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Brownsville Area High School

PROJECT "OUTLAW" ROV

Technical Report For 2004 MATE/MTS National ROV Competition

Brownsville Serpents Underwater Robotics Club

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Limitations of this report

This report was prepared in accordance with accepted standards of technical reporting for secondary education students in public schools in the United States of America and in the Commonwealth of Pennsylvania. It contains information regarding the construction of equipment for the 2004 ROV Competition sponsored by Marine Advanced Technology Education Center to be used for the purpose of evaluation of said equipment. It contains no other information, either stated or implied, that should be used for any purpose other than as stated above. This report has not been prepared for use by other parties other than the ROV Competition Evaluation Committee and its designees.

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Abstract

Mankind has never viewed most of the surface of the Earth. This is due to the fact that the waters of the oceans cover over 70%. It is difficult, but not impossible, to overcome the limitations of high pressure, low temperature, effects of corrosion, current movement and opacity to electromagnetic radiation.

Many methods have been developed to study and perform useful work in this hostile environment. One of the most productive has been the development and utilization of underwater remotely operated vehicles (ROV).

ROV's are designed to descend into the ocean while operated from a remote location. They are designed to perform a wide variety of functions, including observation, data collection and manipulation of materials and equipment.

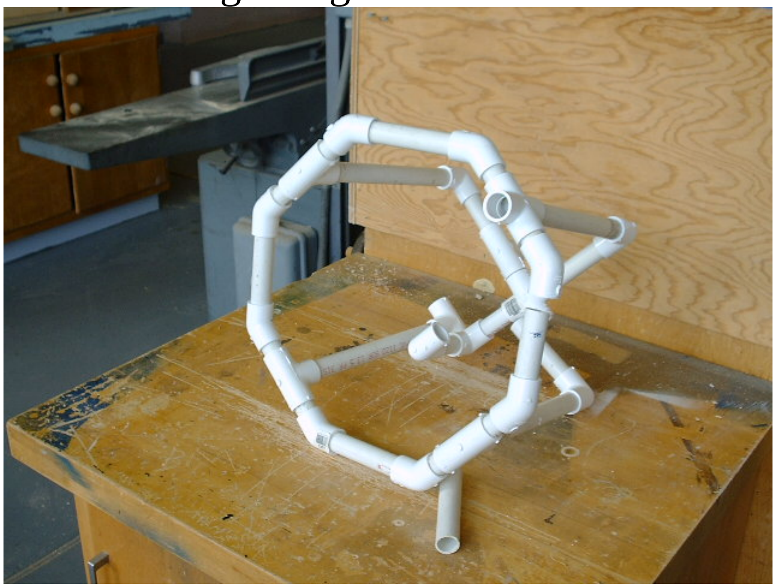
The construction and operation of ROV's ranges from very simple and inexpensive to extremely complex and costly.

This paper will describe the processes and activities involved in the construction of an inexpensive ROV designed to perform specific functions designated as requirements for the 2004 MATE Student ROV Competition: Ranger Class.

Major components and activities described in this report include, but are not limited to, reviewing activities of our previous ROV building efforts, developing the ideas about the requirements of the 2004 ROV, the design integration techniques of the various components, the types of materials that would be available, affordable and functional for each application, the ability to assemble all of the modules and parts in an integrated package and learning to operate the ROV via remote sensing equipment.

Photographic essay:

Outlaw is beginning to take form



Outlaw is semi-completed

Budget and Expense sheet

School Name: Brownsville Area High School

Instructor/Sponsor: Ken Harasty/ Kayla Harasty

Funds:

Date	Deposit/Expense	Description	Amount	Balance
7/03	Deposit	Funds from 03	$536	$536
10/03	Deposit	Donut Sale	$35	$571
11/03	Expense	PVC	$86	$485
12/03	Expense	Wire	$24	$461
2/04	Deposit	MVEC Grant	$424	$885
3/04	Expense	Misc. parts	$68	$817
3/04	Expense	MATE grant	$100	$917
4/04	Deposit	CFoFC grant	$2000	$2917
4/04	Expense	Elect. Parts	$78	$2839
4/04	Deposit	MATE grant	$1500	$4339
5/04	Expense	Airfare	$1256	$3083
5/04	Expense	Misc. parts	$87	$2996
6/04	Deposit	Golf tickets	$190	$3186

Design Rationale:

Our team followed two major slogans that apply to most design situations during the primary phase. They are that “form follows function” and “KISS”, meaning keep it simple and stupid. These allowed us to keep our focus on developing an ROV that would do the jobs MATE had asked it to do and would be built as basic and low-tech as possible. History is replete with examples of machines that have failed, sometimes tragically, due to overly complicated designs.

We decided to stay with a basic static flotation system in order to eliminate the complications of a variable ballast system. Our one advantage in this regard was the possession of a block of ECCM SYNTAC foam that was donated to our team during our tour of the Applied Research Laboratory at the Pennsylvania State University.

For a method of controlling our thrusters, the choices were between a joystick system and toggle switches to send power to the thrusters. At first we all wanted the joystick because we were used to using them to play video games and to drive RC cars and trucks. But after viewing the MATE “BotMatrix” victory on the Discovery Science Channel, we noticed that their high-tech, sophisticated system failed and they resorted to a simple switch system that took them to victory. With this evidence and our own trust in the “KISS” concept, we decided to go with the tried and true double pole, double throw toggle switches.

Tether material choices are wide and varied. Materials considered for the outside cover included polyethylene tubing, automotive wire covering, PVC tape, wire covers for sail boats and elastomer tubing. Our need was to keep all the wires together in a confined area for safety purposes and for ease of operation, but to still remain flexible enough to negotiate all the twists and turns of the competition course. Our major limiting factor was price. We decided to do the job with the least expensive material that would provide 100% safety at the lowest cost. Aesthetic factors were a non-issue.

For a video source, there really was no choice. We had to recycle the waterproof video camera purchased for the 2003 competition due to cost factors. It performed perfectly last year and we hoped we could count on it for the coming competition.

Our greatest discussions revolved around the design of a manipulator arm for the ROV. Some of us wanted to go with a hydraulic system, others were pushing for an electrical system of 12-volt actuators and there was also discussion about the use of a strictly mechanical system with just a few moving parts. After lengthy discussions over a long period of time, we decided to eliminate the hydraulic system due to potential problems with the use of water as the hydraulic fluid and its lack of lubrication properties for any O-rings needed in the system.

The electrical actuated system was considered because of a source of free actuators from a local automotive scrap yard.

Materials:

There were three basic materials choices for constructing the ROV superstructure. titanium, aluminum and PVC Schedule 40. Titanium was eliminated due to cost and lack of knowledge about methods of joining the parts. Aluminum was rejected as too time consuming due to the requirements for bending and for MIG welding. By default, we were left with PVC Schedule 40. It is a very low-cost material, but lacks the durability and strength of the other two materials. But the requirements of the MATE ROV Competition mission did not place a premium on either durability or strength. It is also very easy and safe to work with. Both are important considerations when working with high school students. Therefore, the low cost, large supply, workability and safety factors combined to make PVC our material of choice for the “Outlaw” ROV.

Control System:

Two different control systems were considered for “Outlaw”. The first was a joystick system. At first, we were unsure on how to wire the motors to the joystick, but with some experimentation, we were able to get it working.

We also still had the toggle switch system leftover from the 2003 competition and decided to try it as our control. We discovered that it offered more options for the operation of the thrusters. With the double-throw, double-pole toggle switches, we could operate any of the motors in either direction and could also use any combination of the thrusters, also in any direction of operation.

A real dose of reality was provided to our team upon viewing the Discovery ROV Competition. The BotMatrix ROV from Monterey Peninsula College was the eventual winner of the event, but came close to having to drop out due to the failure of their joystick-based control system. They won with the use of a jury-rigged contact system that appeared to be very primitive.

Propulsion

Propulsion for “Outlaw” is provided by three (3) Attwood 750 12 volt DC electric motors. They were designed for use as boat bilge pumps. Each pump draws 2.8 amps at 12 volts of DC power. At full power draw, a total of 8.4 amps would be used to run all three motors, well below the competition limit of 25 amps. These were connected to model airplane tri-prop propellers designed for model airplanes. They had a shaft diameter slightly larger than the shaft diameter of the pump motors, so we used epoxy for cement them into place.

Buoyancy

Our buoyancy consists of a static system based on SYNTACTIC foam. The structure of this foam is that is made of millions of glass microspheres, each one containing a small amount of air. The major advantage of this system is that the foam in not compressable when compared to other flotation materials. This problem with using materials that compress due to their gas content is that they lose buoyancy as they undergo hydrostatic compression.

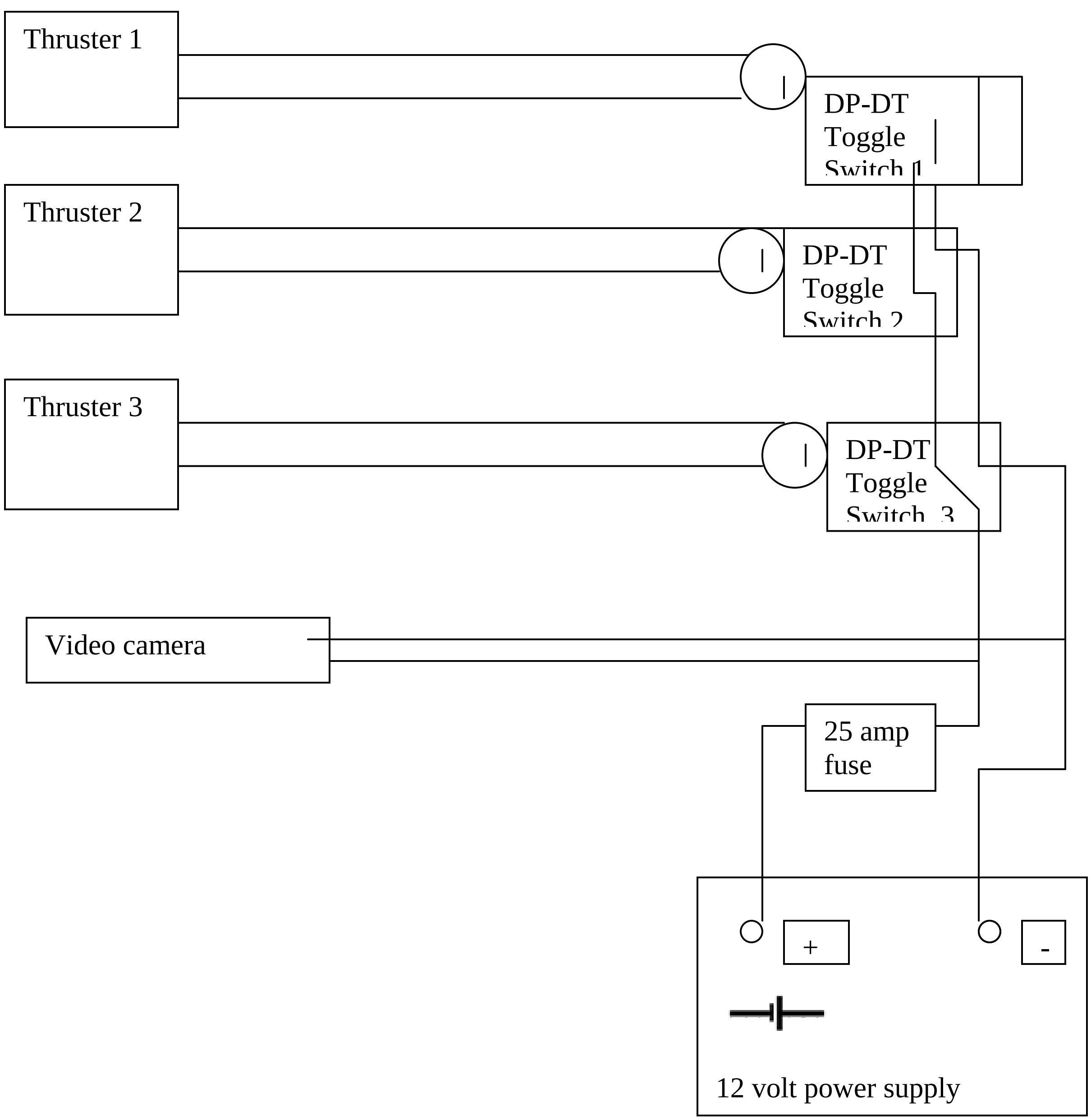
Communication System

Our ROV is equipped with an underwater microvideo black and white camera supplied by Supercircuits of Liberty Hill, Texas.

It has a video chip set from SHARP Electronics with 1 Charge Coupled Device (CCD). It also has six (6) infrared (IR) Light Emitting Diode (LED) lighting elements that are designed to come on when the light level becomes too low for the CCD to receive enough photons for the use of the available ambient light. Therefore it can operate at zero(0) lux. It has a depth rating of 50 feet and a horizontal field of view of 85 degrees.

We selected this camera due to the low price, but have been very satisfied with its performance to date.

Electrical Schematic



Challenges

Our challenges were many and varied. They included, but were not limited to, lack of funding, absence of a work area and teammates having to quit the team.

A goal of the team was to have as many students involved as possible. The total number of student who worked on Project Aqua Rover during the year was eight. We thought that the level of creativity would have been higher if we would have had at least eight or ten more students involved.

During the length of the entire project, we worked in Room 108, in the Woodshop in Room 136, in the janitors work area, in the cafeteria, at Mr. Harasty's parent's house and in the garage of Cole Shimshock's parents. Most of this constant shuffle was due to the fact that our high school is undergoing a major construction and renovation project. We were never allowed to interfere with the progress of the construction in any way. As a result, we were forced to move from one area to another just to have a place to work. Each move provided a different working environment with different facilities. In some areas, we could leave our work sit out, but other areas had to be cleaned up after every work session. Other areas had assess to machine tools, but most didn't. Some areas did not even have electricity to operate small electrical hand tools.

One of the effects of living in a low-income area is that most students have after school employment. This became evident when

Troubleshooting

We had to troubleshoot the entire project due to lack of working space and changes in the students involved. Of the students who started in December, none were still involved at the end.

Mechanical troubleshooting included problems with finding propellers that fit a 3 mm shaft of our motors. This was solved by just using epoxy to hold the props in place for the short time of the competition.

Lessons learned

Start early, have a secure work site, expect the unexpected, be creative, learn to improvise, accept the errors of others as you expect them to accept yours, money helps and it's good to have a network of friends. Also melted solder is very hot.

Future improvements

In the future, we would love to be able to have a larger budget to allow more students to participate. We would also like to learn to build an ROV with more functions in the operations of the manipulator arm(s). None of us have had any experience doing any of this type of work before, except for Cole, but he had to quit the team. We would suspect that our experiences this year would allow us to have a much better idea of what to expect and how to perform all of the required activities.

Although the Explorer class presents a more prestigious challenge, we do not feel that we have the time, skills or resources to participate at that level.

ROV use in National Marine Sanctuaries

ROV's have a wide variety of uses in US National Marine Sanctuaries. The primary use appears to be to provide a visual survey of an area to be studied or to determine the population of flora and fauna with a non-destructive method. They have also been used to locate and survey ships that have wrecked in NMS area and to locate the source of pollutants that are affecting the wildlife in protected areas.

One example of a use of an ROV was at The Olympic Coast National Marine Sanctuary (OCNMS) An ROV was used to monitor benthic recovery from a cable laying. OCNMS authorized a special use permit allowing Pacific Crossing to install 2 fiber optic cables (PC-1) through 30 nm of the Olympic Coast National Marine Sanctuary (OCNMS). OCNMS used an ROV for monitoring benthic recovery from the cable laying.

A second example was in locating the Steamship Portland. It was part of NOAA's effort to search the nation's 13 marine sanctuaries for archaeological and other so-called "cultural" finds. Stellwagen Bank NMS is planning for a series of expeditions to identify the dozens of wrecks thought to be in the vicinity, although no other sinking is associated with such a large loss of life as the Steamship Portland.

In a statement from US Congressional hearings, it was stated that, " Mandatory on-site archaeological survey and artifact recovery activities must, by law, precede engineering and stabilization efforts; they will require exceedingly time-consuming and expensive efforts due to the extreme depth and adverse weather conditions. These archaeological activities could be accomplished by diving teams that included persons relatively unskilled in archaeology, so long as they were constantly supervised by professional archaeologists; other tasks, such as photographic documentation and mapping, might be accomplished by remotely-operated vehicles (ROVs), also under archaeological supervision”

At the Olympic Coast National Marine Sanctuary, Ed Bowlby, the mission coordinator, Craig Bailey, ship’s CO and Vince Gerwe used ROV’s to study the seafloor of Nitinat Canyon. Nitinat forms a cleft in the continental shelf that reaches into the coastal foothills of Vancouver Island. It was used to study the different forms of life found at this boundary zone between shallow coastal waters and the deep sea environment.

Other research projects that utilized the services of ROV’s at Monterey Bay National Marine Sanctuary included: Characterization of the Benthic and Planktonic Communities of Elkhorn Slough, Carmel River Steelhead Count, Underwater Behavior of Large Whales Using Suction-cup Attached Tags, Abyssal Fauna Associated With a Whale Fall in Monterey Canyon and Habitat Characterization and Biological Monitoring on and around Cordell Bank.

Acknowledgements

We would like to acknowledge the support of the following individuals and organizations.

Mr. Richard Gates, principal of Brownsville Area High School, provided support in many ways. He was in charge of the ROV Team financial records and accounting. He established a special fund for the ROV Team that kept all the funds available for team use and established an accounting system for the funds. He also was able to find our team a suitable work area during a year on continuous construction on a major remodeling of the school.

Ms. Jo Lofstead, Executive Assistant for Representative William DeWeese, assisted in grant writing efforts. Although her days are filled with requests from organizations throughout the entire tri-county area, she was always willing to give of her time to edit and improve on any grant applications that our team was attempting to submit.

Mr. Robert Wetzel, Executive Director of the Community Foundation of Fayette County was instrumental in providing the major grant that allowed our team to participate in the 2004 ROV Competition.

COMMUNITY FOUNDATION of Fayette County PENNSYLVANIA

Mrs. Patty Hoak helped provide additional funding through the Mon Valley Education Consortium via a Great Ideas Teacher Grant.

MON VALLEY EDUCATION CONSORTIUM

The Pennsylvania State University's Applied Research Laboratory not only provided the ROV Team with a guided tour of their high tech facility, but they also donated the SYNTAC foam that we used for our flotation material.

Ms. Jill Zande has been a tremendous asset in providing this opportunity to the students of Brownsville Area High School and to the entire nation. She has overdone her assignment via the MATE Center and has become a major force in marine technology in education.