



*King High School Technical Report
The Lionfish ROV
ROV Engineering Report
Lion Fish ROV*

*Submitted by:
King High School
Lion Fish ROV Team
Tampa, Florida*



Team Members

<u><i>Steve Banister</i></u>	<u><i>Team Coordinator</i></u>	<u><i>Guidance</i></u>
<u><i>Razi Ullah</i></u>	<u><i>Team Captain</i></u>	<u><i>Head Engineer</i></u>
<u><i>Siva Beharry</i></u>	<u><i>Vice Captain</i></u>	<u><i>Asst. Engineer</i></u>
<u><i>Aryan Beharry</i></u>	<u><i>Engineering/Repair</i></u>	<u><i>General Help</i></u>
<u><i>Hannah Frisby</i></u>	<u><i>Secretary</i></u>	<u><i>Fundraising/Poster</i></u>
<u><i>Shannon Stewart</i></u>	<u><i>Secretary</i></u>	<u><i>Publicizing/Poster</i></u>
<u><i>Jamie Adams</i></u>	<u><i>General Help</i></u>	--
<u><i>Ryan Allen</i></u>	<u><i>General Help</i></u>	--
<u><i>Brett Owens</i></u>	<u><i>General Help</i></u>	--

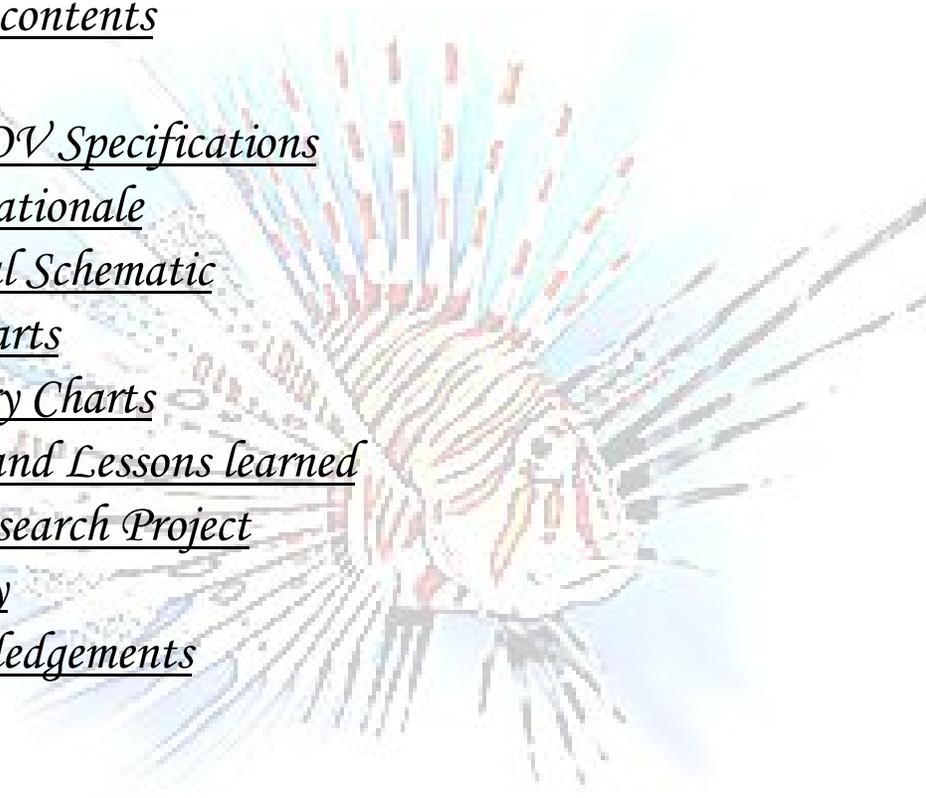


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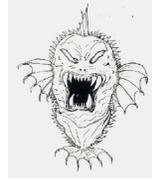
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Abstract

A report containing the summary of the trials and tribulations of King High School's "Lionfish" ROV team; the report contains full technical readouts of the "Lionfish."

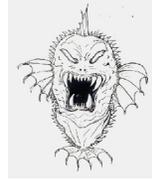
The Lionfish Project, launched in January 2006, immediately set upon the decided goals of primarily winning the Regional ROV Competition, as well as competing at the National ROV competition to be held; both are hosted by Marine Advanced Technology Education Center. The secondary function of the "Lionfish" is to retain the versatility needed to compete in other ROV and robotics competitions.

The technical Report, presented here, contains the final electrical schematic, construction designs, charts/graphs, and other material related to the construction and functionality of the ROV.





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Final ROV Specifications

Size:

Length: 80 cm

Width: 57 cm

Height: 55 cm

NOTE::: “Lionfish” ROV is constantly being modified to the best of its functionality and the size will, most likely, change.

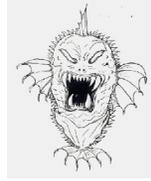
Frame: The frame is made up of 1.9cm, 2.5 cm, and 5.1 cm PVC pipe. The frame is held together by more than 100 standard screws and is connected to the tether towards the back, at the top. The frame has gone through many phases of testing and has emerged as a very strong and easily modifiable component of the “Lionfish.” The ballast tank, working on the same principals as Submarines, is connected at the top of the frame with numerous tie-wraps. Instead of using it as an air-tight tank, holes were drilled towards the bottom of it, providing flooding which results in decrease in buoyancy. When more buoyancy is needed, air compressor is used to push the water out, thus filling it with air, resulting in more buoyancy. Major benefit of having such a frame, as seen in the functionality of the “Lionfish,” is the under-water balance that it provides. With every component being well balanced, with the concept of Yin-Yang in mind, provides remarkable stability i.e. where there is one motor on the right, another one, at the same position/angle is placed on the left. Where there is one thruster facing the top, at the center of the frame, another one is placed right underneath it.

Control System: The control/monitoring system is set into a plastic electrical wiring box provided by the King High School’s head custodian. The control box contains a total of 3 momentary switches and 1 toggle-switch – which, when turned on/off, stays in that position unless changed manually. The control system is also equipped with both an amp meter and a volt meter. Even though such a setup makes the wiring slightly more complicated, it is well worth the arduous work. A personal anecdote, without doubt, can support our claim:

During the regional competition, the “Lionfish” went limp – that is to say, it stopped responding in general. A quick check by pilot proved to be very beneficial; the volt meter showed zero power. In the pilot’s opinion, “it is very important for every member of the group, if possible, know the construction of the ROV. This philosophy proves to be very beneficial because during an emergency/malfunction, any member of the team can trace the source of such nuisance.”



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Optical Input and Output System: The cameras for the *Lion Fish* consist of 3 Chicago Electric Underwater® Cameras [Item #: 91309]. The cameras are 12 volt, with 270,00 pixels of clarity and a 70° viewing angle. The cameras are hooked up to a series of three channel monitors. These cameras, costing approximately \$100, proved to be very beneficial. It is not to say that we were using off-the-shelf parts; our mounts for the cameras, as well as the positioning, is absolutely original. Our first camera, which is primarily used for surveillance, proved to be ineffective. The camera was mounted inside a self-fabricated capsule, which proved very poor visibility. Every component, of that particular camera, was hand fabricated. Since our primary goal is to maintain the “*Lionfish*” as-practical-as-possible, the camera was disapproved of by the team captains due to its poor functionality; camera placement diagrams are posted below.

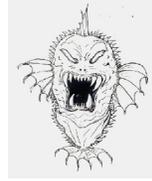
Environment Manipulation Devices: Our function is not to manipulate the environment, but rather, to work in harmony with nature. However, if such a device is needed, the “*Lionfish*” is easily modifiable and will require no special adaptation in adding such a device.

Unit to Surface Connector: the “*Lionfish*” is connected through an umbilical cord to the control box, which is then connected to the power supply. The umbilical cord consists of three wires that are connected to the cameras. There is a 0.6 cm. polyethylene air-hose which is interconnected to the ballast tank and the air compressor. This particular tubing, manufactured by WATTS, is ideal for low pressure, food/water uses.

Propulsion System: propulsion is provided by three RULE model 27DR 12V 6amp bilge pumps, rated at 4169 liters/hr. One benefit of using these bilge pumps is that it is purchasable as a cartridge only, with exposed shaft, thus requiring less fabrication. The motor mounts were also hand-crafted by the engineers of the team. There were two thrusters on the outside during the Regional Competition. However, since the metal propellers were uncovered and posed a threat to the environment, they were moved inside the mainframe of the ROV. They were positioned at an angle since they were moved inside the frame. Our testing proved that if they were to be pointed straight backwards, like they were before, the maneuverability would be harmed. The angle-mounting provides very precise maneuverability. Also, there is an up/down thruster which works very well when the “*Lionfish*” is filled with just the right mixture of air and water to make it neutrally buoyant. Another thruster, purchased from local K-Mart, provides strafing. However, since this particular motor was damaged, another



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one is being fabricated. There are two plastic Glass Filled thrusters made by Octura Model/Marine Supplies, with the pitch at $1.2 \times \text{Dia}$. Also, for forward/backward/turning thrust, two beryllium copper thrusters with a greater pitch of $1.4 \times \text{Dia}$., also manufactured by the same company, were used.

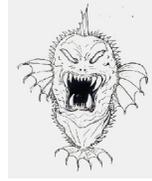
Cowling: Our cowling ducts are currently made of PVC reducer attachments. However, they are causing weight-issues under water, resulting in less maneuverability and speed. A better and more functional system is still under development.

Power: Our power is supplied by a 12 volt battery. It is the same battery that is used in cars, trucks, marine vessels, etc. The battery provided during the Regional Competition was provided by Interstate Batteries. As for the camera/monitors, the package came with their own 12 volt rechargeable battery. Another device, a Power Pack, is also used. It is a very effective invention; it hosts an air-compressor – same one which we used during the competition, a 120 volt ac power supply for repairs, i.e. drill machine, dremel rotary tool, solder, etc., as well as a powerful flashlight.





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Design Rationale (The Method behind Our Madness)

The original idea to enter in the ROV competition was sudden and left us little time for long plans and testing. Physics teacher, who is also our ROV Team Coordinator, Stephen Banister, attended a class hosted by Hillsborough Community College. It is there that he, Mr. Banister, learned of the competitions. He brought back a small and cheaply constructed ROV kit. Upon our inquiry, we learned that the kit was later assembled by students. When these students learned that there are actually competitions held for ROV engineering, a group meeting was called for and a club – the King High School ROV Club, was formed. A decision was made to enter the competition and we were taking small steps to our enlightenment into the field of marine engineering.

Our first step was to design an ROV based on:

- Cost
- Size
- Power Consumption
- Maneuverability
- Complexity
- Practicality
- Time to build

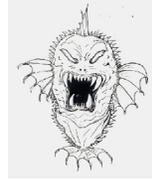
All team members were given the task of designing a possible ROV and then creating a model based on these criteria. The decisions were made as a group and every aspect was analyzed to the best of our abilities. Possible frame designs were first made of popsicle sticks, followed by the PVC one, which mutated into a remarkable ROV named “Lionfish.”

Cost

The cost was our biggest concern. With only four months there was little time for fundraising. We had to work with whatever we had and what we received from our numbered donors. However, it is people such as Mr. White (Mr. Banister’s Neighbor) and Rairigh Construction Company, etc. who donated whole-heartedly who made it possible for us to create “Lionfish.” It is due to a limited budget and overpopulations



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that the school-board was unable to provide significant financial support – an understandable reason.

Size

The size of the ROV was a minor concern. Based of the rules, we knew that the ROV could be no larger than 60cmx60cmx80cm. All team members were instructed to keep their models within the size requirements. All original concept designs fit well into the set limits.

Power Consumption

Our design team was worried about power consumption. All throughout the building of the ROV, team members constantly tried new ways to reduce power consumption. The design team did its job perfectly. They created an ROV that ran at 50% of the projected power. This was accomplished on the first try and no rewiring was required. This major success was due in part to the electrical design team's research and calculations. There were no problems with power consumption due to any wiring done by the KHS Lion Fish team. It is also very important that everything be checked, and later, double checked; during Regional Competition, we were running on a fuse of much lower capacity than allowed and we had none at hand... it could've resulted in a costly mistake.

Maneuverability

The maneuverability of the ROV was a major subject from the beginning. We knew that the success of the ROV was linked directly to its ability to move precisely through water and the pin-point accuracy required for the tasks. All designs were required to exhibit high amounts of aqua-dynamics. These aqua-dynamics were created using rounded edges, maneuvering vanes, and additional engines.

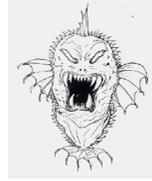
Complexity

All initial ROV designs had to be within set guidelines of complexity. Specifically,

- 1. The ROV could not require any special screws, nuts, bolts, drivers, etc. or any connection/strengthening device that requires a special tool to be modified.*
- 2. The ROV could not run on any form of chemical power.*
- 3. The ROV would be completely remotely operated without any form a prior programming. The ROV was designed to be run only by a human pilot, requiring great skill and preciseness.*



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4. *All parts must be universal so that in case of malfunction/emergency, another is readily available.*

Practicality

All designs had to be practical. Specifically,

1. *No unnecessary arms, pipes, cameras, motors, Etc.*
2. *No over-decoration.*
3. *No weapons or other items that can accidentally cause harm to living things, Including: Harpoons, pyrotechnics, acid, and combustible chemicals.*

Practical rules were set in place to keep the ROV as functional as possible. Early concepts designs had too many decorative and otherwise unnecessary items attached. Also, two side-mounted torpedoes (for decorative purposes) were mounted. However, since they caused weight issues (they were air-tight and had too much buoyancy), they were discarded.

Time to build

The initial designs were also rated on their estimated time to build. No model could take more than two months to complete. This measure was enacted to insure plenty of time for practice. This criteria included the time required to find and purchase parts, time needed for assembly, and time needed for human error.



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Time Charts



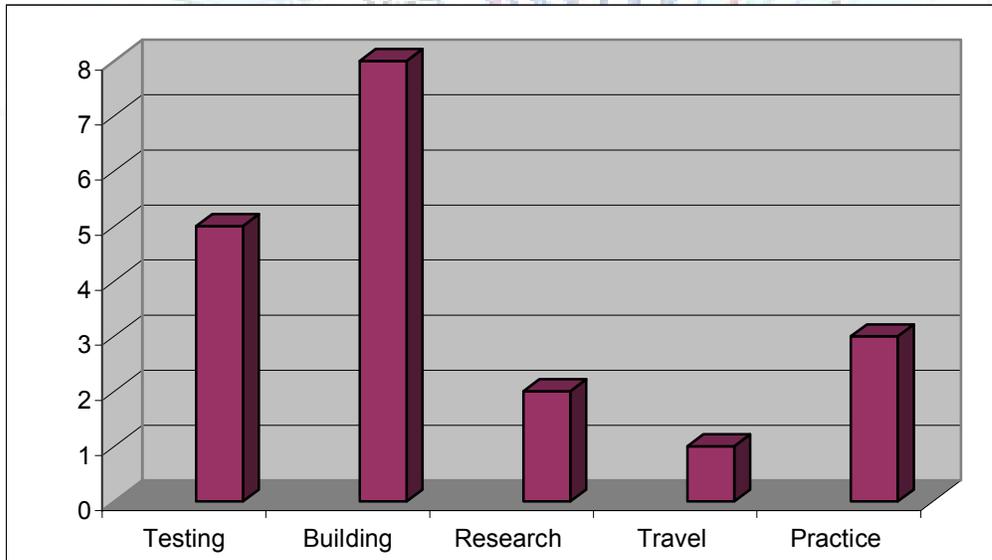
Activity

- Brainstorming
- Early Model Design and Testing
- Early Fundraising
- Reevaluation
- Second Design and Testing Phase
- Final Model constructed
- Final Fundraising and Donations
- Final ROV complete
- Practice Sessions
- Competition

Early January Late January February Early March March-April

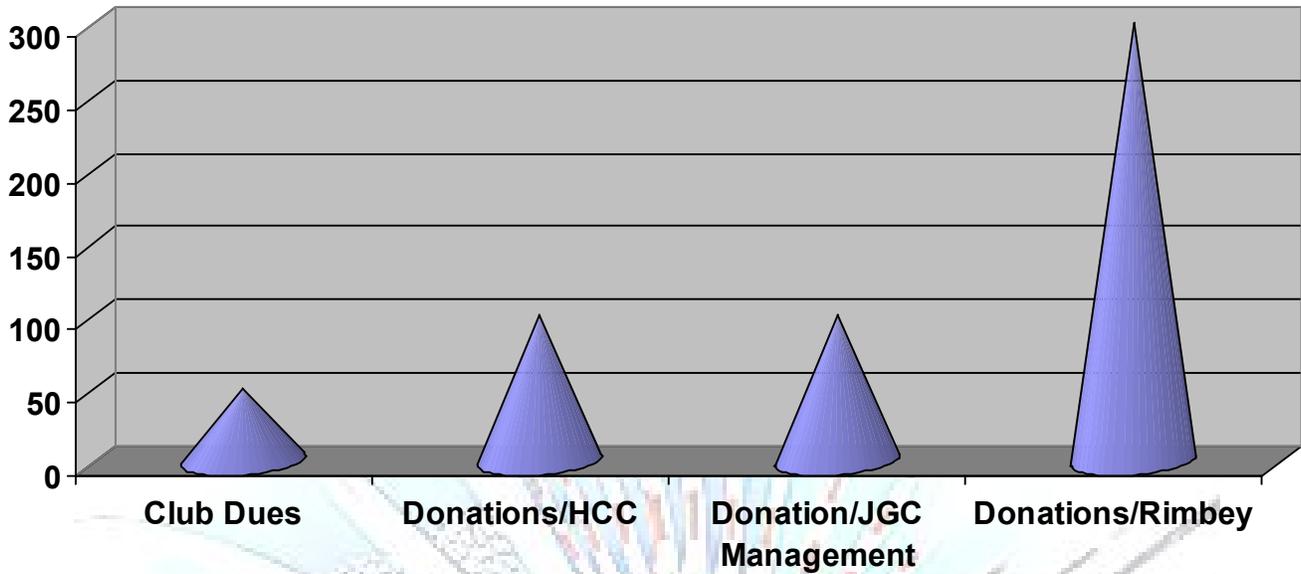


Time distribution (Hours per month)

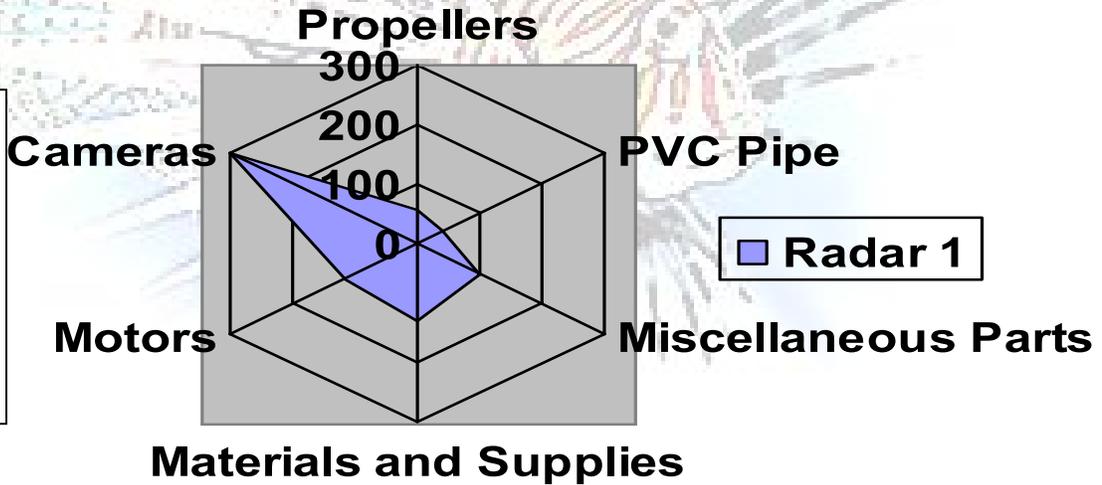




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 Monetary Charts



Grand Total
 \$740
 +
 Other Costs
 **Not
 including
 travel costs!

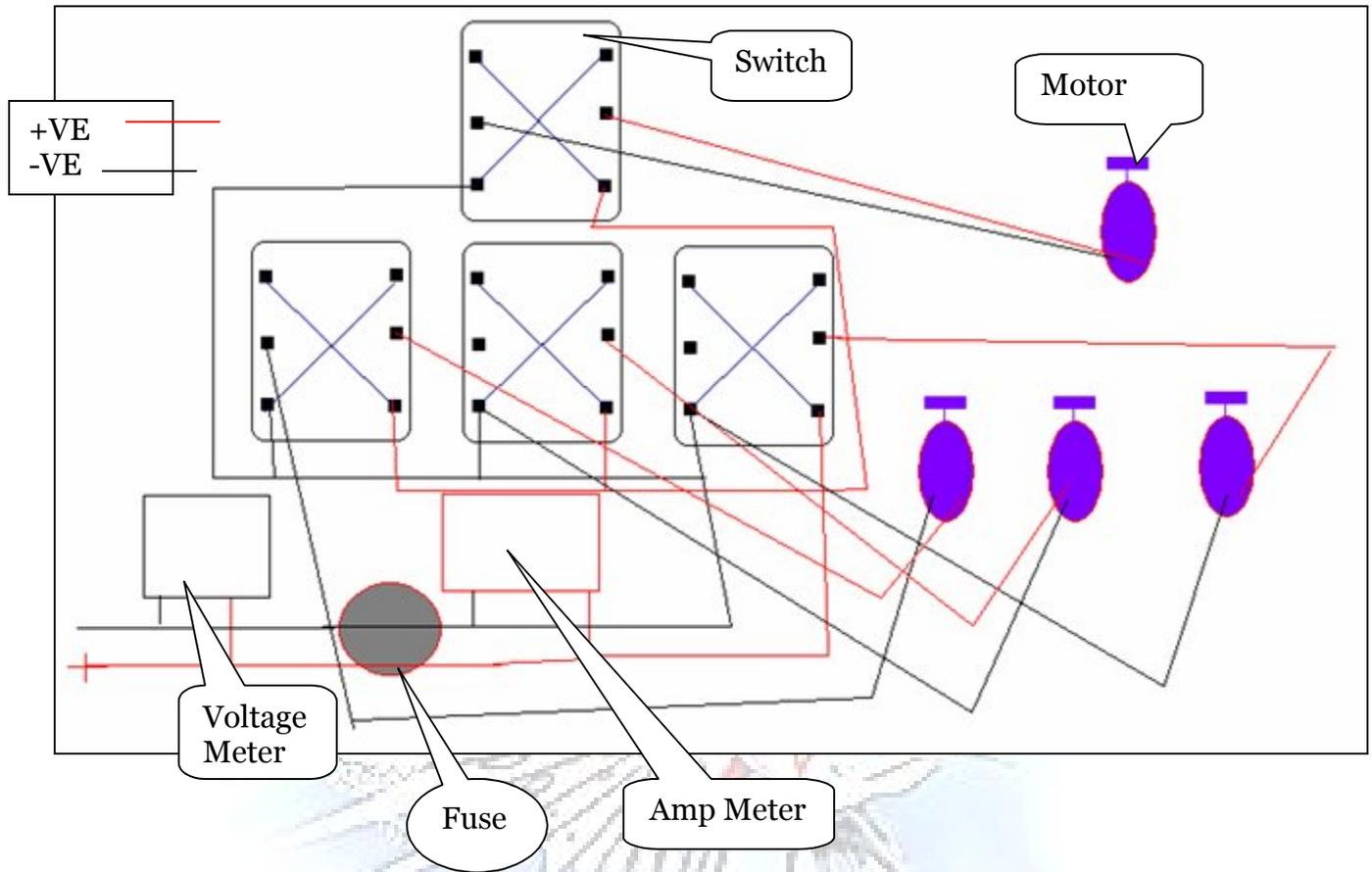




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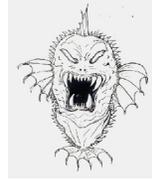


Electrical Schematic





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The *Lionfish* ROV
Testing, Design errors, and problems
(How we fixed them and what we learned)



Like every project, there were many errors and problems. Most importantly, the major concern was funding. We were significantly short on funding; supplies weren't available but having good engineers as a part of the group, availability of tools and equipment was not a significant challenge. Mentors went the extra-mile in helping, as they drove around looking for parts, as well as allowed us to use the workshop/tools for building process. These problems were eventually reduced, and later, eliminated as more funds came in and supplies became readily available. At this point, the whole ROV team compliments the donors and helpers, as well as each-other, for quickly and efficiently eliminating obstacles that stood in our way. A complete list of donors is included towards the end of the paper.

Testing: *Initial testing was slow to begin with. It took our design team considerable time to create a usable Lion Fish model. The time constraints compounded by a lack of time, manpower, and funding, left us with little time for anything more than basic testing.*

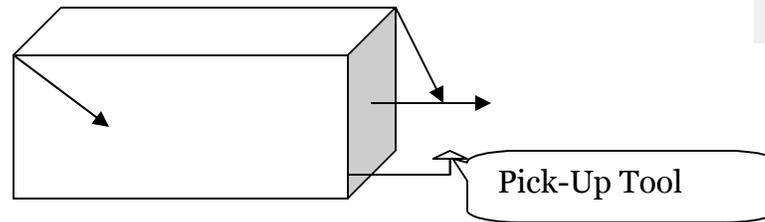
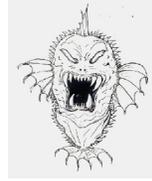
Basic testing done on the ROV included

Speed testing: *Speed testing was used to see how much time it would take for the ROV to get from point A to point B. The ROV needed to move fast enough to complete the tasks in a set amount of time. The test was also used to make sure that all the wiring worked correctly and that the tether was watertight. No major or minor flaws were uncovered during this phase of testing. This was the first test done on the ROV. The ROV managed to clock a speed of 0.8 meters/sec. without the instrument module box attached. Since we did not have the exact box that was being used in the competition, we were unable to test speed of the ROV with the instrument module attached. However, we do understand that the speed will be drastically affected with the instrument module attached.*

Camera Placement: *We knew that another important aspect of the ROV was its camera placement. Since ROV operators would have to rely solely on cameras, this was one of the most vital tests. It was also the second phase test for all wires and sealed modules. The initial configuration of the ROV had two cameras. Although short lived this testing led to the correction of many problems that would have, if left unchecked, rendered the Lion Fish project grounded.*



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One camera was forward facing for navigation (wide-angle view) while the other was pointed directed at the pickup tool. We learned that this design would not work. A large part of the main camera's view was blocked by PVC pipe. This problem was fixed by mounting the main camera to an extension in front of the blocking PVC pipe. More testing indicated that a larger field of view was required. The third camera was placed towards the back, looking down **through** the frame at where the instrument module would be. The instrument module box was guided precisely by our pilot into the housing; even though it was transparent and difficult to see under water, our pilot guided the ROV and the instrument module box through the use of 90° elbows placed around the corners of the instrument module box (using them as corner markers). Placement of the cameras was finally accepted after testing by the ROV team.

Buoyancy

The third group of tests was done on the Lion Fish's buoyancy. The initial buoyancy of the ROV was a major problem. The ROV had no form of buoyancy control, even though the top frame was air-tight. The original model had to be manually lifted out of the testing sites. The second phase of the buoyancy system was created by adding a ballast tank to the ROV. This second phase design worked and allowed the pilot to actually control the buoyancy remotely. We didn't calculate up/down thrust since it will differ as the ballast tank is made more/less buoyant.

Ability to perform tasks: Perhaps the most crucial phase was the phase dealing with the Lion Fish's ability to perform tasks. Testing was done within a controlled environment, with special handcrafted devices. The three set tasks for the LION Fish project were as follows:

1. Take an instrument module box down, under water, into its housing.
2. Retrieve a "probe" from the bottom of the pool and place it into a port inside the instrument module box recently lowered inside its housing (after the door is opened to reveal the port).
3. Remove a pin from a floating instrument package so that it floats to the surface.

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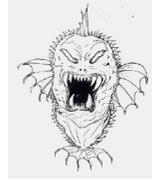
Please disregard the date; it needs to be re-adjusted in the camera system.

We created our own test props that were somewhat identical to the ones used in the missions. The main problem with the first task was attaching the module to the ROV and then letting go. The original plan for this task was to create a manipulator arm that would open and close via a switch. However, due to the cost and general complexity of building such a device, this idea was scrapped. The second idea for this task was to use a hook to pick up and release the module. This idea was generally accepted and testing began. After a handful of tests, it became apparent that the ROV was not able to maintain its balance. Then, another genius idea came to our engineers' bright minds; they thought about attaching an igniter to a wire and attaching the instrument module box with a thinner wire (box weighs less under water) and then burning the wire off, to release the instrument. However, the ingenious idea was scrapped because it would release harmful material into the pool. The method that was used at the contest was painfully simple. The module was attached to the ROV with a fishing line (7 lb test), and then, after the module was in place the ROV would use its own propeller (4th motor) to detach the module. Obviously, this means that the ROV pilot only has one chance to complete the task. Also, if the module slips away/breaks away, there is no way of retrieving it. Due to the dicey nature of this method, the ROV team continues to explore new ways of completing this task in a safer and less time-consuming manner.

The second tasks required the construction of a mock probe. The probe was extremely useful because it helped the ROV construction team create the perfect pickup device. It is strangely simple, shaped like Texas Longhorn horns; all the pilot has to do is snag the pin/probe from the loop and carry it along.



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ROV Research Project
(A List of Ocean based Careers)*



Oceanography- Those people who wish to become extremely knowledgeable about the world's oceans, might like to become an oceanographer. There are many different types of oceanography including: Geological, Chemical, and Physical. Oceanographers work in a variety of fields including meteorology, marine biology, and geophysics. This career path can earn anywhere from \$50,000 to millions (Odyssey Marine excavation of S.S. Republic resulting in millions of dollars' worth of gold, etc. Suggested education is at-least high-school diploma, but upon our inquiry, we have learned that as long as one possesses great talent and skill, it is possible for him/her to make copious amounts of money and have a secure financial future.

Outline of careers

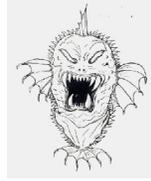
- ┆ Meteorologist*
- ┆ Atmospheric Chemist*
- ┆ Excavation*
- ┆ Marine Engineering*

There are endless possibilities in the field of marine engineering and 98% of the ROV team members stated that they had gained interest in the field of marine engineering. Most of the group members claimed that they would be veraciously interested in the marine engineering field. As far as knowledge gained from the project goes, it is indescribable..

Many stated that prior to the project, they had little to none practical skills. However, when everyone had a chance for a more practical and hands-on work on the ROV, much knowledge was gained. For example, a team member was able to repair the kitchen sink in his house by using ordinary house items and some PVC parts, saving an estimated \$167.



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Summary

The ROV Lion Fish project has been a large operation fueled by its creators' desire to see their dream become a reality. The Lion Fish project represents the hard work of many different students, working together, in synergy, forming friendship and learning to depend on each-other in times of need. Every member of the group has learned much from this opportunity, and thanks to MATE, has fueled a desire to enter the field of marine engineering. It is learned that working in teams can sometimes be difficult; as learned, however, it is the best method for a large-scale project where times are both good and bad. Thanks to all the students who sacrificed so much of their time to make this project a such success, "Lionfish" is well on its way to Houston, TX, to compete at a national level with even a few international teams.. In closing, hopefully, the success of the KHS Lion Fish team helps inspire others to get involved with engineering projects and to always do their best.

***It is anticipated that many aspects of the ROV will change as the time allows for improvement before the final competition. King High School's ROV team is constantly trying their best to upgrade the ROV to the best of its practicality. Also, the total cost will change as well since more parts and equipment is needed/purchased. Keeping in mind that as more and more funds are becoming available, thanks to citizens who are actively involved in making the community a better place, their names will be updated in our acknowledgement list. Their generous donations will be used for the benefit of the ROV club, mostly used for travel, housing, and equipment related fields.

Acknowledgements

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HCC Foundation

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Erica Moulton, Regional Coordinator

Temple Terrace Beacon

Steve Banister, ROV Team Coordinator

USF college of marine science

Robert Foster

Gary Strout

Gaspar's Bar and Grill

Concrete pump dispatch, Inc.

Bruce E. Johnson

Joey Everheart

Bar-Fab of FLA, Inc

Adventure Island (Tampa)

Temple Terrace News

C. Leon King High School

Odyssey Marine Exploration



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Side-View. Notice the camera placement and the torpedoes/side tanks.



Side tanks/torpedoes will probably be discarded; the tensions and testing continues.



Top view. Notice the motor placement and the hand crafted mount. Motor is for up/down thrust.



Top view. Notice the ballast tank (top u-shaped). It is tied down by zip-ties.



The newly made manipulator arm to grab instrument module box. Uses actuator from car doors.



Angle mounted thrusters. Hard to see but are mounted inside the frame boundaries. Cowlings are also original. Might be disposed for weight issues.

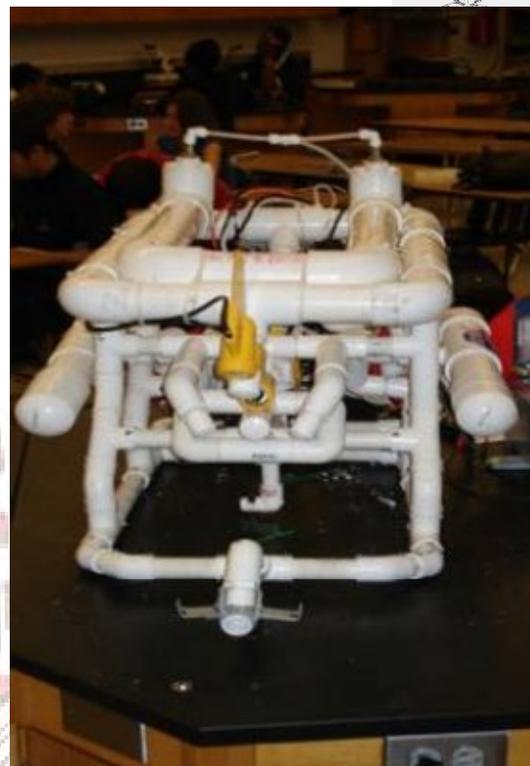


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ROV as it competed at Regionals. Notice the side mounted motors (uncovered) Original hand-crafted camera is on top which was discarded for visibility issues.



Front view. Torpedoes were discarded b/c too buoyant. Notice the front grabbing device.



Another setup which was tried; the L-shaped tool was used to snag the instrument module box from the middle loop. It was later discarded for its inconsistency.



Wiring terminal strip. This is being improved and re-organized.



Ingenious control box. Notice the two meters (voltage and amp). The two center switches are for up/down thrust and the left/right switches are for turning/forward/back.