Tigershark

(Spelling mistake intentional)

Taipei American School ROV Program
Senior Team of 2011
Taipei, Taiwan (R.O.C.)

Total Members: 13 individuals

Lawrence Chang (12th Grade) – Chief Executive Officer
Alex Chen (12th Grade) – Chief Electrical Engineer
Kevin Lin (12th Grade) – Chief Waterproof Specialist
Justin Lin (12th Grade) – Chief Mechanical Engineer
GaHyun Kim (12th Grade) – Assistant Secretary
Derek Meng (12th Grade) – Chief Financial Officer and Chief Secretary
Hanpin Tai (12th Grade) – Assistant Secretary
Arthur Chang (11th Grade) – Assistant Financial Officer
Sarah Lu Chang (11th Grade) – Assistant Waterproof Specialist
Mandy Chow (11th Grade) – Assistant Mechanical Engineer
Kevin Ku (11th Grade) – Assistant Electrical Engineer
Kateline Lin (11th Grade) – Assistant Mechanical Engineer
Loren Weng (11th Grade) – Assistant Electrical Engineer

Instructors/Mentors for ROV
Mr. John Simonton
Dr. Rafael Garcia

Table of Content

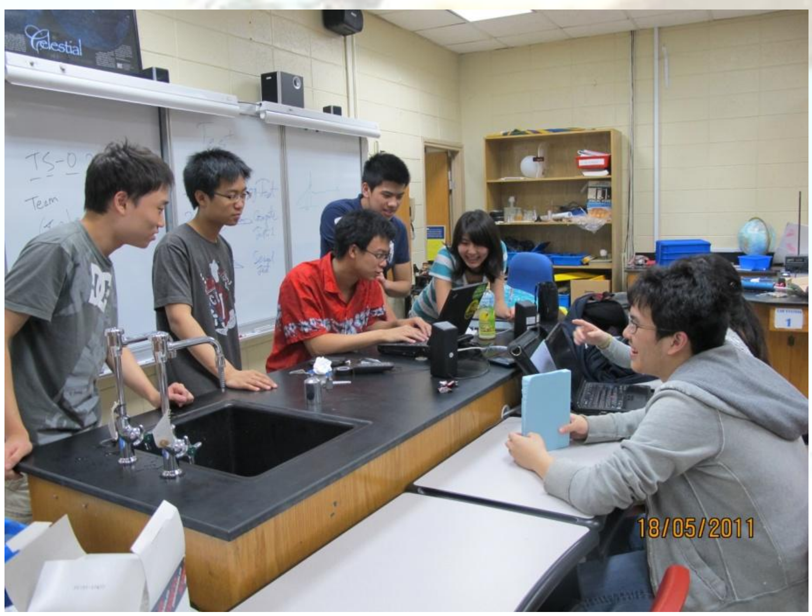
Abstract

“Once we accept our limits, we go beyond them.”-Albert Einstein

The 2011 Marine Advanced Technology Education ROV competition is modeled after the tragic oil spill off the coast of Louisiana over a year ago. In four operations, the ROV team is responsible for minimizing the oil spill damages by measures ranging from plugging up leaks to retrieving marine creatures for a post-cleanup operation. With thirteen dedicated individuals, the team seeks to improve upon past mistakes, explore new techniques, and encourage every member to participate, even with an increased number of members.

The ROV team simulates the work of a team of marine biologists and petroleum engineers. Our team has designed, built, tested, and completed an ROV. It can deploy pressure sensors to identify current depth of the vehicle and move against a current to replace broken pipelines with servo arms and to cap the oil well. Additionally, it utilizes an additional extraction device to collect biological samples, and employs a suction device to obtain special solvent samples to conduct analysis and further evaluate the damages of the oil spill.

The following technical report deals with the specific details of the design rationale and the general principles behind all tools and the various systems. The report also provides a thorough explanation of all components of the ROV, including a detailed budget sheet, planned future improvements, lessons learned, and trouble-shooting techniques. Finally, the report concludes with a reflection, challenges, and acknowledgments of those individuals who gave their valuable time to assist this team in completing its ROV construction.



Budget/Treasury Report:

I. Initial Account Balance: 198058 NTD

II. Breakdown of fund source: 50.49% from donation, 49.51% from last year's balance.
   a. 100,000 NTD was from an anonymous donation, thus denying the team of any chance to properly express its gratitude for such a generous amount.
   b. 98,058 NTD carried over from previous year's budget.

III. All monetary value recorded in New Taiwan Dollar (NTD) unless specified otherwise. The currency exchange rate of NTD to USD fluctuates between 31 to 29 NTD per USD over the course of 2010 to 2011.

IV. Financial Conclusion of the year 2010-2011 (in NTD)
   a. Total Budget: 198,058
   b. Total Expenditure: 83898.6 (42.36%)
   c. Current Account Balance: 114159.4 (57.64%)

- Purchases for manufacturing of props for simulation:

Date mm/dd/yy	W/D[1]	Item	Unit	Unit Price	A.C[2]	T.P.[3]	C.B.[4]
1/25/2011	Withdraw	Screwdriver	1	57	3	**60**	197998
2/1/2011	Withdraw	PVC pipes	1	798		**798**	197200
2/11/2011	Withdraw	Pearl board	1	250		**250**	196950
2/12/2011	Withdraw	Dial caliber	1	65		**65**	196885
2/14/2011	Withdraw	Stationery	1	238	12	**250**	196635
2/18/2011	Withdraw	Lines (線材)	1	650		**650**	195985
2/21/2011	Withdraw	Taxi	1	400		**400**	195585
		PROPS TOTAL				**2473**	

- Purchases for core (referring to the central part of ROV, excluding items such as the manipulator):

Date	W/D	Item	Unit	Unit Price	A.C.	T.P.	C.B.
2/1/2011	Withdraw	Motor Driver	1	650		**650**	194935
2/1/2011	Withdraw	Servo Motor	1	300		**300**	194635
2/7/2011	Withdraw	Mineral Oil	5	220	55	**1155**	193480
2/7/2011	Withdraw	PVC connector 45 degree	7	8		**56**	193424
2/7/2011	Withdraw	PVC special pipe endings	4	40		**160**	193264
2/7/2011	Withdraw	Super Glue	1	380		**380**	192884
2/17/2011	Withdraw	PVC connector	1	104.1		**104.1**	192779.9
2/18/2011	Withdraw	PVC connector	1	192		**192**	192587.9
2/21/2011	Withdraw	Acrylic	1	220		**220**	192367.9
2/21/2011	Withdraw	30A Motor Driver	1	2350	187.5	**2537.5**	189830.4

[1] W/D refers to Withdraw/Deposit

[2] A.C.: Additional cost refers to shipping cost or import taxes

[3] T.P. Refers to total price or the final sum spent on the purchase of that good.

[4] C.B. Refers to current balance of our budget

3/16/2011	Withdraw	Electronics[5]	1	385		**385**	189445.4
3/16/2011	Withdraw	Tools and components	1	435		**435**	189010.4
3/16/2011	Withdraw	Electronic Parts[6]	1	63		**63**	188947.4
3/16/2011	Withdraw	Materials	1	895		**895**	188052.4
3/25/2011	Withdraw	Electronics	1	465		**465**	187587.4
3/25/2011	Withdraw	Electronics	1	6398		**6398**	181189.4
3/28/2011	Withdraw	Electronics	1	6696		**6696**	174493.4
3/31/2011	Withdraw	Electronic parts	1	350		**350**	174143.4
3/31/2011	Withdraw	Wires & PC boards	1	660		**660**	173483.4
3/31/2011	Withdraw	Servo	1	1638		**1638**	171845.4
3/31/2011	Withdraw	Shipping fee additional tax	1	376		**376**	171469.4
3/31/2011	Withdraw	Servers	1	3120		**3120**	168349.4
3/31/2011	Withdraw	Plastic wrap	1	465		**465**	167884.4
3/31/2011	Withdraw	Electronic materials	1	190		**190**	167694.4
3/31/2011	Withdraw	Vex metal parts	1	US$ 468.76		**19605**	148089.4
3/31/2011	Withdraw	Silicone rubber	1	US$ 125.16		**3603**	144486.4
3/31/2011	Withdraw	Digi-key sensors	1	US$ 72		**2073**	142413.4
3/31/2011	Withdraw	Tools and components	1	435		**435**	141978.4
3/31/2011	Withdraw	Electronics	1	60		**60**	141918.4
3/31/2011	Withdraw	Materials	1	895		**895**	141023.4
3/31/2011	Withdraw	Servos	1	1470		**1470**	139553.4
4/5/2011	Withdraw	Plumbing hardware	1	168		**168**	139385.4
4/5/2011	Withdraw	Toothpicks	1	46		**46**	139339.4
4/6/2011	Withdraw	Tubing	1	473		**473**	138866.4
4/7/2011	Withdraw	Butane + 3M glue	1	179		**179**	138687.4
4/8/2011	Withdraw	Pliers	1	60		**60**	138627.4
4/11/2011	Withdraw	Electronics	1	7403		**7403**	131224.4
5/3/2011	Withdraw	Electronics	1	685		**685**	130539.4
5/3/2011	Withdraw	Acrylic	1	220		**220**	130319.4
5/3/2011	Withdraw	Import Duty Tax for parts order	1			**0**	130319.4
5/3/2011	Withdraw	Motor Driver	1	US$ 239.7		**6901**	123418.4
5/3/2011	Withdraw	Motor Driver	1	377		**377**	123041.4
5/7/2011	Withdraw	Cement	4	50		**200**	122841.4
5/7/2011	Withdraw	Lock & Lock	2	358		**716**	122125.4

[5] Electronics refer to smaller (relatively) items, such as small chips or a single resistor.
[6] Electronic parts refer to large items, a whole sale electronic device for example.

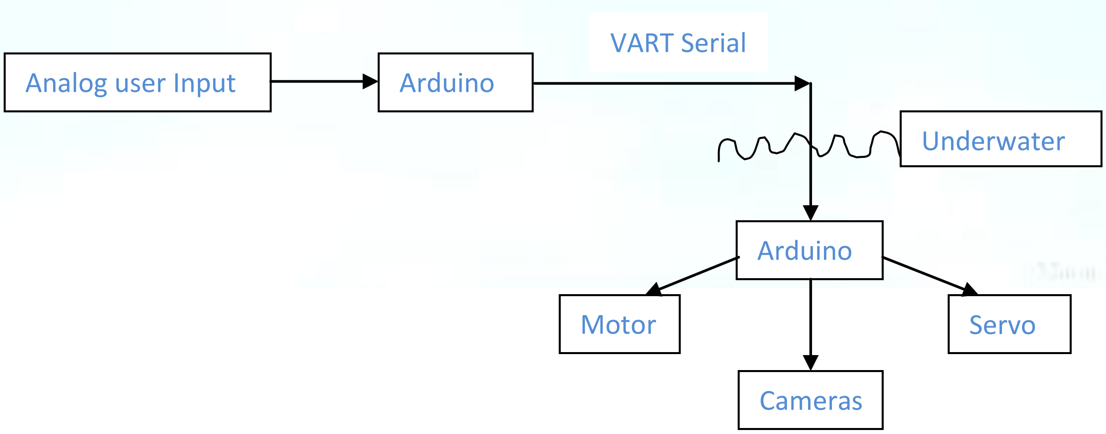
		Boxes					
		CORE TOTAL				**73459.6**	

- Purchases for auxiliary (refers to parts added on to the ROV, like extensions such as manipulators) parts:

Date	W/D	Item	Unit	Unit Price	A.C.	T.P.	C.B.
2/1/2011	Withdraw	Electronic Servo	1	302		**302**	121823.4
2/1/2011	Withdraw	Electronic Servo	1	667		**667**	121156.4
2/1/2011	Withdraw	Servo Control Box	1	333		**333**	120823.4
2/1/2011	Withdraw	Power source	1	47		**47**	120776.4
2/1/2011	Withdraw	Purchasing tax	1	68		**68**	120708.4
3/16/2011	Withdraw	Tools	1	60		**60**	120648.4
3/16/2011	Withdraw	Camera	2	500		**1000**	119648.4
3/31/2011	Withdraw	Camera	1	1050		**1050**	118598.4
5/3/2011	Withdraw	Vex Claw Kit	1	US$ 39.98		**1151**	117447.4
5/4/2011	Withdraw	Vex Claw Kit	2	US$ 39.98	US$ 79.96	**3288**	114159.4
		AUX TOTAL				**7966**	

- Traveling per person is 50,000 NTD – including plane ticket, hotel fees, and dining plans. Thus, the estimated total cost of traveling is 500,000 NTD. This part is covered by our school budget as negotiated between Dr. Hartzell and Mr. Simonton.

Electrical Schematic



Design Rationale

Propulsion System (figure 1)

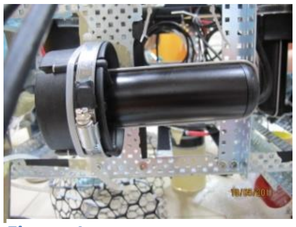


Figure 1

The key to propulsion system, keeping the power supply limit in mind, is to provide reliable and controllable propulsion to move the ROV into the desired position (a wild stallion is not wanted). In short, the propulsion system should be more of a dependable mule. Thus, based on this line of reasoning, we recycled last year's Seabotix thrusters. There are two main reasons for this choice: first, the Seabotix thrusters are water-proofed thrusters that deliver large thrust to move the ROV at a relatively high speed; second, we recycled last year's thrusters to cut cost.

Given that the Seabotix thrusters are already tested for their reliability, durability, resilience, and water-proof quality throughout last year's competition, the thrusters are the best choice. In addition, practicality must be considered – in this case the cost. By recycling the thrusters, we are able to save more than a third of our total budget for other purchases. Factoring the cost concern into our design rationale, we came to the conclusion to use the same thrusters.

Tether - Seacon (Seacon refers to the tether, the port that connects the tether to the waterproofed box and the nuts that hold the port) (figure 2 and 3)

Figure 2

No matter how waterproofed a container is, once one drills a hole on the side of the box for incoming cables and wires, the waterproofing quality is in doubt; the weak points of a compound are its entrances. Knowing this problem, a hard-learned lesson based on last year's water tests, we opted to use Seacon for making our tether. Combining other lessons from last year, we know we want a simplified and durable tether that is also flexible for repairs.

In addition, beside the pre-waterproofed quality (for both the tether and the plug) of the Seacon, we chose Seacon because the tether gives us the ability to detach the tether when needed. This detachability gives us more flexibility in conducting repairs for the ROV. So instead of having to remake the ports every time when we need to make a repair, we can now simply detach the Seacon and proceed to maintenance or repairs on the box or the tether itself.

Figure 3

Last, but not least, the Seacon simplifies the tether by integrating visual, control, and other functions into a few cables that are wrapped tightly into a waterproofed tether. With the tether now simplified down to one single tether, not only is the tether easier for transport but also general handling from testing to maintaining. Thus, Seacon fulfills our initial design goals, based on last year's lessons and this year's new knowledge, completely.

Buoyancy (figure 4)

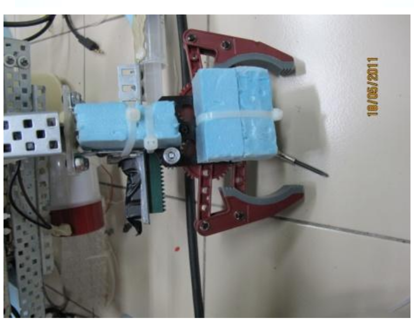


Figure 4

There are two main factors in choosing our buoyancy system: past lessons and cost. Building upon last year's buoyancy designs, we continued with the usage of empty and sealed PVC pipes, metallic weigh and Styrofoam. However, even though this year's raw materials are the same, last year we learned that smaller pieces of positive buoyant materials are better at adjusting the buoyancy of the ROV than large pieces. The reason is that large pieces, though providing more buoyancy, lifts large section of the ROV up, sometimes even reinforcing positively buoyant regions we are trying to correct. As a result, this year we only used the sealed PVC pipes as generally positive floats while the metallic weigh and Styrofoam are purchased/made into small pieces to allow more precise adjustment to the buoyancy of the ROV. In addition, we continued to use the same material because all of them are locally available at relatively cheap price while being waterproofed (a metallic weigh does not suck water, and the Styrofoam we purchased do not act like sponge), making economic sense for a small company like us with a limited budget to produce a qualitative product.

Cameras (The cameras used are the same as last year, as the cameras provide qualitative pictures while sold at an acceptable price and small enough to be mounted in almost all casings we made) (figure 5-8)

The goal of our cameras is to provide a reliable image of the ROV's direction and components. We currently have three different types of cameras that each specializes in a certain area: Regular cameras, one-servo cameras, and a two-servo cameras. Each camera has a different number of servos and serves for a different purpose in the ROV's navigation system.

The regular camera's design does not include a servo and thus cannot pan left/right nor up/down. Below is the simplest design out of the three and has improved from our last year's design with the addition of a removable PVC screw-in casing. The current design utilizes an o-ring and an end cap for better waterproof quality. The removable cap also allows for fast repair in case the camera is damaged. The design has been simplified from the long cylinder design used last year and the flat lens has been replaced by a dome shape lens. The curved lens, together with the difference between the water and air's refractive index, creates a fish eye effect for the camera image. The only two cables that come out from the camera are for the camera's power and signal.

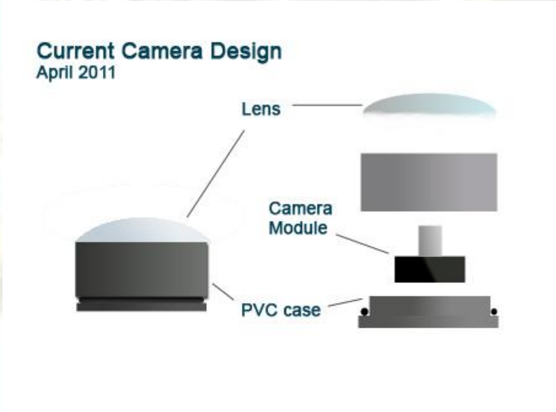


Figure 5

This camera is used as the most generic and reliable camera due to space efficiency and the lack of servos needed. We currently use this camera for the rear view of the ROV as the rear view is doesn't need to be as flexible as the front view.

The one servo camera's design is similar to last year's but also includes the removable mechanism. This enables the camera to be removed in the similar way to that of the regular camera. This design includes a cylindrical case and a servo that allows the camera to rotate and view 180 degrees. Since the rotation of the servo is along one axis, the curvature of a cylinder was optimum for this camera's purpose. The electronic cables were also simplified by connecting the ground lines together, effectively merging 5 wires into 4 to minimize the use of wires. The signal cable still goes up directly to the shore.

Legs that support the ROV create more space at the bottom for extra attachments. This camera is attached at the very bottom of the ROV and is utilized as the camera that provides us with a crisp image of our crab cage. This camera also has a clear image of the ROV's view from ground level due to the placement of the camera inside: The sensors are placed as close to the ground as possible to give a reliable image of both the front and rear views for the ROV.

Figure 6

The two-servo camera is the most complex camera because not only is it also removable, but includes two axis of rotation. We originally had difficulties figuring out how to attach the two servos to work on the correct rotational axis. The sketch below was one of our initial ideas.

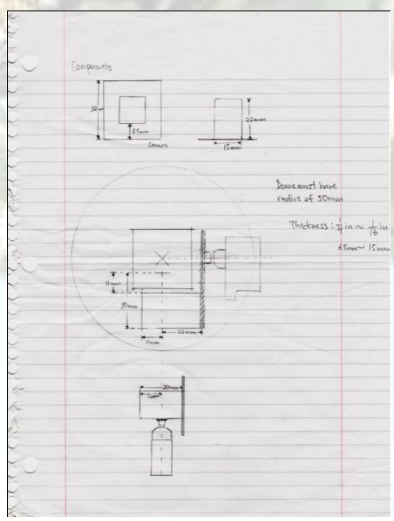


Figure 7

Eventually we adopted the design that attached the servos to each other at a 90 degree plane so that the camera can pan both left/right and up/down. A dome was used as the primary choice for enclosing this camera, as it could easily accommodate for the larger range of movement that the two servos would provide. Using a dome also reduces any uneven distortions for the camera and helps to create a fish eye effect for the camera image. The cables were also reduced from eight connections to five by wiring the two servo's power and ground together in parallel and by connecting the camera's ground to the servo's common ground.

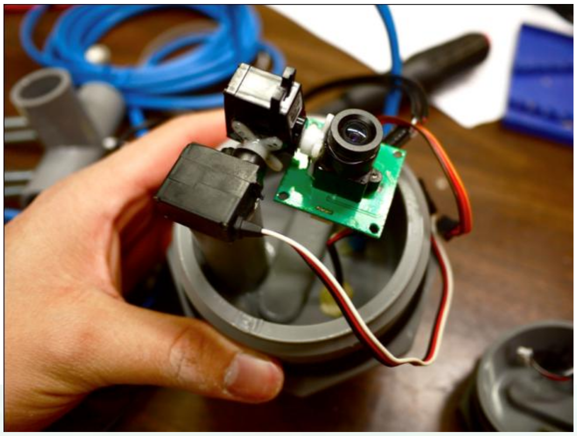


Figure 8

Waterproof Box (figure 9)

The Waterproof Box is used to house the circuits that are used to control and regulate the individual components onboard the ROV.

A double-layer Lock&Lock box design was used this year to minimize the chance of water seeping in and damaging the electrical components. We experimented with several different ideas such as utilizing a removable cylindrical case that could house the electronics, similar to the one-servo camera case. Another idea we had for the waterproof box was to design a custom manufactured box that could also serve as the frame, attaching different components onto its surface.


Figure 9

However, in the end, we came to the conclusion that the cylindrical design would be hard to waterproof wires coming out of it and the custom made frame/box would be too inflexible to changes in the ROV. Using plastic boxes we could drill holes much easier for the wires and use silicone to seal each opening to prevent water from seeping in. The smallest box would be used to house the circuits, and a larger box would enclose the smaller box. This design was inspired by the submarine's flooding compartments, creating several layers of protection. The plastic rings on the lids of the boxes also help keep water out.

Bilge Pump Mechanism (figure 10 and 11)

This design is primarily used to collect the sea creatures in the last task, the sea cucumber, the glass sponge, and the sea crab. The idea was mainly inspired by observing everyday objects such as vacuum cleaners. The original idea was to have a suction device using the input side of the bilge pump, but eventually due to certain constraints related to the bilge pump itself as well as a change in the main design of the ROV and its robotic arm, it was changed to be more similar to a blowing device using the water output side of the bilge pump. Essentially, the device would have the same purpose as a leaf blower, in the sense that it is able to push objects around in a specific direction by influencing and manipulating the medium in which it resides. To complement this design, a "crab cage" was designed, inspired by


Figure 10

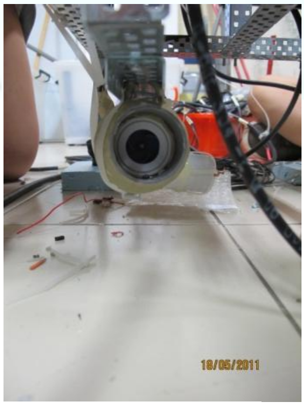


Figure 11

the lobster pots used by commercial fishermen to catch crustaceans.

This design was used to optimize the space on the ROV. The task couldn't be completed with the robotic arm, so a separate mechanism was to be designed to help complete the task of collecting biological samples. As there was space on the bottom of the ROV, the bilge pump and cage idea was utilized so that space could be used. Also, the pump would be a lot easier to control from the deck as it only utilized an on/off switch. The simplicity of the design would help minimize hassle and precision needed to collect these three samples.

Syringe Suction Mechanism (figure 12)

Instead of using a complex suction device such as suction cups, we chose to use syringes because they were cheap, easy to find, and almost fail-proof for high school students like us. Since the third mission required our ROV to be able to suck at least 100 mL of water, our group chose to use two 60 mL syringes for sucking. We glued the plunger ends of those two syringes onto one side of a piece of plastic. A third syringe was glued onto the other side of the plastic. Finally, a tube was used to connect the third and the fourth on-shore syringe. The design rationale here was that when the third syringe was filled with water and the fourth syringe was empty, pulling the plunger of the fourth syringe would suck out the water from the third syringe and cause the plunger and glued on plastic piece to move up into the third syringe, and thus pull the plungers of the first and second syringe to suck the red water.

Figure 12

After the first water test, it was discovered that the syringe suction device didn't work. The plastic piece didn't move *up*, but rather, the third syringe moved down towards its plunger. Hence, no water was able to be sucked in at all. There were still more glaring problems. The suction device was too bulky, and the on-shore syringe was too hard to pull, considering the great underwater pressure and the force of pulling water. These issues were finally solved with a new design. Instead of having syringes on both sides of the plastic board, all three syringes were combined and glued on one side. Epoxy putty was placed between each syringe so that the three syringes would move as one single unit. With the new design, the syringe suction device was much smaller, and the on-shore syringe no longer had to be pulled, but rather *pushed*, which proved to be physically easier. Pushing water from the on-shore syringe into the middle syringe would fill it up and push it up, while also bringing the other two sucking syringes up along with it, effectively extracting 100+ milliliter of red water.

As a result of the design, before each water test, there were certain procedures that had to follow before the suction device can be used. The tubes running up to the pool side and the tubes going into the soft water bottle had to be fully filled with water without any air bubbles, since air is compressible. Allowing only water to travel through the tubes and syringes ensured that we would obtain a maximum amount of red water.

The Frame

Our goal for the frame is to provide flexibility, stability, and minimal weight. At first, we designed our frame on CAD. We continued with our previous rectangular shape design from last year because this is the most stable design that will provide easy placement and arrangement of devices. We were going to custom frame it our design because we wished to increase the stability and minimize the weight by choosing our own material to customize it. However, we found a better resource, VEX pieces. VEX pieces are like advance Lego pieces: we can buy pieces online and build it however we want. Yet, the VEX pieces we choose are long, thin, edged pieces of metal with numerous holes for screws. (a picture of a vex edge piece may be included beside this paragraph) The holes on the metal VEX pieces provide great flexibility. If we custom frame, we will most likely be limited to the original design and will hardly be able to move around or implement more devices. With the VEX frame, we can easily make detachable but yet stable devices with nuts and bolts.

The Manipulator (figure 13 and 14)

Based on last year's experience, we have come to the conclusion that a manipulator that is only capable of grabbing items is not sufficient to deal with the tasks at the competition. The nearly non-existent mobility of last year's manipulator taught us a dear lesson. As a result, the aim this year is to give the manipulator at least some mobility in manners such as the ability to turn 360 degree. With this in mind, we began to construct a more easily maintained, repairable, flexible, sturdy, and waterproofed manipulator.

Aiming to complete the greatest amount of tasks with the smallest amount of specifically tailored tools, we had to first set down restrictions to avoid last year's unsatisfactory result. First, we seek to simplify two qualities before any building: functions and maintenance. Given that complexity of any machinery only adds to the risk of malfunctioning or complete failures, a good manipulator should be able to achieve sub-tasks specific to the tasks with generic capabilities instead of functions specifically tailored to every single sub-task. In addition, given Murphy's Law, simple machinery is easier to maintain and repair even if the worst case scenario occurs, putting aside the fact that spare parts demand of a simple machine will be less than the requirements of a complex machine. Thus, the two key ideas influenced our final decision to go with Vex Claw Kit to make our manipulator. Also, the principle of easy maintenance led to the manipulator constructed in such way that all parts can be removed.

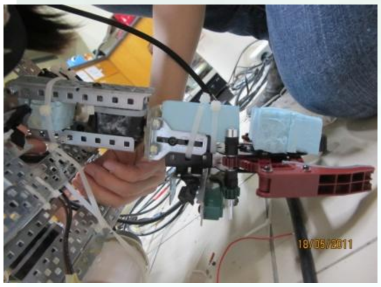


Figure 14

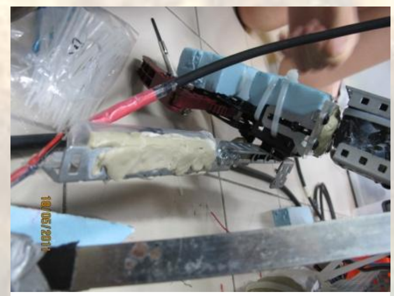


Figure 13

Acknowledging the technical difficulties for a group of high school students to manufacture precisely made metal and plastic parts to form a smoothly functioning manipulator, we ordered Vex claw kit instead (containing a claw, nothing more). Using the claw as a "hand", we added a servo to end of claw, granting the claw the ability to turn 360 degree. The purpose of this turning function is important: the turning allows angle adjustment to grab objects as well as easier turning of valves in this year's mission. In addition, the team then attached a second servo to the end of the manipulator to grant it the ability to lift up or drop down, granting much more mobility to the manipulator and decreases the necessity of shifting the entire ROV to grab an object. Thus, with these two servos, the team fulfilled the requirement of increased mobility.

Yet, because the Claw Kit only contains a claw, the team also had to build a system to give the claw the ability to close and open (and actually hold on to an item). Given last year's relative success in powering the manipulator based on hydraulic force (assisted with servo this year), we adopted a similar method this year, also based on hydraulic force. Pushing water through a pipe linked to a syringe that pushes the various gears, we are able to open and close the arm with relative ease as well as a tight grip.

The Electrical System (figure 15 and 16)

The electronics system is an upgrade from last year. Because we know that the MATE association desires the ROV teams to convert to digital system, we decided to not touch analog system, despite its advantage. So this year, we used the Arduino system which is celebrated for its easiness for household developers. The Arduino system uses a UART Serial communication system which only relies on 2 Channels excluding the power and ground. From this we developed a 'intranet', which four Arduino systems communicate and control the ROV. To make the electronic box even more pact, we decided the build our own arduino boards to remove the serial to USB communication portion of the board. This is done through several guides online, which displays Arduino's advantage – community support. Most programming is done through the programming software Arduino provided, and then the actual computing chip (ATMega328) is removed from the official Arduino board to be placed on the remodeled board that we built. This year's tether could have been shortened even more, but we are not sure if this network system would work, thus we decided not to risk it and included 2~3 extra cables.

Figure 16

We decided to us the Pololu Dual axis driver carrier MD03A, for its compactness. Moreover, the whole board is surface mounted technology (SMT), with exception of the replicable capacitors to prevent power peaks. The SMT gives the board more durability and water resistance. The reason that SMT gives the circuit more water resistant is because most of the chip is sealed in the IC chips and connections which are not sealed are visible and can be easily cleaned. Last year, the whole system failed due to the motor driver failed. Thus this year we decide not to used the motor driver that not only not durable to water but also cannot be repaired by us. On the other hand, the MD03A is a motor driver carrier meaning that most of the circuit is actually in the IC chip VNH3SP30 and the board itself is just a carrier to extend the IC chip to something a hobbyist can solder and use.

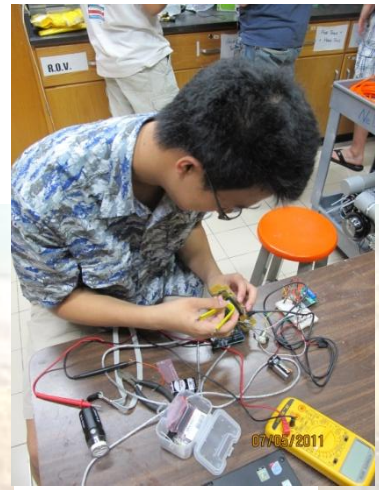


Figure 15

During the development stage we tried to use a USB gaming controller to control the ROV. This is accomplished by recreating a board that will support the ATMega328 chip (the Arduino computing chip). This board will then replaced the main board on the controller. This has failed for the multiple errors have occurred, such as copper lining for the front plate buttons, the mirror effect for drawing circuit (everything is mirrored for the solder joint is beneath the board instead of the same side as the chips), and other errors. Thus we decided to build our own controller out of cheap hobby box and some switches.

A multi-meter is used to display the depth in exact meter. This is done using the PWM signal (5V -0V) from the Arduino chip, which perfect for our use (0~5 meters). This is an improvement from using a binary LED array (which we have to convert Binary to Decimal), or computer display (which would then involve too much computing work to be stable).

Challenges

One of the main challenges our team encountered was to make a control system that transforms analogue signals into digital and vice versa, which allows more kinds of commands. When we encountered technical problems, the group followed a two-step solution:

1. Search online for solutions (on forums or just general information).
2. Discuss the problem with faculty advisers.

As a general design guideline to minimize technical errors, the group usually drew out the designs first. For example, the group "drew out the arm before proceeding to building a prototype...to test if the design is feasible" said Kevin Ku. The group tested the ROV in parts so if one component doesn't work, the group could change the design accordingly, instead of completing the whole design, only to find out that some component doesn't work. As Kevin Ku said, "We test the clamp isolated from the rest of the arm so we can make sure that it works before it is attached onto the whole arm." The components were made with every part as compatible as possible with other parts in order to allow future adjustments. On the servo arm, for instance, there were a few spots designed to hold servos that would allow the team to replace them. This way the troubleshooting process would go smoother as the team will be able to locate the faulty parts efficiently.

Another challenge encountered during assembling was creating the syringe suction component of the ROV. The team's first plan is to have two syringes glued to once side of a plastic board, and one syringe glued to the other side. The lone syringe is connected to another syringe on land. The land syringe would be pushed in, the underwater syringe would be pulled out, and the other two syringes would be pushed in. The two syringes will be connected to tubes, which will enter the soft water bottles. When the tubes are aligned in the bottle, people on land will pull the syringe, causing the lone syringe to be pushed in, causing the plastic board to move up, and the two syringes to fill with water. But since the two syringes are glued onto a piece of plastic, they were not very stable. In order to stabilize them, the team had to putty in between the two syringes.

In addition, the angle of the syringes was shifted with each cycle, and prevented the syringes from working properly. "In order for the suction to work", Mandy Chow said, "We had to put something inside the tubes because air is compressible. We chose to use mineral oil because the density of that and the red water would be different." As Kateline added, however, the team is still "having issues because the mineral oil we put in the syringes are actually expanding the rubber. Thus, it's pretty much impossible to pull out the plunger out. So we're going to try to put water in the tubes and syringes and hope that it won't dilute the red water solution too much. If that fails, we'll need a backup water extracting mechanism."

Furthermore, the force needed to pull up the syringe was too big for us to handle in a short time. The original suction device was really big, and because the size of the ROV should be minimized, Alex came up with a great solution. Instead of having one syringe on one side of the plastic board, and two syringes on the other, all three syringes will be on the same side, and puttied together. The middle syringe will be the one originally from the lone side. Its opening will be connected to a syringe up on land. All of the syringes inside the ROV should be pushed in, while the syringe up on land should be filled with water (pulled out). When the syringe up on land is pushed in, it will cause the middle syringe to pull up, causing the two syringes on the outside to pull out as well. the two syringes will have tubes leading into the soft water bottle, thus, the red water will flow into the two side syringes.

The finance division of the ROV team is equally important, and resolving the challenges was a first priority. Arthur Chang said, "I was assigned to a group responsible for purchasing the necessary materials, we always take the issues head on as soon as possible, as the entire project cannot properly progress without the materials readily available." Even though the Internet has made finding products relatively easier and more convenient, but the team still tries hard to obtain materials needed from the local area to avoid expensive shipping fees.

Trouble Shooting Techniques:

Our team's troubleshooting techniques (on a more individual basis) generally follow a set routine: water testing, performance analysis, and redesigning or tinkering with the ROV components accordingly. A significant difference is that our approach is more systematic and less random compared to trial and error. Usually, prior to a water test, we would anticipate many potential problems. Instead of trying to fix what may or may not be a problem, we systematically conducted water tests while bearing those possible flaws in mind. If there was indeed a problem, then we could fix it directly. This is a more efficient way of troubleshooting than to tinker with every single detail.

One example of our team's troubleshooting process can be seen in the testing of the cameras. Kevin Lin, one of the directors of R&D and Engineering explains that when he encountered a potential problem concerning the pressure underwater, he cannot accurately simulate the underwater environment on the surface. Hence, he takes a bold step of trying on strong waterproof containers for the cameras and begins the trials. The container with the best performance was chosen to be integrated into the main ROV with minor alterations on the design.

Another example is the troubleshooting process of our other director, Alex Chen. He explains that his method is definitely not guess and check. Instead, he often had a clear idea of what is going to happen even before conducting the water test. Thus when he encounters a problem, he can look toward a number of viable solutions to solve the problem. This dramatically speeds up the troubleshooting process because the every step is anticipated, and solved with remarkable swiftness.

As our CEO explained, however, we used a different technique from the individual approach when working as a team. A lot of the work in this project is distributed, and we followed a divide and conquer model. However, often times, an individual may get stuck and not know how to solve a particular engineering problem. I feel like one of the best solutions to these "engineer's blocks" was our weekly meetings. During the weekly meetings, we not only update each other on our progresses, but we also bring up any problems we are facing. We go through everyone's problems and discuss verbally while putting our heads together to solve the problem. I think talking to each other verbally helps a lot in providing new inspiration. In addition, everyone has their own points of view and new ideas often spring up from mixing or inspiring each other with these new points of view.

Lessons Learned and Skilled Gained:

We, as a team, learned several lessons related not only to our personal development but also to us as an organization, a group. First, on personal development, this competition is arguably the closest activity all of us have in relation to engineering in general, going beyond computer programming and Lego robots. The integration of software and hardware into a unified product is not common in our experience. Far too often, we are limited to one engineering aspect or the other. With this competition, and a sufficient number of participants, we are able to put these two aspects together, understand and work first hand, and gain valuable lessons for the future.

More importantly, as a team, we came to understand how to function in an organization that is different from a usual school club. Instead of a rigid hierarchical system, the team is multilateral, with everyone giving feedbacks that influence the direction the team is moving towards and granting greater independence to all of us. Perhaps this is the most important lesson, a social organization based not on a single authority figure giving orders for all activities, but a much more equal, interactive, and communal body.

Future Improvement:

Working as a company, the team tried to keep in mind that the mission is not only to build a functional ROV, but also to manufacture a machine that fully satisfies the client’s demand within a set cost. Learning from last year’s mistakes, we were able to improve our technology and ideas in designing and building the ROV. We also tried to maximize the team’s ability by dividing the team into several specialized groups. The strategy was very successful in managing time and improving our ROV.

Yet, as a company, we realized that we need to work on increasing efficiency and variety in order to meet the clients' needs. Since our service should be able to solve the problems that the clients face in marine-technology, we would like to have gathered more information in that field beforehand so that the company would be able to understand and plan the solution more logically and effectively. Also, considering that the company and its projects and services involve in making profits, our team hopes to manage the projects more efficiently in time for completion. If we could organize and divide the work better, we believe that the company would be able to serve more clients quickly with satisfactory results, thus increasing our company's profit. I

n order to develop more innovative and effective solutions for the marine-technology problems, the company also plans to invest in the Department of Research and Development. This would let our team grow as a creative and competent company that would be able to satisfy a variety of clients' needs. Our company's complete array of services will be available for more clients in different fields and the company would be able to expand our business and establish a close connection with the clients. Understanding the necessity for improvement in ROV technology, efficiency, and marketing, our company hopes to invest and develop our ability to create unique solutions to the clients' needs.

On the technical side, there are three main areas of focus: the cameras, the waterproofed boxes, and the bilge pump mechanism.

For Cameras, there are three specific improvements and a general one. For the regular camera, we still need to find some way to protect the front from scratching. The servo motor used in one of the servo cameras required a larger case. The whole mechanism could be shrunk even more if a smaller 180 servo could be found. For the dual-servo cam, we could redesign the camera so that the sensor is moved more toward the center, wasting less space. Lastly, but most importantly, for all cameras, we hope to integrate Seacon female ports for increased removability and accessibility in case there is a need for a backup installment. However, due to the limited time we had in working with the Seacon cables, we have not yet had the chance to order more.

As for waterproofing boxes used to hold the circuit "brain" of our ROV, there are several improvements that should be made. We need to make the box smaller and figure out an easier way to open both boxes as the current configuration has a gap between the two boxes that makes it hard for hands to open the flaps that keep the lid on the inner box. By making the whole box smaller, we can optimize the space used in the ROV frame, increasing efficiency and decreasing buoyancy. The waterproofing capability of the boxes was optimal, but in the future, more sturdiness is desired, as the plastic is very thin and flimsy.

Finally, the Bilge Pump Mechanism used to collect biological samples is a must, given the vast demand for such service as demonstrated by the repeated occurrence of such tasks in the MATE ROV competition. The angle of the bilge pump would have to be changed, as the way it is attached to the main frame of the ROV does not allow for the optimum angle; the water should be hitting the sea creatures that are lying on the pool floor. It should be angled more towards the bottom of the ROV so that it makes contact with the sea creatures, therefore being able to push the creatures into the cage. Also, the water flow has to be diffused from its original structure, as one concentrated stream of water would not be as likely to hit the sea creature with limited navigation from the surface. This was solved by creating an "x" structure at the opening of the output pipe on the bilge pump, therefore diffusing the concentrated stream of water into a fan-shape and lessening the force of the water that was being expelled from the pump.

Reflections on the experience:

Arthur Chang: Honestly I feel very fortunate to even be part of the team all the way to the competition. As a member of the senior team, I've spent most of my time serving as the "rover" or "guerrilla force", tackling all sorts of miscellaneous tasks here and there from time to time. Throughout the course of the year, I've learned to operate the Dremel, cut pipes into segments using a stationary chainsaw, solder a circuit board, request for reimbursements, and – as simple as it may sound – purchase items efficiently. Once I was also assigned to come to school early in the morning to clean up after a water test performed the day before. Overall my involvement in ROV was truly a holistic one.

Lawrence Chang: The MATE ROV competition has once again been very rewarding. This being our second year, we had a chance to work with some more advanced equipments that have allowed us to improve our design and the capabilities of our ROV. In addition, there was more specialization of skills and task this year than last year, which allowed us to distribute the tasks more easily and efficiently. Overall, it was just a fantastic experience

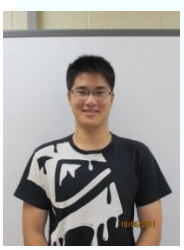
Sarah Chang: Through ROV, I've learned so many things that I would not have even had the chance to learn in any other activity. The team works together, and from our different skills, we can solve various problems and find input from different perspectives. Although I have not been in a competition thus far, I am extremely excited to work and travel with this team that has worked so hard at this point.

Alex Chen: ROV offers students like us an opportunity to explore and learn about hands-on works and DIY. The two years I have joined the team are great.

Mandy Chow: This has truly been a memorable experience; I never thought I would be building an underwater vehicle! The team has also worked extremely well together; we come up with potential problems for each others' work, and help each other in times of crisis. Although the work is time consuming, but the process and product is definitely worth it!

GaHyun Kim: It has been a very meaningful experience since we began working for this project. All of the members learned not only how to build up a successful ROV, but also how to cooperate with others and accomplish our goals. I hope this project could be continued and provoke more interest in the robotics field.

Kevin Ku: My experience in ROV has been very worthwhile this year. Not only did I learn a lot of new skills in mechanical and electrical engineering, I also have the opportunity to apply those new skills in a fun environment. I also enjoyed working with all my teammates toward completing the different mission tasks. It gives me a great feeling of accomplishment as our hard work materializes in the form of our ROV.



Justin Lin: I was determined to be an engineer before joining our ROV team. My two years experience in the ROV team only straightened and brightened my passion for engineering. I just really want to thank everyone in the TAS ROV team for giving me such a wonderful time this year.

Kateline Lin: ROV was largely a learning experience for me since I learned about things I would never have learned in the school classroom. For the most part, I enjoyed being part of this experience, even though it could get difficult with the deadlines and the weekend workdays. It feels good to see what we've accomplished over the months!

Kevin Lin: My ROV experience this year has been even more rewarding than last year. By recruiting new members, our team not only shared the workload, but also made the sharing of ideas more than dynamic, more fun than last year. I hope that this year's members can continue this legacy by passing on their knowledge and fostering a similarly stimulating environment for next year's team.

Derek Meng: Participating for one last time, I came to one conclusion. I will be an engineer, not primarily because of the salary (at least not the primary reason, this I admit with certain shame), but because engineers change the world in tangible, visible and, sometimes, immediate fashion. This year's theme, based on the tragic Gulf oil spill, led me to truly understand what engineers are capable of, and how their actions can change the world for a better place. Though still playing the same role as last year (as a treasurer), I must say this year's ROV gave me a lot more than what is immediately apparent.

Hanpin Tai: I find my experience in ROV this year quite satisfactory. This year I am more focused on the technical report, and is thus less concentrated on the experimental process (trial-and-error testing process). I think the ROV competition itself is still exciting than ever, and I am very glad to be a part of it

Loren Weng: This experience was uniquely thought-provoking, as this was my first time working on robotics without any pre-fabricated materials or input system. This is probably the most time consuming project I've participated in this year, yet I can still say that it is also one of the most interesting, as working in a team and seeing a product finally come together is one of the most satisfying feelings.

Acknowledgements:

Firstly, we would like to thank our principal, Dr. Hartzell, and our Superintendent, Dr. Hennessy for their financial support and absolute confidence in the ROV team, willing to give us the funding while believing in our capability in handling the funds with care. Their flexibility allowed us to respond quickly to challenges.

Next, we would like to thank Mr. Tsao as well for sharing his knowledge and connections to local Taiwanese hardware and materials stores so we were able to quickly buy materials for the ROV. Also, we would like to thank Mr. Augustine for his equipments and knowledge in manufacturing. In addition, we must thank our lifeguard Ms. Emily Huang for her constant vigilance in ensuring our safety. Furthermore, we would like to thank Mr. Sinclair for his advices on VEX parts, without which this year's ROV will be harder to build.

Lastly, but definitely not least, we would like to thank Mr. Simonton and Dr. Garcia, our sponsors for their unwavering support. Knowing we are capable of handling technical difficulties and hurdles, Mr. Simonton and Dr. Garcia gave us maximum freedom in designing, manufacturing, and testing the ROV and only coming intervening , by giving hints, when we are unable to solve a problem. We thank them for your confidence, and we hope this year's ROV competition will be a gift to them for all the trust they have given us. Also, their willingness to assist us in handling the traveling details, as well as negotiating with the school over other issues, earns our deepest gratitude.