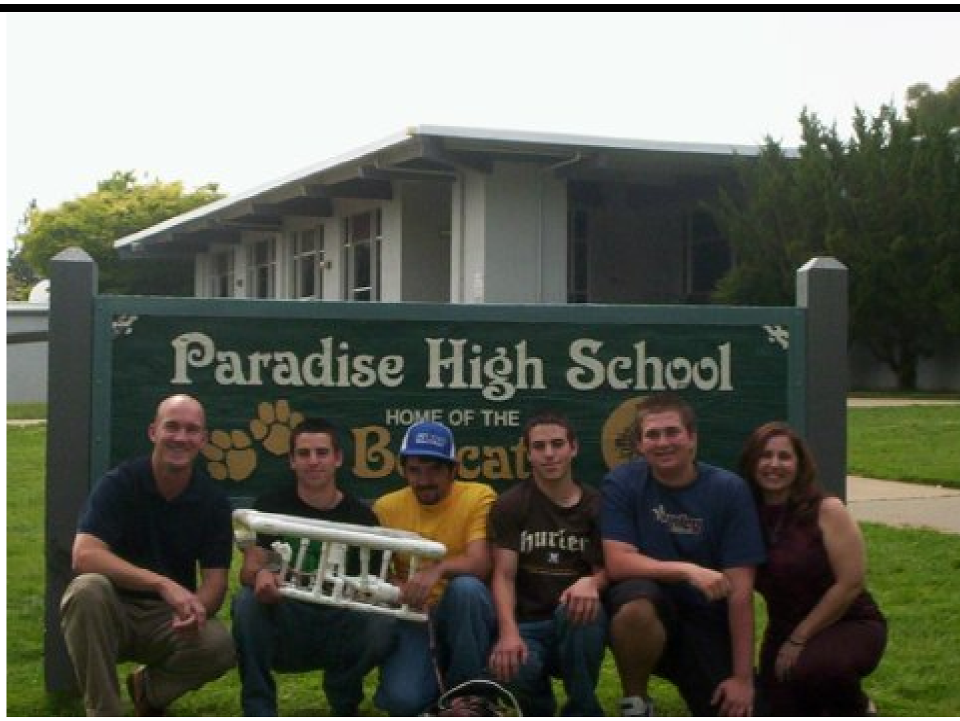
Paradise High School
PHS ROV Club

Technical Report

MATE National Competition

Houston, Texas 2005



Team Members

Ryan Randar

Brent Farris

Zach Farris

Richard McCurdy

Team Instructors

Kim Jones

Chris Jensen

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Abstract

We constructed our first ROV, “THE BEAST!!,” to compete at the Monterey Bay Regional ROV Competition (April 16th, 2005) an event sponsored by the Marine Advanced Technology Education (MATE) center. The first ROV club to be established at Paradise High constructed “THE BEAST!!". The Paradise High School ROV Club is located in beautiful Paradise, California. We designed and built our ROV around the mission specifications provided by the MATE center. All of our components are low cost and have been modified to fit our needs (to be discussed in design rational). We started our endeavor by researching examples of other ROV’s constructed by other schools in previous years and used those to gain design ideas to build our ROV. We added our own ideas and knowledge of RC hobby cars to design the ROV. The ROV uses three modified bilge pumps to propel itself through the water. It is powered by a 12 volt battery and is controlled by three dual pole/dual throw toggle switches connected to our ROV using 18 gauge stereo wire. Our tether leads to a terminal block located on our ROV waterproofed using melted toilet bowl wax. The type of camera that we decided to use is a color Charged Coupled Device (CCD) camera. Lastly, We had support from our community as well as from our parents and teachers and we now hope all of these efforts help to bring a marine biology class to Paradise High.

This is the view of the right side of our completed ROV, “THE BEAST!!”.

This is our simple control box for “THE BEAST!!”.

This is a left side view of “THE BEAST!!” in its completed state.

“THE BEAST’s!!” Vital Statistics

Mass and Weight of “THE BEAST!!”

Dry Mass	5.68Kg
Wet Mass	1.79 Kg
Dry Weight	55.67 N
Wet Weight	19.5 N

“THE BEAST!!” Time Trials (4.3meters)

Trial #	1	2	3	4	5	Average	Speed
Time (s)	12.0	11.5	12.3	11.3	10.7	11.6	.37 m/s

Power of “THE BEAST!!” (Newtons)

Motor	Right	Left	Both
Forward	9N	10N	22N*
Reverse	4N	4.5N	9N
Vertical	9N (peak power)	5 N(sustained)	

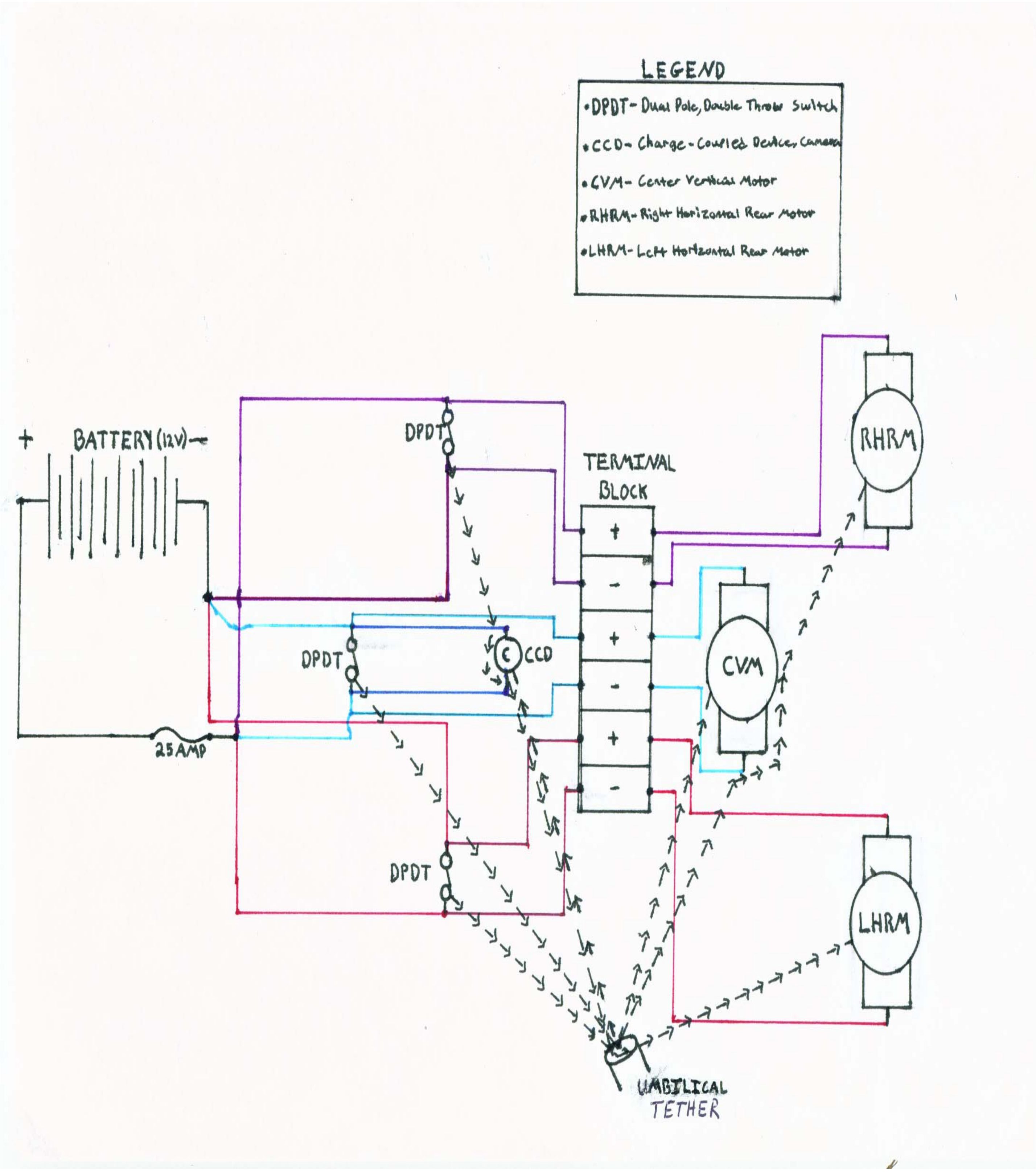
*this measurement is an estimate due to the limits of our spring scale

Budget/Expense Sheet

School Name:	Paradise High School	From: 1/17/05
ROV Name:	THE BEAST!!	
Instructor/Sponsor:	Chris Jensen and Kim Jones	To: 4/12/05

Date	Funds Deposit or Expense	Description	Amount	Balance
1/17/05	Deposit	Donation From Paradise Dive Center	$ 25.00	$ 25.00
2/5/05	Deposit	Donation From M.A.T.E.	$ 100.00	$ 125.00
2/2/05	Expense	Camera from M.A.T.E.	$ 15.00	$ 110.00
2/8/05	Expense	Bilge Pumps from iboats.com	$ 45.45	$ 64.55
2/14/05	Expense	PVC 1/2 inch pipe and 1/2 inch fittings from Ace	$ 10.79	$ 53.76
2/25/05	Expense	PVC and hardware from Ace	$ 3.75	$ 50.01
2/26/05	Expense	Epoxy (Saturday build day) from Ace	$ 1.91	$ 48.10
2/26/05	Expense	PVC Pipe (Saturday build day) from Ace	$ 2.36	$ 45.74
2/26/05	Expense	PVC Pipe and hardware (Saturday build day) from A(	$ 2.96	$ 42.78
3/7/05	Expense	120 Feet of Speaker wire from Ace	$ 7.72	$ 35.06
3/14/05	Expense	Motor mounts from Ace	$ 4.68	$ 30.38
3/28/05	Expense	PVC from Ace	$ 4.54	$ 25.84
3/30/05	Expense	PVC and wax ring from Ace	$ 5.03	$ 20.81
3/31/05	Expense	Props from RC Hobbies	$ 13.20	$ 8.17
4/2/05	Expense	safety hook from Ace	$ 2.03	$ 6.14
4/5/05	Expense	Zip ties and PVC from Ace	$ 5.71	$ 0.43
4/5/05	Expense	Hardware From Ace	$ 0.48	$ (0.05)
4/7/05	Expense	Hardware and fuse from Ace	$ 2.03	$ (2.08)
4/8/05	Expense	Tape from Ace	$ 1.29	$ (3.37)
4/12/05	Expense	Hardware from Ace	$ 0.90	$ (4.27)
			Total Budget Left =	$-4.27
			Total Spent =	$129.27

“THE BEAST!!” Electrical Schematic



Design Rationale

In designing our ROV, we started by looking at the mission tasks and designed our vehicle with these specifics in mind. We wanted our robot to have enough power to get to and from our missions quickly, so we used three powerful bilge pumps(450gph). We put two of the motors on the back in order to control the turning, forward, and reverse thrust. The third motor was a vertical motor to allowed our vehicle to descend under water and also ascend to the surface. We used our knowledge of building RC cars and construction skills to build the skeleton of the ROV. We used hydro and aerodynamic information to make the ROV stable and move easily through the water. I watched "NASCAR Wind Tunnel" to get some ideas of how to build our ROV to move swiftly and stable. I brought these ideas back to our team. We knew that the ballast needed to be strictly on top of the ROV and the weight had to be towards the bottom and centered to maximize stability. It worked out, that where we placed our motors and camera we didn't need to change their placement in order to achieve our desired results. Our ballast is made out of 1 1⁄4" (3cm) PVC. We first tried 3"(8cm) PVC, which wouldn't allow our ROV to sink with even 1.344kg of weight.

We should have calculated the volume of all the pieces on our ROV by water displacement at the very beginning of the building process. That way we could figure out what size ballast to use, to make our ROV slightly positively buoyant. We would have used the weight (in Newtons) of the ROV and the buoyant force of water to figure out what size ballast we needed. Instead, we used trial and error and came up with 1 1⁄4" (3cm) PVC. When we were writing our technical report we decided that we needed a scientific way of calculating the right size ballast. We spent a lot of time trying to find the volume using Archimedes's principle, which states that any fluid applies a buoyant force to an object that is partially or completely immersed in it; the magnitude of the buoyant force equals the weight of the fluid that the object displaces. The equations we used were: $Weight_{ROV}$= $(density_{ROV})(volume_{ROV})(gravity)$. Then determine the Buoyant $Force_{max}$ of water which would be F_{max}= $(density_{H2O})(volume_{ROV})(gravity)$. Then using these force calculations, we could have found the amount of our cylindrical ballast using the formula $V=\pi r^2 h$.

Our motors are 450 gph bilge pumps that we modified by removing the impellers, adding shafts and adapting propellers. We took the strainer off and adapted the shafts to achieve maximum performance, which is a forward force of 9.5 Newtons, a reverse force of 4.5 Newtons, and a downward force of 9 Newtons.

We potted our camera and put it on the front of a piece of PVC cut in half so we could move it around. We needed our camera to be adjustable because we had attachments for our payload that would change our field of vision and we wanted to be able to see the end of the payload. We screwed together every PVC connection, rather than gluing so everything would be modular. This allowed us to easily make efficient changes as needed. In some places, we used glue for spots we didn't want to move at all. We zip tied the wires to our robot in places where they wouldn't cause drag or get in the way of the propellers. We also zip tied our ballast to our robot. We took 2 1⁄2" (6 cm) PVC and cut it in half to make a push bar to cap the oil well. We figured the push bar wouldn't slip off of the valve very easily. We used a hook on the end of our payload to drop the probe. The hook has a spring loaded, flexible latch, that would allow us to drop the probe in the tube and back away simultaneously releasing the probe.

Description of Challenge

While we faced many obstacles, one of the major ones was the issue of buoyancy. Although troublesome, this obstacle was overcome due to rational thinking, perseverance, and much trial and error.

Our main issue while building the ROV was buoyancy. The first issue we encountered was being positively buoyant. This is a major issue because we need to be able to submerge our ROV to even try and complete the tasks that we were given. To try and solve this problem, we simply replaced our ballast with a ballast made of smaller PVC pipe. This then created another problem.

Our problem became that our ROV was negatively buoyant. In order for us to complete the mission tasks, not only did we have to be able to submerge the ROV, but we also had to retrieve it. Since our ROV was negatively buoyant, it would not reach the surface, even with the help of the propellers. Finally, after much trial and error, we were successful; our ROV was neutrally buoyant.

While we have briefly explained how we overcame this obstacle, we shall explain more detail about this and the several other challenges we faced in this next section.

Explanation of Troubleshooting Techniques

Our first big problem our team faced was the fact that we did not communicate very well. We started planning in late November not really knowing what we were doing. We all had different ideas and we were not sharing them. We were basically working as individuals on the same project. We soon found this got us nowhere and decided that we needed to start setting dates to consistently meet as a group and make deadlines for different stages of the designing and building process. This was even still difficult because each of us had different schedules. Everyone on our team had after school programs on different days that obligated them to take time away from working on the ROV.

Another problem we faced was that three of our teammates were not showing up to the meetings and helping with the project. Though it was not a problem with the ROV, it still needed to be fixed. Our team captain, Ryan Randar, decided that the four of us that were showing up to the meetings consistently should discuss the situation. During that meeting, it was decided that we would talk to the teammates who were not showing up and tell them what we expected of them. During that discussion, they decided to not continue the project.

Surprisingly, we didn't have many complications while building and driving our ROV. We tried to think of every possible obstacle we would face and the best way to accommodate those obstacles before moving forward. We stressed making sure that our ROV was extremely stable and maneuverable, and spent a few days figuring out how we wanted to go about doing it. We think that the time we took to plan, share our different ideas, and combine them to design what we thought was best, helped lower our need for troubleshooting.

One problem we did face, though, was our ballast was too big. We used 3" (7.62 cm) PVC pipe to make our ballast. This was sealed so no water could get in, but it wouldn't let the ROV sink. We even put four pounds on it. With the four pounds and the help of the engine, we still couldn't get the ROV to sink. We decided that the ballast had to be smaller, so we went to the hardware store and bought 3⁄4" (1.91 cm), 1" (2.54 cm), and 1 1⁄2" (3.81 cm) pipe and made three new ballasts. The 1.91 cm and 2.54 cm was too small and the 3.81 cm was too big. When we found out that we still didn't have the right sized ballast we decided to put the 1.91 cm and 2.54 cm ballasts on at the same time. This was almost perfect, but we didn't want two separate ballasts. Because we didn't want two separate ballasts, we calculated the volume of each separate ballast and added them together. Then we calculated different sizes of pipe and found that 1 1⁄4" (3.18 cm) pipe was almost the same volume as the combined 1.91 cm and 2.54 cm pipe.

Some non-building issues we encountered during this procedure were beyond our control. The wire that we bought was measured incorrectly at the hardware store, which caused a holdup in our building since our wire had to be continuous in length. We had to go back and figure out how much wire needed to be exchanged. This was a minor problem, but an important lesson of our process. It showed us that we have to be careful when buying supplies and we should always check to make sure that we are getting what we need.

Even though our troubleshooting techniques were simple, they were all we needed. We didn't face any real major problems in design, therefore we didn't have to get complicated in solving a problem. Most of our problem solving was done by trial and error. We all feel that, in the end, our project went pretty smooth. We learned that if we had initially applied physics to planning our design, we could have reduced the amount of structural/buoyancy issues. With the little experience we now have in our pockets, we are now aware of the importance of teamwork, communication, and careful planning.

Lesson learned/skills gained:

We learned that to get the robot built, we all have to show up consistently and work on it together. A lot of us have other activities and it is hard to get together. Working on this robot taught us more about buoyancy. We learned that all our weight needed to be on the bottom and the ballast had to be on top. We learned some more about electronics and applied it in a different area. We anticipated having to modify our structure, so our modular design made our construction time more efficient. We learned to take measurements and plan ahead before we start building. This would have helped us tremendously when it came to writing this report.

Discussion of Future Improvements

Overall, we are fairly satisfied with the design of our ROV. It seems to be stable and it is easy to maneuver in the water. Even though winning the regional competition in Monterey gave us confidence in our ROV, we found changes we needed to make to improve the function and safety of our robot, "The Beast." Most of the changes are minor, with the exemption of one major change to make on the ROV.

The minor changes that we have in mind are a variety of safety features. Reviewing the judges' evaluations from the Monterey Regional competition, we became aware that we needed to address some safety issues. Our plan is to go through the evaluation score sheet and try to fix all the problems where we received low scores. Again, most of these are minor adjustments to the ROV that require only a little engineering.

During the evaluation at the regional competition, the judges said they would like to see safety shrouds and warning labels for the props on the motors and any sharp edges on the ROV that could be harmful to the divers in the pool. We are going to address this issue by adding safety shrouds and warning labels for the props. We are also planning to either add warning labels for the sharp edges of the zip ties or cover up the sharp edges with foam or tape.

When we were almost finished building our ROV, we came up with the idea to put a motor that runs laterally to give us extra maneuverability, but we decided that it would be too complicated for the amount of time we had left to complete and test the ROV before the regionals. The idea of the lateral motor was to create a way of moving from side to side without having to back up and turn, like backing up a car. We had already tested the ROV, and the idea came during that time.

We constructed simulations of the actual mission tasks for practice before the competition. While practicing these tasks, we noticed that we had to do a lot of backing up and repositioning each time we overshot our target. This caused a problem because it made our completion times significantly slower. The hardest mission for us was installing the new instrument module on the Hubble space telescope, which is why we wanted to install the lateral motor. When practicing this mission, we were frequently off center on either side of the Velcro patch. It was extremely hard to try and reposition the ROV and hit dead center with the instrument module. If we had the help of the lateral motor, we could easily move it to the side and stay the same distance away from the intended target.

Because we ended up not putting the extra motor on the ROV and we had a need for it at the regional competition, we are now going to take the time to install this extra motor on the ROV. Our team thinks that this major change will be a big improvement for the ROV, and that it will help us quicken our competition times, be more efficient, and have no safety concerns.

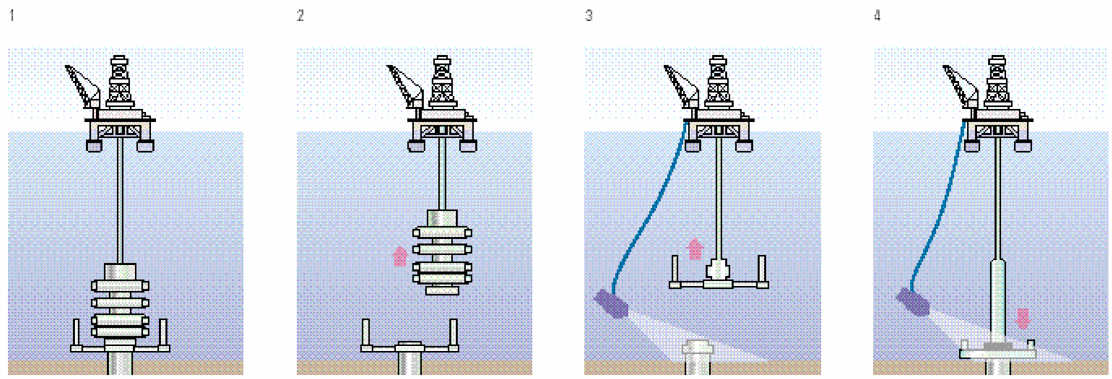
Description of a Career, Organization, or Technology That Supports One of the Mission Themes

Remotely Operated Vehicles, ROV's, are used in a wide variety of tasks in the offshore oil industry. One of our tasks is capping of an oil well. In this task we are instructed to operate our ROV underwater and search for an oil well. After we find the oil well that is no longer producing enough oil, we need to shut it off by closing a valve.

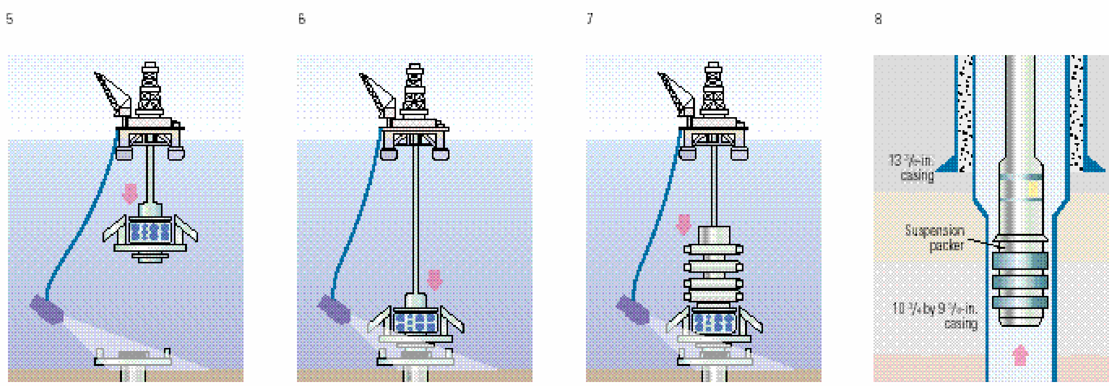
There are many benefits to using ROV for this type of task. One reason is that ROV's can use hydraulic power, and are therefore, stronger than human strength. This allows the ROV to be a more competent device to shut off the valve. Another reason it is beneficial to use a ROV is that they are able to operate under increased pressures. This is necessary in dealing with the ocean's depth. The deeper you go in the water column the more pressure is exerted on the object. People are not able to go down as far without being crushed, unlike ROV's which are made to handle the pressure exerted on its structure.

These are other dangers that are a concern when deciding to send a ROV or a human underwater to complete a task. One danger is a human is not as capable of carrying as much sensory info (i.e. cameras, lights, ect.). ROV's allow the pilot to sense what is around the entire vehicle. Visually humans do not have the same amount of freedom as a ROV would have. Humans are limited in how long they can remain at certain depths. ROV's can also have up to a 360 degree range of "vision" where a diver has around 90 to 180 degrees of vision at all times. These are just a few ways ROV's are more practical than humans in regards to underwater missions.

A company that currently uses ROV technology is Texaco. This company uses ROV's to make sure that their oil wells are in good condition (See diagram below). It uses ROV's instead of humans is because of the extreme weather conditions. The ROV's for this particular assignment is designed to be able to disconnect from the oil well if the conditions of the sea and the weather become too rough. They have proven time and time again that this is more effective than trying to send a diver to complete their needed task.



Subsea completion sequence. 1. Complete drilling and install the suspension packer. 2. Retrieve the drilling riser and BOP stack, move rig off. 3. Retrieve drilling guidebase with ROV assistance. 4. Run the production flow base and latch on 30-in. wellhead housing.



5. Run subsea horizontal tree. 6. Land the tree, lock connector, test seals and function valves with ROV. Establish guidewires and release tree-running tool. 7. Run BOP stack onto horizontal tree, lock connector, run BOP test tool and test, function-test tree. 8. Retrieve suspension packer, remove wearbushing from tree, make up SenTREE7 system, rack back.

Graphics illustrate how Texaco establishes connections to oil wells in the Gulf of Mexico.

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