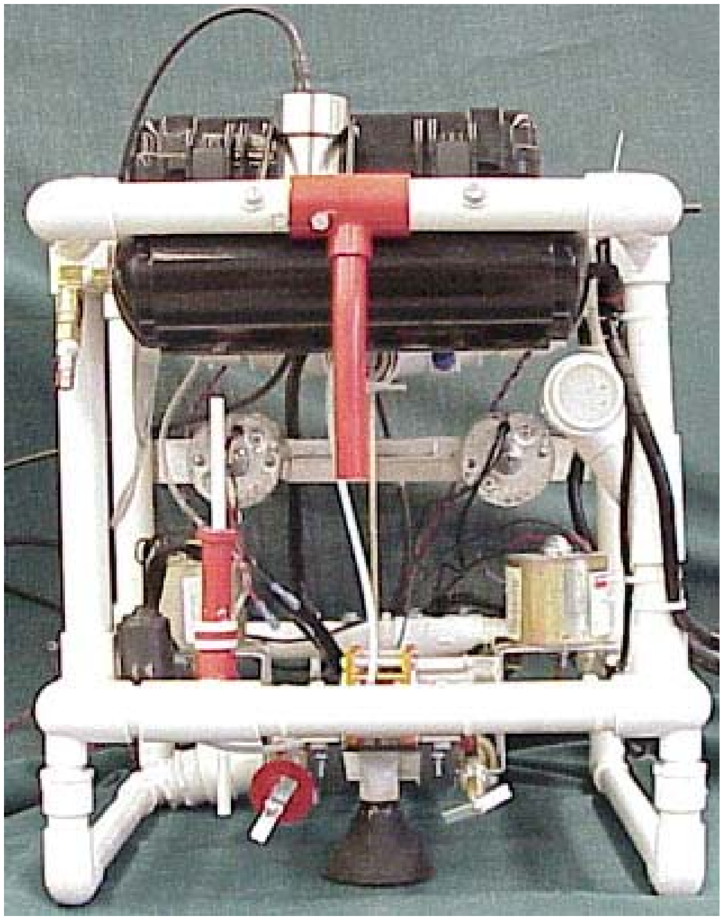
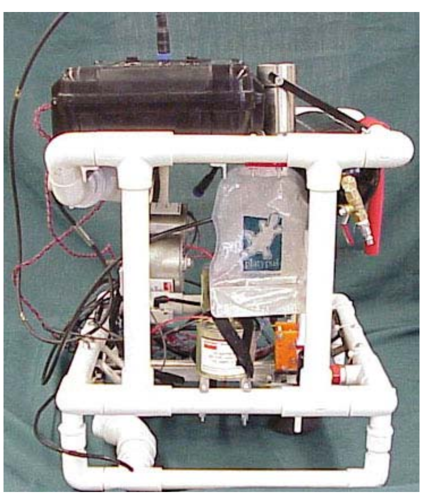
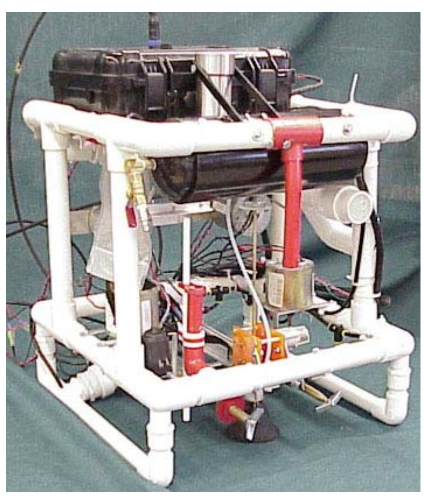
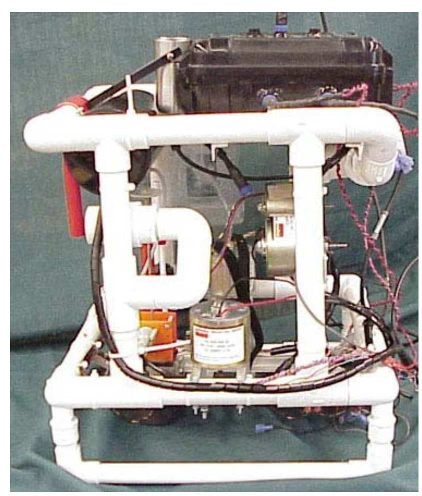








2005 MATE ROV Competition

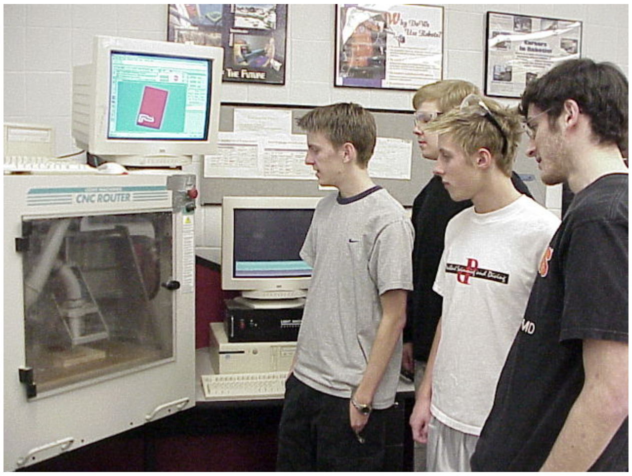
# Parkland High School Engineering Club

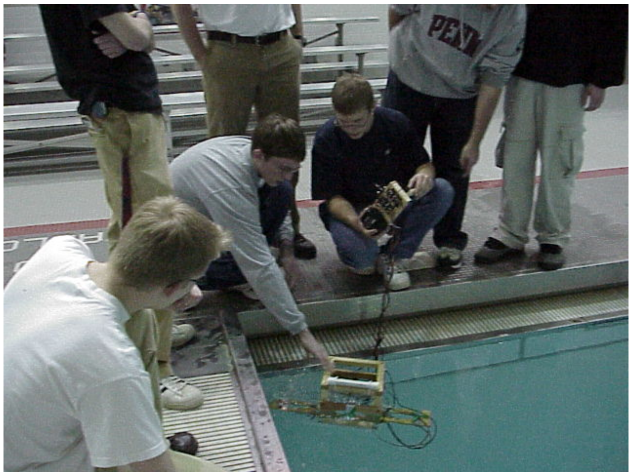

## ABSTRACT

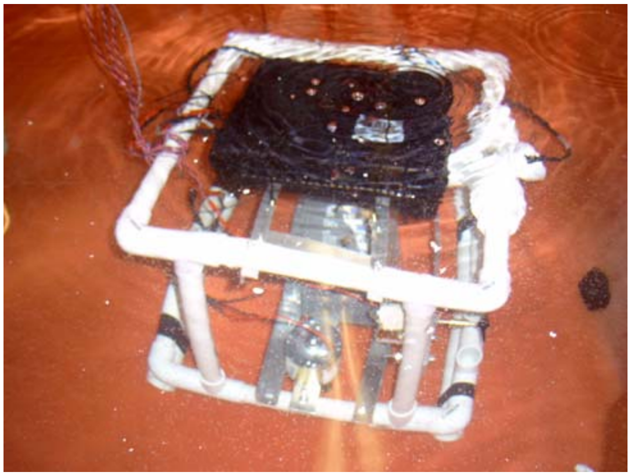
The Parkland Engineering Team puts into practice a systems approach when undertaking a problem such as the MATE Competition.

The ROV project was broken down into five major systems: Structure, Propulsion, Tools, Sensors, and Electrical. By breaking down into multiple systems, the students could work efficiently and appropriately distribute the massive amount of work. This approach promotes workmanship between systems and allows individual team members to use their skills to the best of their potential, along with learning new valuable skills.

Continuing with the systems approach, all possible solutions to the mission tasks must be researched, sketched, and prototyped. Research included interviews with industry professionals, use of the Internet and practical application using mission task mock-ups. Sketches were either free hand or drawn with *Inventor*, *AutoCAD*, or *SpectraCAD*. Prototypes were manufactured out of wood, polyvinyl chloride (PVC), or acrylic. Furthermore the team utilized a wide range of construction tools; including a CNC mill, CNC lathe, drill press, table saw, band saw, and laser cutter. The team employed their previous experiences in the FIRST ROBOTICS Competition along with new ROV ideas and technologies. Technical highlights include the entire sensor (CCDs and RTD) subsystem and innovative pneumatic data probe retrieval device.

## Design Rational- Structure and Drawer Opening

The structure subsystem dealt with the ROV frame that was continually stressed during the entire project. Research included the ballast system, material properties, geometry, and current ROV designs. The ultimate goal for the structure is to be neutrally buoyant, allow for a strong flow of water for the propulsion system, greater vision for the cameras, while being as small as possible. Early in the design process, it was decided that the structure should attempt to resemble a geometric cube, this would allow for a stable and easy to manufacture frame, while providing water flow and vision; wood prototypes reinforced this decision. With the shape decided, PVC was chosen as the building material because it is easy to assemble and obtain, along with being very cost-effective. The design called for the frame to be filled with a ballasting agent to achieve a structure as neutrally buoyant as possible, PVC tubing would allow this. To help with stability and ballast, the heavier battery was mounted on the bottom of the ROV, while the air-filled electronic box was mounted on the top. The prototype used a window sealing foam that was supposed to help with ballast. Unfortunately this foam acted as a sponge due to its open cell structure. A two-part closed cell foam was used for the final design, resulting in a lighter and more buoyant frame than the prototype. Two PVC skids were designed and implemented to protect the props and pneumatic system on the bottom of the ROV. In addition, compared to the prototype, the final ROV's width and length were each 5.08 cm smaller; this allowed for a greater ease in exciting and entering the ice hole along with making the ROV lighter.

*Structure Prototype*

To complete the drawer opening mission task, the tools and structure subsystem collaborated to design and implement a simple solution. By using a PVC reducing tee, PVC tubing and one PVC coupling (for support), the team designed an "inverted horn" to pull back the handle, this original idea was spurred on by an image of a rhinoceros' horn. The team inverted this horn and designed it with PVC. At first the team had difficulties aligning the horn, as a solution, the team painted the horn red, providing a clear contrast with the yellow drawer handle.

*"Inverted horn"*

## Design Rational- Propulsion

The team, with advice from professional companies, decided that low RPM, high torque, low amperage motor would be most applicable for the competition. Testing began with various small DC motors, such as computer cooling fans and other inexpensive model motors. Testing encompassed using a stroboscope, and charting the amperage of the motors out of water, underwater, and with only the propeller underwater. An acceptable trade-off of speed reduction, and slightly increase amperage was the result of not waterproofing the motors, as overall performance was not inhibited. To help prevent corrosion, the team sprayed the motors with a food grade silicone before and after every run to reduce friction. The motors purchased for the ROV met all team requirements and were cost-efficient: 1/35 HP, 2350 RPM, 3.70 F.L. Amps, 12 Volt PM DC *Dayton* motors were purchased. In addition, the ROV was designed to incorporate four motors, with two X-Z-axis motors each using a speed controller and two Y-axis motors sharing a speed controller.

*Propeller*

The next task was to outfit the motors with appropriate propellers. After testing propellers that ranged from inexpensive model airplane propellers to small water propellers to propellers used by *VideoRay*. It became apparent that the propellers needed to have a large diameter than the motors, to create enough force to move in both directions efficiently. If the diameter was smaller than the reverse water wash created a water block, preventing propulsion. The team chose three bladed propellers with a 7.62 cm diameter. To mount the propellers, stock was milled down, using the CNC lathe, to create an adaptor for the propellers, which attached with setscrews to the shaft.

To mount the motors to the PVC frame, multiple solutions were prototyped and tested. The first was designed to be a moveable, twistable mount for different motor positions. This mount was made of heavy gauge brass sheet metal, bolts, and wing nuts. Another was made out of acrylic. Yet this mount had a tendency to move on its own from the force applied by the motors, and the mount severely blocked the flow of water. A static mount was designed instead. With testing the mounts, it was observed that the tighter the motors were mounted on, the greater the torque and RPM, similar to tuning a car. Using this to the team's advantage, the motors were fastened as tight as possible using a torque wrench. On the prototype, the up and down motor were mounted similar to the horizontal ones, but a different design was incorporated for the final ROV. The team bent two long and thin metal plates into an orthographic "U" shape, which screwed directly into the PVC frame. This increased water flow and increased propulsion.

*Horizontal Motor Mount*

## Design Rational- Pneumatics and Data Probes

Numerous solutions were designed and tested to collect the three data probes from the science package. Solutions ranged from a simple hook to pneumatics. A core design concept for the solutions was that this system would extend and retract from the ROV. A drive train system was designed so that a metal rod with a hook attached will extend out from the ROV and the pilots would maneuver the ROV and hook to grab the data probes. With completion of this task, the drive train would run in reverse and bring the data probes within the confines of the ROV. It was decided that the data probes would be attempted to be stored or placed with the ROV during transport to the surface. The complexity of this design worried numerous team members. To comprise and produce a seemly simpler design, pneumatics were introduced. Using a pneumatic cylinder to extend and retract instead of a drive train along with using a butterfly clip, the team was allowed to implement a simpler system, in comparison, for the final ROV design. The butterfly clip would allow the data probes to slide onto the rod but not fall off. Subsequently, the team design implemented a second pneumatic rod for the CAT 5 data probe, except the butterfly clip was reversed, allowed the probe to be removed and placed into the port. With the design in place, an air canister would be required to operate the pneumatics. The air canisters available to the team proved to be too heavy and weighed down the ROV too much. Instead, an air canister made from PVC was designed. Using a large tube of PVC and two end caps, along with PVC cement, a lightweight and airtight canister was manufactured.

*Pneumatic System*
*Left: Cat5 rod*
*Right: Data Probe rod*

### Design Rational- Fluid Extraction

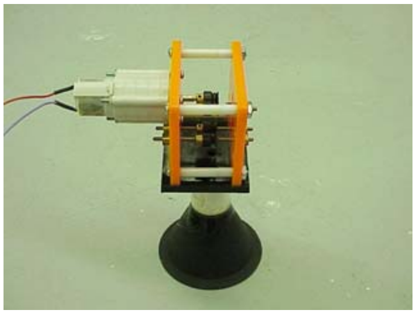
To complete the fluid extraction mission task, a portion of the tools subsystem researched existing methods of fluid extraction while other members researched products that would be acceptable to use underwater.

After generating a list of 12V electric pumps, the team decided to purchase a *Kavan* 12 V electric geared motor pump in December. During the design process, it was deemed that the pump could use no more than 12V because of power restrictions and had to be small enough to mount on the ROV. It pumps approximately 1.8 L per minute at sea level. Mounting the pump consists of using the supplied brackets screwed directly into the PVC frame. To extract the fluid, a brass tube with a .5843 cm outer radius and a .4826 cm inner radius was fitted with an adaptor that allowed it to connect to a flexible plastic tube. This plastic tube connected the pump to the brass tube.

The team determined that a flexible bladder would solve the problem of air in the system; a 500 mL model from *Platypus* was purchased. In addition, another *Platypus* bladder was purchased to construct a mock-up with competition barrel, to help design the tube lowering system and practice with. A brass tube was inserted through a typical bottle cap and joined into place with epoxy. This tube will allow the collected fluid to enter the *Platypus* bag. During testing, it was determined that before starting to pump the fluid in competition, the pump will be run in reverse for approximately five seconds. This will evacuate all air and water from the system and will provide an untainted sample of fluid. Incorporating a design similar to an inter-venous bag found in hospitals led to a solution of mounting the bladder, the bag is mounted near the top of ROV and hangs downward. On the prototype, the bladder is mounted on the case supports, with nuts and bolts, using acrylic, which are joined with epoxy and manufactured using the band saw. For the final design, an acrylic piece was cut out using the laser and screwed the bladder directly onto the PVC frame.

*Bag Mount*

The team designed two possible solutions for lowering the brass tube into the fluid. The first involves using rollers to roll the tube down into the fluid. A motor is used to rotate one roller with the other three serving as support; rubber O-rings were added to provide sufficient friction to increase the system's efficiency. The rollers were manufactured using a CNC lathe, and the acrylic sides using a CAM and the laser. The other system designed uses a screw to lower the tube carriage. This system requires a very fast motor and will rust because of all of the steel parts. The team decided to use the roller system, because this motor consumes very low current while being more efficient than the other system.



*Tube Lowering System*

After mounting the tube lowering system on the ROV, another problem was encountered. There was no way to tell where the tube was going to be lowered. The solution involves mounting a simple kitchen funnel to a small length of PVC that slides over the PVC protruding from the extraction bucket. This solution was inspired by the method of refueling by in-flight aircraft. The unit was glued onto the system and works as a stabilizer for the robot as the fluid is being extracted. The entire system was then mounted on to the robot on the battery tray supports, providing an ideal viewing angle along with a sturdy mount.

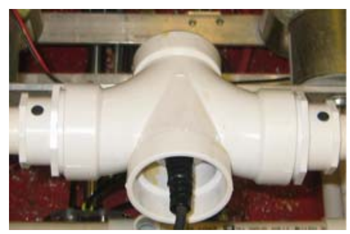
## Design Rational- Sensors

The sensors subsystem is concerned with vision, lighting, and temperature recording. This subsystem consisted of two members. One member researched camera and lighting options, the other researched temperature recorder options. The final ROV includes two color cameras and two black and white cameras, along with two LED clusters, and a temperature data logger that accepts a Resistance Temperature Detector (RTD).

Research for the vision of the ROV began in early November. Research included conversations and interviews with camera companies and ROV companies, such as *VideoRay*, along with collection of data from the Internet and periodicals. By early December, the team formulated two possible solutions. The first would be to purchase or receive a donation of an underwater camera. This option is direct, simple, and very effective. An important aspect is that the camera would not have to be sealed or waterproofed by the team. A downside to this option would be the cost of the camera. The next option would be to purchase a normal or receive a donation of a CCD, and have the team waterproof and seal it. This option allowed a wider range of cameras to be looked at, but waterproofing would provide a challenge.

In early January, the team negotiated a deal with *Splashcam* to donate a Delta Vision Heavy Duty Color underwater video camera in exchange for a Gold Level Sponsorship. The camera is waterproof, extremely durable, and provides great vision. The camera also has three screw holes for mounting. The team decided to use this camera as the main camera, and mount on the backside of the ROV. This camera would mount directly onto the back of the frame; this placement would allow the drawer-opening device and the sides of the ROV to be used as reference points for vision. Placing the camera in two 5.08 cm PVC four-way connectors and screwing it directly into the piece achieved this. The mini camera tether flowed out of one end, with the lens protruding out. Next a 5.08 cm to 3.81 cm PVC bushing was attached to two sides of the of the four-way, then 3.81 cm to 2.54 cm bushings were then attached to the other bushings and the 2.54 cm frame.

*Splashcam Camera*



*Splashcam Mount*

*Everest VIT* donated another camera, a Toshiba's IK-M43Series Camera in early January. This camera is extremely small (.762 cm) with a zoomed in image, yet it is not waterproof. Once again, the camera was mounted directly into the frame and is used to observe the liquid extraction and some of the pneumatics system. In addition, the camera requires a camera control unit (CCU) to operate. The CCU was simply placed within the electronic box. A .762 cm hole was bored into a 1.905 cm acrylic rod that was then shaved down to 1.5 cm outer radius, and then placed into a 1.905 cm PVC tube. A larger acrylic lens and washer was manufactured using the laser, which was placed in front of the PVC and an o-ring.

*VIT Camera*

During testing with the prototype, it became apparent that to enter through and exit back through the ice hole, that two vertical cameras would be required. The team investigated the solution of movable camera mounts, but the idea was shortly shot down. To help maneuver down the ice hole, a black and white CCD camera was purchased. Using the potting method *Video Ray* supplied, the camera was waterproofed and placed onto the underside of the ROV. Realizing the success of the color *Splashcam* unit, the team tried to design a solution around a similar system. In exchange of being named top sponsor, *Splashcam* donated a black and white camera. B&W

cameras were requested because of the greater picture definition; an external lighting source would not be needed. To mount the *Splashcam* B&W camera, the team designed metal supports on the top of the frame, so that the B&W camera would be as center as possible, which would help the driver, navigate up to the ice hole.

After researching ideal sensor situations, the following list was complied for desired temperature sensor specifications:

- Accurate to .01 with Real-time data collection
- 1.27 cm radius; 15.24 cm length
- Waterproof, Light-weight, Sturdy
- Low-voltage, low amps

By the end of December, the team negotiated a Gold Sponsorship with *Microdaq* in exchange for $1331.00 in sensing equipment. This includes a Resistance Temperature Detector (RTD) along with the appropriate software. This highly accurate measuring system senses temperature by measuring the change in resistance of metal wires. The RTD was placed with a thin plastic tube, for protection. Then it was mounted to the PVC frame using acrylic mounts that were modeled using a CAM and manufactured using the laser cutter.

*RTD Mount*

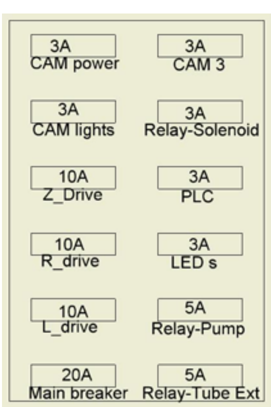
After the power distribution figured out, using the “left over” power, it was deemed that there was availability to mount external lights. It was reasoned that the other systems were deemed vital than external lighting and that lighting should be the final items to purchase. The color *Splashcam* CCD already has 12 ultra-bright LEDs mounted around the camera lens. Additional lighting solutions were researched, resulting in 30 ultra-bright white LEDs were purchased. Conversations with industry lighting professionals recommended using white because it would produce the greatest luminosity. The LED’s purchased have a maximum voltage of 4.5 V; the cluster is designed with two sets of four LED series that are in parallel.

After the electrical schematic was drawn, members from the electrical and sensor subsystems constructed the LED clusters from scratch. The cluster was mounted inside a PVC tube, filled with potting epoxy and had a clear acrylic lens mounted over it. During test, along with the apparent success of mounting other sensors directly into the frame, it was decided to use PVC tubing to house the cluster(s). One of the clusters is analogous to a headlight found on an automobile.

*LED Cluster*

## Electronics- Power

The electronics subsystem of the ROV comprises numerous elements, which facilitate the operation of all the other components. The primary purpose of the Electronics subsystem is to provide power and control to the components and feedback to the operators. The first objective of the Electronics subsystem is to provide a constant power source to the robot. While researching the topic the team reviewed numerous methods of power supply. The first method chosen was to power the robot using solely shore power. The team preferred shore power because it allowed the robot to run for long amounts of time without the limitation of battery loss. The team later scrapped this method due to a number of problems. Shore power would require running 240W down two twenty-gauge pairs to the robot. This was problematic because due to voltage loss it would require a custom

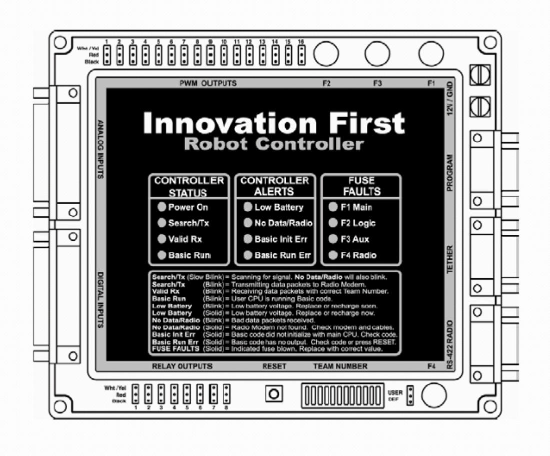



*Fuse Box*

power supply, resulting in unstable use of motors. Due to the limitation that shore power must be "electrically isolated" from underwater battery power we ended up running everything off of a battery which does not recharge while running. After determining the source of power the electronics were wired to allow current to flow to each device. A fuse block was used with automotive ATC style fuses and auto-resetting breakers to provide circuit protection and ROV safety. Another safety and organization feature involves the wires on the ROV. Using spiral tubing for computers, the wires were run along the PVC frame.

## Electronics- Control

In addition to power, every system requires control to operate properly. The core of the control system was the Innovation First F.I.R.S.T. 2001 PLC. The FIRST PLC was a very economical choice because we already owned one, which we removed from an aging robot. The control system consists primarily of innovation first components. The robot controller was programmed using PBASIC and driven in real-time based on the actions of the operator interface. The operator interface box contained joysticks, knobs and switches, which are sent as a serial signal down to the robot controller. The serial signal of the operator interface ran down to the robot on two pairs of 28-gauge wire, one Rx and one Tx pair. Based on operator input the robot controller would then vary motor speeds using speed controllers, and would turn systems on and off using mechanical relays. The motors of the robot were controlled using PWM (Pulse Width Modulation) speed controllers known as Victor 884's manufactured by innovation first. The speed controllers were used to vary speed by taking an input signal from the PLC and subsequently vary the width of pulses of electricity sent to the 3 drive motors. Lights, motors, and the fluid pump were operated using mechanical relays. These relays provided power to various devices based on the relay outputs transmitted by the robot controller. In an effort to gain better control over relay driven motors, limit switches were positioned to cause motors to stop when they reached their limit. These switches were wired as digital inputs that connect the input pin to ground when they are ON.




To help save tether length, a shore side box was designed and manufactured. The box has four RCA jacks for each of the cameras, while sharing a common ground. In addition, the tether box contained a ninepin connector for the temperature sensor and control system.

## Future Improvements

An early design concept, which was removed to make the ROV simpler, was a pressure sensor. This would allow the team to monitor depth and assist the ROV in diving down to a desired depth, such as 40 meters. Another early design concept that did not make the final design was the use of surface power, instead of onboard power. To implement this, DC-DC converters and additional wires in the tether were required, and the team could not spare any space in the electronics box or any wires in within the supplied tether. If implemented, it would allow for greater availably of power and higher power instruments could be used.

Other improvements included a larger air canister, which would allow more uses from the pneumatic rods, in case difficulties arise during the data probe collection. Also, two pumps could be employed to decrease the time to pump out the fluid.

Another improvement would be to run the wires through the PVC frame, but the foam used for buoyancy prevented this. The foam had to be poured into individual sections of PVC, and then cut into the appropriate sized pieces for use on the final design, preventing the wires from being allowed to run through the frame. The process could be improved where the wires can be run through the frame before the foam was caste, embedding the wires within the frame.

## Challenges

One of the first challenges the team faced concerned the donated camera from *Everest VIT*. The camera has power input with four pins, two positive, two negative. The camera did not include any cables to connect the CCU (Camera control unit) to the DC power supply. After researching the type of connector required, and contacting the manufacture, Toshiba, along with salvaging a similar connector from a dead microphone, the team designed a power cord, which would allow the team to operate the CCU properly. Unfortunately the microphone cord, which had the proper connector, utilized only two of the four pins, and the positive terminal needed to be connected through the jacket. An intense testing process ensued to make sure the connector would work reliably and flawlessly. Tech support at Toshiba also assured the team that the camera would operate using only the two pins.

The process of testing the camera included numerous technical difficulties. After creating a plug, there was a problem with finding and using a suitable a power supply for testing. At first the team attempted to use a variable AC-DC power supply, however that idea failed when the power supply emitted 24V regardless of the variable setting. A computer power supply provided the next best option, using the 12V rails. Some form of load was required to operate the computer power supply; an old hard drive was salvaged and acted as the load. The 'home-made' power supply adequately worked for our purposes.

With a suitable power supply found, during the tests (after verifying the camera worked properly), the power supply would shut-off as soon as the camera was plugged. Team members knew that computer power supplies are designed to do this if there is a short circuit, to prevent further damage to components, and was an ominous warning. Our concern of a short was confirmed when the camera did not activate the following time it was powered. It was quickly determined that the camera had been subjected to an improperly direct current, and after some additional troubleshooting a small fuse was replaced and camera operation returned to normal. A second major technical challenge the team faced involved the color donated camera from *Splashcam*. This camera was designed for underwater use and is extremely rugged. In some of the initial tests using the camera, the center of the screen would fog, impairing vision. The outer edges of the image remained clear. The most immediate solution was to remove power to the series of 12 LEDs that were part of the camera. The LEDs were generating enough heat to create a large temperature difference between the water and the air between the lens of the camera and the glass. The small amount of moisture in the air between the lens and glass plate created condensation on the glass. To solve this, the lighting on the camera was put onto a separate spike, allowing the lights to be turned off if fogging occurred. The entire process of discovering and determining the problem, surmising and testing possible solutions, and implementing the most efficient took place in a single day; however it proved to be an extraordinary problem-solving feat for those involved. On the final design, since the frequency of fogging increased, it was determined to remove the separate spike and completely forgo use of those LEDs. To produce the lighting source, an LED cluster was strategically placed on the front of the ROV, to act as headlight.

## Troubling Shooting Techniques

Numerous problems stemmed from the propulsion system, resulting in a one month set back early in the competition. Problems ranged from RPM, torque, and size of propulsion devices. Early prototype propulsion devices produced a too high RPM and not enough torque; in addition they drew too much amperage. To solve this situation, intensive research occurred concerning propulsion. A series of motors were purchased that ranged from computer fans to power tool motors to hobby airplane motors. It became apparent that the relatively high torque motors preformed better underwater. Once the propulsion device was selected, the team had to trouble shoot methods of mounting the motors. The original mount proved to be heavy and unstable. Troubling shooting for the mount consisted of designing numerous mounts and manufacturing them out of both acrylic and metal. This would allow the team to test the durability, weight, and strength of each mount design. The final design was chosen to be metallic static mount because it earned the best score from a design matrix. A design matrix was also used in choosing the propellers for the motors, along with using physics to analyze the flow of water.

## Skills Gained

Students gained numerous skills while constructing the ROV, ranging from waterproofing the electronics box to important business skills. Yet, the creation of the LED clusters provided students from multiple subsystems to gain an abundance of skills. Skills for the LEDs included designing and constructing a circuit board and wiring the LEDs onto the board.

After the electrical schematic was drawn for the cluster of eight LEDs, two circuit boards were made. The team learned to apply the appropriate stickers and outline the board itself. Before applying stickers, the students were instructed to rub the boards with steel wool to clean

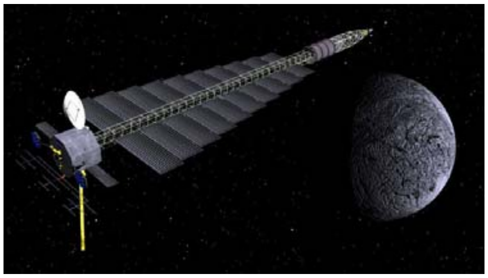

the boards and help the stickers apply better. The outline consisted of the center-holes for drilling and the electrical paths between the LEDs. These stickers, students learned, prevented the ferric chloride from removing the copper layer. The team practiced with two circuit boards before constructing the final board for the LEDs. Team members had to learn to place the stickers properly so that they remain onto the board during the ferric chloride acid bath and that they do not touch each other.

Subsequent to placing the first board within the acid, it was observed that placing the board above the bubbles created by the pumps and the use of heat accelerated the etching process. Team members also learned to properly safety techniques by wearing gloves and using appropriate ventilation. Team members then learned the suitable drill press speed and bit to drill out holes for the LEDs. To cut the boards out, team members learned to use a band saw to cut out material into a circle. Some team members also soldered for the first time when applying solder to the board outline. One team member gain knowledge of the importance of applying flux, during one the practice boards.

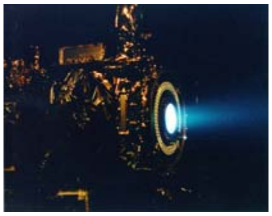
With boards ready, team members began to place the LEDs onto the board, learning that the longer wire was positive. After gaining the skill of soldering two wires together, the LEDs were soldered together and the board completed. The teams decided to use potting epoxy to help stabilize and protect the LEDs in their PVC mount. This required the development of a different range of skills. The team learned that depending on the amount of catalysis applied to the polyester epoxy, the clarity of the mixture differed. When adding less catalysis, the mixture became "cloudy" and helped to diffuse the light generated from the cluster. Yet adding more catalysis resulted in the light being more focused.

## Mission Theme Application

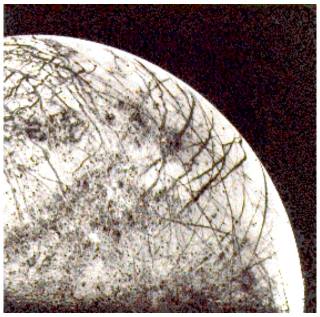
The need for space exploration is now taking the steps forward, especially the moons of Jupiter. The proposed mission of Prometheus is Jupiter Icy Moons Orbiter (JIMO). According to NASA, Prometheus Nuclear Systems and Technology is developing mission-enabling nuclear electric power and propulsion programs, which would lay the foundation for a new and challenging set of missions that would represent a major step toward understanding the origins of our solar system. Whereas JIMO, in accordance with the Explorer class mission theme, will research and observe three of Jupiter's Icy Moons: Europa, Ganymede, and Callisto, with Europa as the highlight of the mission. Same as the competition theme, JIMO will study these planets for oceans and other biological and geological aspects.



JIMO would use a revolutionary ion engine to propel itself to the moons. This would be the first satellite that would use nuclear power. Ion propulsion creates thrust by the discharge of an electrically charged gas. An image of the engine is shown to the right, here the faint blue glow of charged atoms being emitted from the engine are shown. According to NASA with the advent of nuclear power in space, along with the ion engine, JIMO's power system could give the craft more than 100 times as much power as a nonfission system in comparison to another craft of similar weight. This propulsion system would allow it to become the frontrunner for deep space, long duration missions.



Similar to the mission theme, Europa is the main mission objective because the strong evidence of vast salt water oceans below its icy crust. The lack of large craters provides evidence for oceans, suggested that the oceans right below the surface, and washed over the larger craters. In addition the presence of a magnetic field is more evidence for European oceans.   Because of this evidence JIMO has been promoted to a "Flagship" mission and receives top priority within NASA. With water as one of the three main ingredients (thermal energy, water and organic chemicals) for life, Europa is an interesting moon. The other important aspect of the mission would be its groundbreaking propulsion system and power system. Whereas the ROV requires an external power source, JIMO is completely contained with a nuclear reactor. Also both missions have time limits, where the ice will refreeze in MATE and Jupiter's radiation belt limits JIMO's mission time.



Some possible instruments that JIMO will use are similar to the ROV; they include a camera and instruments for studying material. Whereas the ROV mission studies red fluid, JIMO will examine charged particles, atoms, and dust around each of the moons. Drawing from the groundbreaking power source, high-power instruments, never before used in space, could be used on this mission. This power source would also significantly boost the data-transmission rate back to Earth. NASA compares this better data-transmission rate as switching to a high-speed cable Internet connection from an early-model dial-up connection.

As JIMO relates to the MATE mission, more importantly the ROV relates back to NASA's mission themes, fostering the next wave of deep-space exploration.

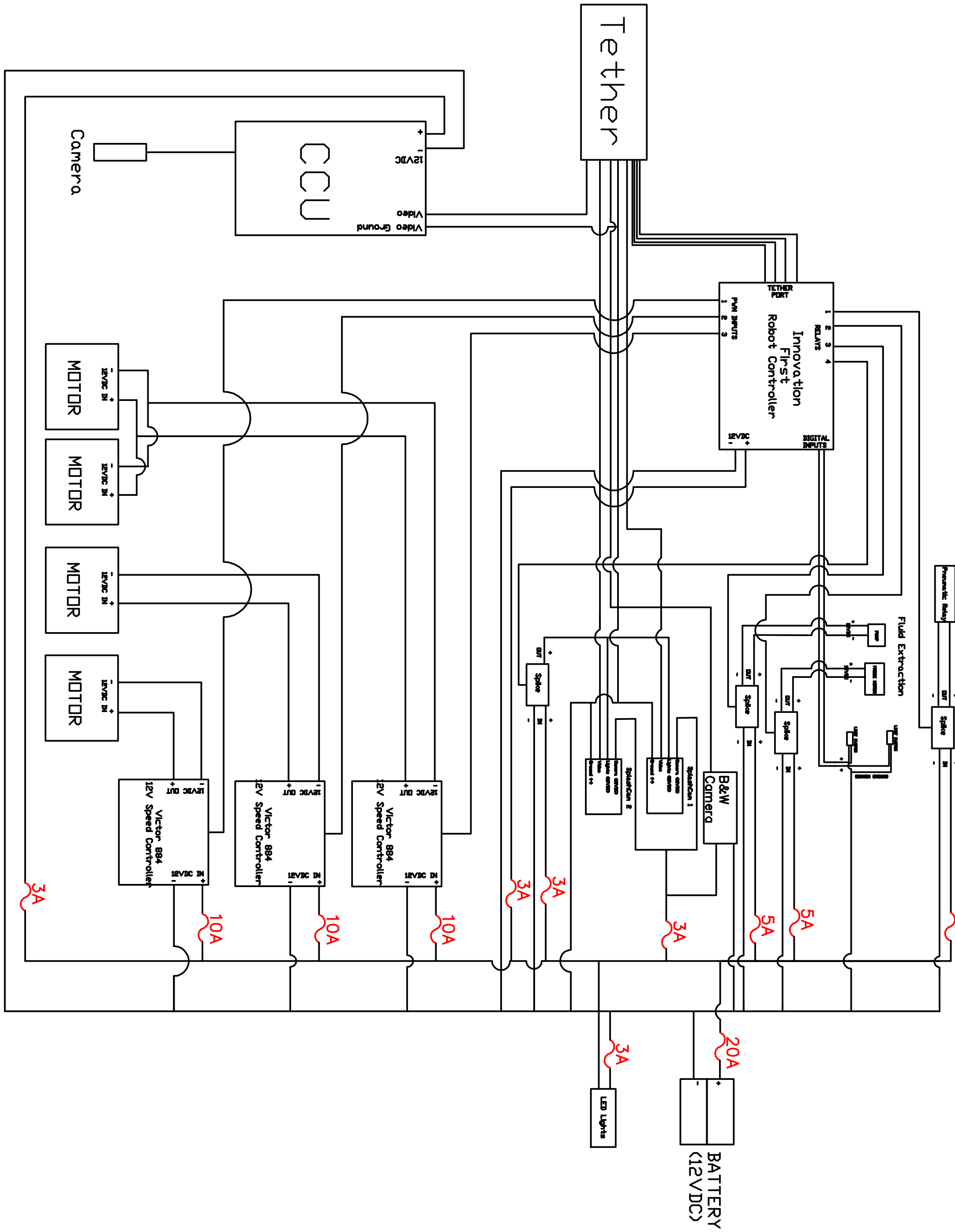
| Parkland High School Engineering Club | | | |
|---|---|---|---|
| Budget Sheet | | | |
| **Name** | **Amount** | **Balance** | **Sponsor Level** |
| Alvin H. Butz, Inc. | $100.00 | $100.00 | Bronze |
| Kokolus Builders LLC | $100.00 | $200.00 | Bronze |
| D'Huy Engineering, Inc. | $500.00 | $700.00 | Silver |
| Mancor | $500.00 | $1,200.00 | Silver |
| Personal Donation | $550.00 | $1,750.00 | Silver |
| Acutech Construction Inc. | $250.00 | $2,000.00 | Bronze |
| BioMed Sciences, Inc. | $200.00 | $2,200.00 | Bronze |
| Krause Dodge | $200.00 | $2,400.00 | Bronze |
| Energy Equipment & Control, Inc. | $100.00 | $2,500.00 | Bronze |
| Exxon Haines | $500.00 | $3,000.00 | Silver |
| H.T.Lyons | $100.00 | $3,100.00 | Bronze |
| Air Products & Chemicals, Inc. | $500.00 | $3,600.00 | Silver |

Total Balance $3,600.00

| Parkland High School Engineering Club | | | |
|---|---|---|---|
| Purchase Expense Sheet | | | |
| **Date** | **Item** | **Amount** | **Balance** |
| 12/12/2004 | PVC for Mock-ups | $69.35 | $3,530.65 |
| 2/9/2005 | Propellers | $146.99 | $3,383.66 |
| 3/2/2005 | Tether | $78.60 | $3,305.06 |
| 1/11/2005 | PVC for Prototype ROV | $50.23 | $3,254.83 |
| 1/11/2005 | Prototype ROV miscellaneous supplies | $95.23 | $3,159.60 |
| 3/2/2005 | Electronics Connectors | $250.00 | $2,909.60 |
| 3/2/2005 | Victor 884-12V Fan & 36" PWM Cable | $479.76 | $2,429.84 |
| 3/2/2005 | Spike Relay Module & 36" PWM cable | $239.64 | $2,190.20 |
| 3/2/2005 | Otter Box | $75.45 | $2,114.75 |
| 4/26/2005 | LEDs | $43.80 | $2,070.95 |
| 12/15/2004 | Bilge Pump | $49.50 | $2,021.45 |
| 12/16/2004 | Platypus Bags | $23.90 | $1,997.55 |
| 1/12/2005 | *Dayton* 12V DC Motors | $208.70 | $1,788.85 |
| 5/5/2005 | Castin' Craft Casting Resin Kit (16 oz) | $10.79 | $1,778.06 |
| 5/21/2005 | PVC for Final Design ROV | $56.73 | $1,721.33 |
| 5/21/2005 | Final Design ROV miscellaneous supplies | $45.89 | $1,675.44 |
| 5/14/2005 | Control Box Supplies | $79.62 | $1,595.82 |
| NA | Houston Travel Expenses | $6,955.00 | -$5,359.18 |
| Mid May | Student Dues and MATE Support | $6,000.00 | $640.82 |

| Parkland High School Engineering Club | | | | |
|---|---|---|---|---|
| Purchase Expense Sheet | | | | |
| Date | Donator | Item Donated | Amount | Value of Donations |
| 1/13/2005 | SplashCam | Delta Vision HD Color Underwater Camera | $995.00 | $995.00 |
| 5/5/2005 | SplashCam | Delta Vision HD Black and White Underwater Camera | $579.00 | $1,574.00 |
| 12/28/2004 | Everest VIT | Toshiba Micro Camera and Control Unit | $2,000.00 | $3,574.00 |
| 12/20/2004 | MicroDaq Ltd | RTD-IND-S854PD RTD | $399.00 | $3,973.00 |
| | | RTDTemp101 RTD Temperature Logger | $85.00 | $4,058.00 |
| | | ORTemp1000 300PSI Pressure Logger | $649.00 | $4,707.00 |
| | | MadgeTech Software and Interface Cable Starter Kit * 2 | $198.00 | $4,905.00 |
| 2/9/2005 | Mabuchi Motors | Dayton 12 Volt PM DC Motors | $200.00 | $5,105.00 |
| 3/15/2005 | All About Fun | Dunk Tank | $1,500.00 | $6,605.00 |

# ROV ELECTRONIC SCHEMATIC



## ACKNOWLEDGEMENTS

SplashCam
Everest VIT
MicroDaq Ltd
Mabuchi Motors
All About Fun
Alvin H. Butz, Inc.
Kokolus Builders LLC
D'Huy Engineering, Inc.
Mancor
Acutech Construction Inc.
BioMed Sciences, Inc.
Krause Dodge
Allen Organ
Energy Equipment & Control, Inc.
Exxon Haines
H.T.Lyons
Air Products & Chemicals, Inc.
Mr. Henry Moczlydowski
Mr. Daniel Chaply
Mr. Bob Bohemer
VideoRay
Alpine Import
Pet Supplies “Plus”
Hobby Lobby
Parkland School District