Galveston Ball High School

Underwater Robotics Team

Mate ROV 2005

Technical Report

Team Members:

Evan Segal
Androv Petrov
Ben Weber
Rebbecca Unbana
Long Lee
John Prater

Mentor:

Pete Doak, CET
Associate Professor; College of the Mainland

Abstract

The Mate 2005 ROV consists of two basic assemblies.

Primary Assembly

The primary assembly makes up a versatile, reusable, underwater ROV that can serve any type of mission within it's design specification. This assembly is less than 60 cm square, and includes an on board electrical system with power supplied from topside, an on board self contained air system, and a fully functioning ballast system.

The on board electrical system consists of three parts.

- Propulsion System, consisting of six NEMA 23 stepper motors, each capable of independent control.
- Control System, consisting of an MC68HC11 Micro controller, I/O amplifier board, computer controlled air manifold, lighting system and video system.
- Video System, consisting of up to three water proof video cameras located in such a manner as to allow the operator of the ROV to successfully complete the mission.

The on board air system consists of two 226 CC liquid CO^2 flasks, an on board pressure regulator and volume tank. This system supplies 6.33 kgf/cm2 to the solenoid valve air manifold, the drive motor seals, and the payload.

Ballast System, consists of two fully functioning ballast tanks that are capable of taking the ROV from the surface down to a maximum depth of 15 Meters. The amount of water in these tanks is controlled through the Micro controller and solenoid air valves.

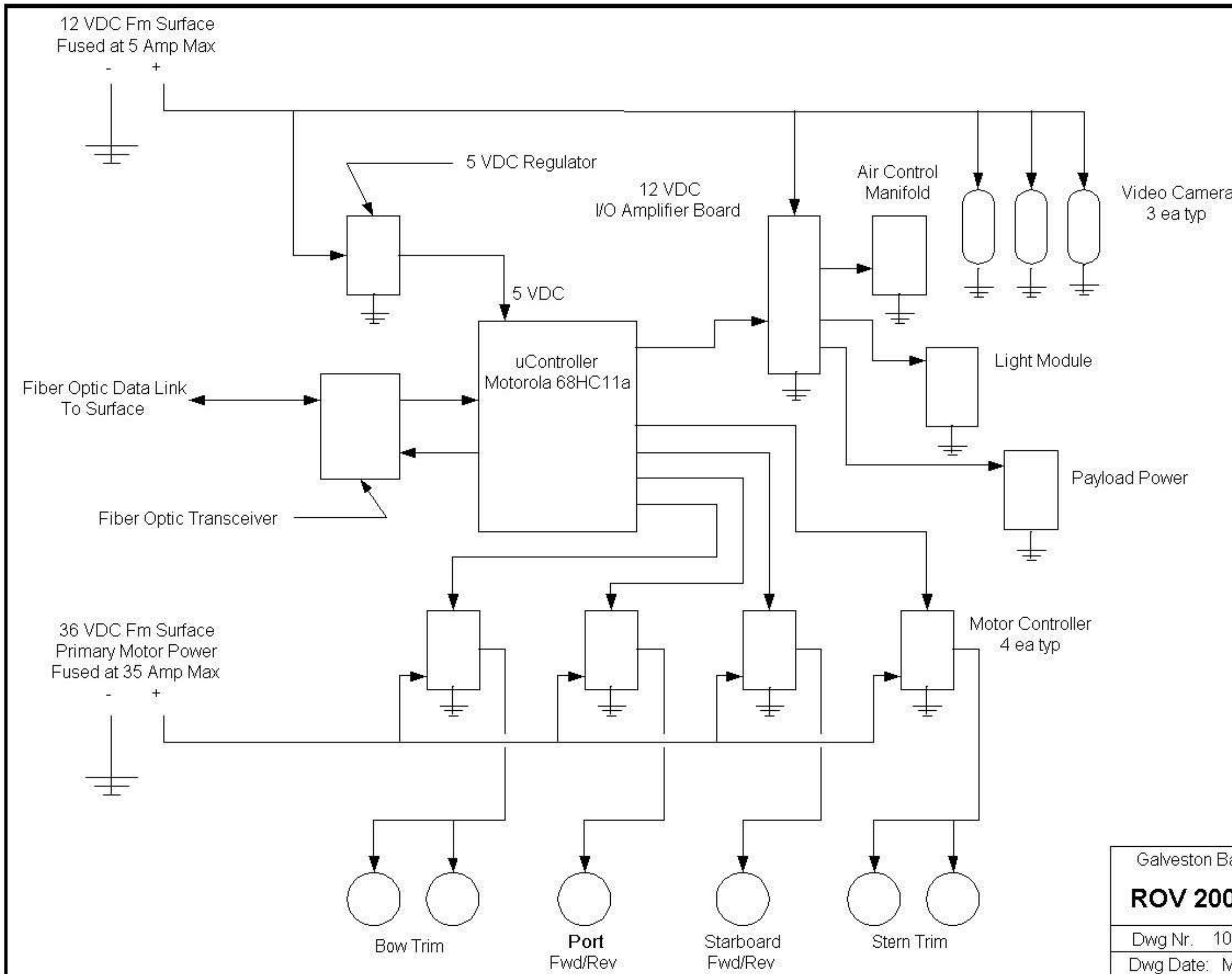
Payload Assembly

The payload assembly is to be designed to meet the requirements of the mission. It is intended to be an interchangeable attachment that is mounted on hard points on the Primary Assembly.

Budget/Expense Sheet

The goal of the Mate ROV 2005 Team this year was to construct the ROV for under $2,500.00. In order to do this the team would need to make use of components from the previous ROV entries.

		Bgt Amt	Actual Cost	
Starting Budget		$2,500.00		
The ROV is divided into major subassemblies				
Primary Hull and Structure		$500.00		
	20.3 cm PVC Pipe		Donated	
	10.2 cm PVC Pipe		$20.00	
	Small PVC Pipe and Fittings		$100.00	
	Plexiglass		$100.00	
	Cement and other misc materials		$50.00	
	Sub Total		$270.00	
Electrical System Components		$200.00		
	Primary on board control system		From Previous ROV	
	Topside control system computer		Donated	
	Topside joystick control		$30.00	
	Primary power supply batteries		Donated	
	Misc connectors and hookup components		$90.00	
	Sub Total		$120.00	
Propulsion System Components		$1,000.00		
	Stepper motor controllers		$280.00	
	Drive Motors		$720.00	
	Water Tight Seals		Donated	
	Machine work for Seals		Donated	
	Misc drive system components		$50.00	
	Sub Total		$1,050.00	
Ballast System Components		$300.00		
	Co2 Air Flasks		$40.00	
	High Pressure Fittings		$60.00	
	Regulator		$70.00	
	Air Control Valve		$50.00	
	High Pressure Ball Valves		$50.00	
	Misc components and fittings		$100.00	
	Sub Total		$370.00	
Tether		$500.00		
	Fiber Optic Cable		Donated	
	Fiber Optic Connectors and Assembly		Donated	
	Video Cables		Donated	
	Primary Power Cable		$75.00	
	Sub Total		$75.00	
	Total Cost			$1,885.00

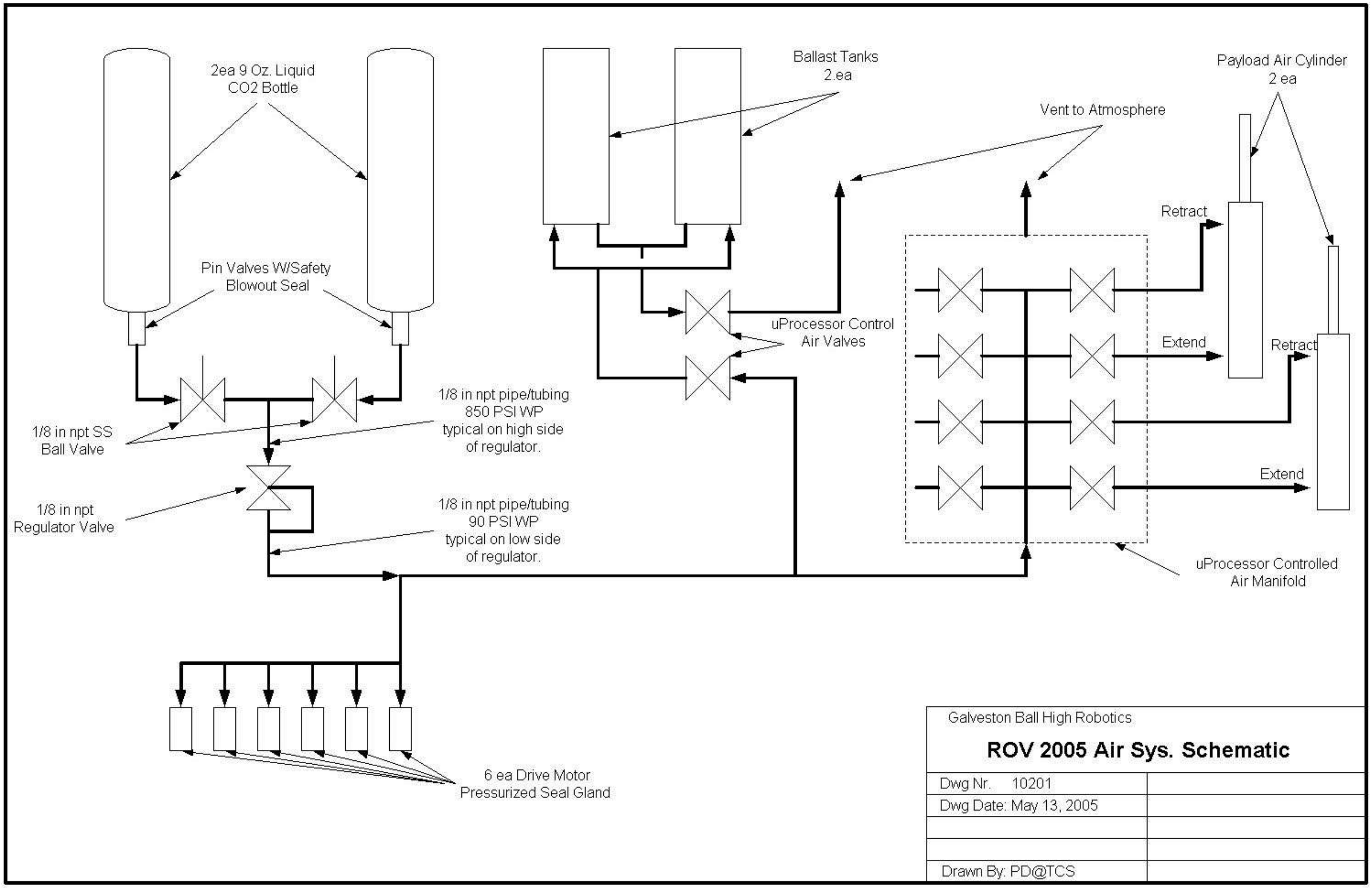


Note: Maximum current available from surface is to be no more than 40 Amps. This includes 35 Amps for primary drive motor circuit and 5 Amps for control circuit

Galveston Ball High Robotics

ROV 2005 Power Schematic

Dwg Nr. 10301	
Dwg Date: May 16, 2005	
Drawn By: pd@TCS	


2ea 9 Oz. Liquid
CO2 Bottle
Pin Valves W/Safety
Blowout Seal
1/8 in npt SS
Ball Valve
1/8 in npt
Regulator Valve
1/8 in npt pipe/tubing
850 PSI WP
typical on high side
of regulator.
1/8 in npt pipe/tubing
90 PSI WP
typical on low side
of regulator.
6 ea Drive Motor
Pressurized Seal Gland
Ballast Tanks
2.ea
uProcessor Control
Air Valves
Vent to Atmosphere
Payload Air Cylinder
2 ea
Retract
Extend
Retract
Extend
uProcessor Controlled
Air Manifold
Galveston Ball High Robotics
ROV 2005 Air Sys. Schematic
Dwg Nr. 10201
Dwg Date: May 13, 2005
Drawn By: PD@TCS

Design Rational

The Galveston Ball High Underwater Robotics Team has competed in the MATE competition for the past three years. Each year a new ROV was developed from the very beginning. This year it was decided to build a primary vessel that could be recycled for a new mission, with no major changes, and very few minor changes. In order to accomplish this goal the ROV was designed from the start with the concept of a Primary Vessel that could be recycled each mission, and an easily fabricated Payload Assembly that could be changed out at the end of the mission.

Based on past experience the Primary Vessel design had to meet the following requirements.

- Power Efficiency: The Primary Vessel should return the maximum control and freedom of operation for a very small investment in power. To attain this a decision was made to replace the normal DC motors with high efficiency Burshless Stepper Motors.
- Small Overall Size: The Primary Vessel design should be as compact as possible, to allow maximum maneuverability while consuming a small amount of power.
- Small Tether: In order to provide the maximum maneuverability desired, the tether needed to be as small as possible. It was decided to use fiber optic cable for the communications link, 12 Ga superflex wire for the Primary Power Supply, and small coaxial cables for the video link. In addition, it was decided that the primary tether should be complete detachable when out of the water.
- Self Contained Air Supply: In order to incorporate as small a tether as possible, and at the same time have an on board air supply, it was decided to make the air supply self contained. This was accomplished by using Liquid Co2 storage flasks. The amount of Co2 required for completing the mission had to be calculated and suitable storage containers and high pressure piping designed into the system.

The Payload Assembly has to be designed to meet the requirements of the mission, and at the same time be small enough to attach to the hard points on the Primary Vessel, and inexpensive enough to be removed after the mission. In order to accomplish this the Payload Assembly has to include the following.

- To accomplish the mission goals, a small extendable claw was designed, which is operated by a pneumatic cylinder. This will be used to grasp various items at different parts of the mission.
- An on board pump, electrically driven and controlled through the on board Micro controller is included for liquid sample gathering.
- A thermocouple system is designed into the payload to measure temperatures.
- The Payload Assembly will include a small basket to be used for returning samples to the top.

Design Challenge

One of the challenges the development team faced was to determine what volume of liquid Co2 would be required to enable the ROV to perform a successful mission. The problems involved in solving this type of problem became apparent early on, when it was noted that liquid Co2 is measured by weight, and the ballast tank and air cylinder capacities are measured in volume.

These problems were then compounded when it was noted that the volume of a gas changes with temperature, and pressure. These factors, when added together, amounted to a challenge that was not easily overcome.

Solving the Challenge

The first step in solving the problem was to find a common factor about Co2 that does not change. Research showed that the one common factor of Co2 that does not change was it's mass. Regardless of the temperature or pressure, the weight of Co2 remains constant.

It was then necessary to develop standards that could be applied to calculations. Because the maximum depth of the ROV is stated as 15 meters, the pressure of the water at this depth is used as the standard pressure. Because the ROV is to operate in water, a temperature of 23 C is used as the standard temperature. The function of the air system that will require the most air is emptying the water from the ballast tanks. The team decided that on a typical mission the ballast tanks may have to be completely filled and emptied no more than 6 times. This became our standard requirement for the volume of the air supply.

Research on the Internet returned an equation, verifiable by proven facts, that allowed us to calculate the equivalent volume of Co2 at a temperature of 23 C and a pressure of one atmosphere, that was the equivalent of one ounce of liquid Co2. This measurement was easily converted to grams. Further research developed the necessary information which allowed us to change the pressure to reflect our desired pressure, and the temperature to reflect our desired temperature.

Once this was accomplished it was simply a matter of calculating the volume of the ballast tanks and the number of times required to fill and empty them. We then added a 50% safety factor to this figure and sized our air supply to meet that requirement.

Lesson Learned

Solving this challenge required a great deal of effort on the part of all individuals involved. At first a problem of this scope seemed beyond the capability of the team. While most of the team members had taken the necessary curses in Science and Math to understand the concepts that were being discussed, all but one were completely lost at how to apply these concepts to solving real world problems.

The team learned that by breaking a problem down into simple steps, and applying known facts to each step, almost any real world problem can be resolved. The team also learned not to be afraid to ask for help, and how to find reliable, verifiable, help on the Internet.

Future Improvements

The primary area of development for the future is in the area of the Payload Assembly. There is a large degree of research, design and development that remains to be done. Some of these include:

- The development and assembly of a better grasping device. While the device we are currently employing will get the job done, it is far from complete.
- A better system of measuring temperature. There needs to be an adjustable module that can be calibrated to reflect changes in the environment to make this device more accurate.
- A method of measuring the depth at which the ROV is. This is a very important factor, and is probably going to be a very difficult one to solve.
- Control and propulsion system modifications. Having the correct drive motors is the first step in this process. There are some areas that are open for possible changes, including the addition of variable pitch propellers.

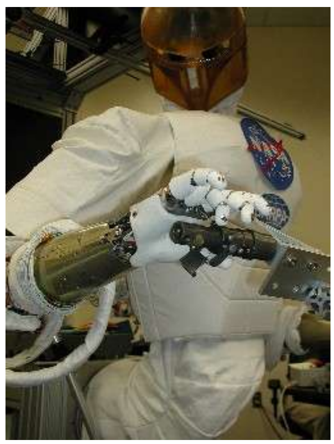
These are the primary target areas that we are looking forward to changing in the future. These are very possible initiatives now that we have a Primary Assembly that we will not have to reconstruct each year.

NASA JSC and Oceaneering Inc.

Working together developing careers in Exploring the Unknown

Living within 40 miles of NASA' Johnson Space Center has for years sparked an above normal interest in exploring the unknown. Simply because it is so close there exists an above normal interest in the exploring the unknowns of space.

Currently the Robot Systems Technology Branch at JSC is developing a project that will “help humans work and explore in space. Working side by side with humans, or going where the risks are too great for people, machines like Robonaut will expand our ability for construction and discovery.” The ideal product of their efforts is a truly remarkable ROV that is designed to be used for EVA while at the same time being controlled by a human through several types of mechanical control devices.



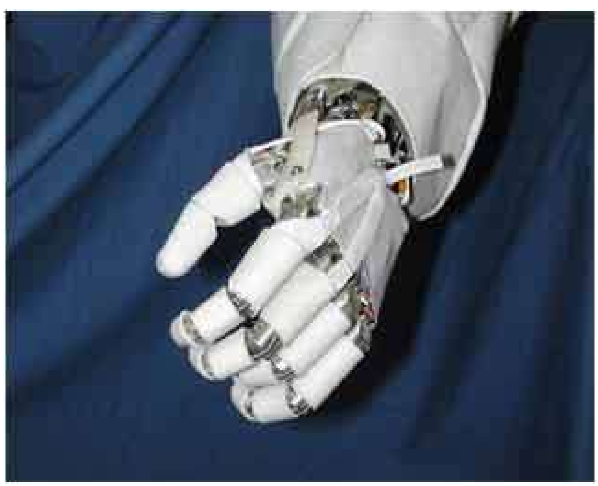
NASA JSC Robonaut

Contrast this with living 40 miles from Houston, Texas with it's ever expanding energy industry and you may feel you are at the place where exploring the last two unknowns, deep space and the deep oceans, has real meaning. While NASA, through such far reaching projects as the Robonaut, continues to move forward in ROV development for space, and space missions, the ever growing Oil Industry is developing just as rapidly in devices for exploring the deep oceans.

Putting these two dynamic forces together leads to the possibility of an ever increasing demand for careers in ROV development, production, and operation. One company that has led the field in this area is Houston based Oceaneering Inc. Through development and implementation of an entire family of ROV's Oceaneering has led the way in proving the versatility and reliability of the ROV in the Offshore Oil Industry.

The Magnum 3 ROV

While Oceaneering has as it's main focus the use of ROV's for the Undersea Oil Industry, that is not their only venture. Further investigation will lead to the discovery that this company also is involved in space research, and is jointly working with JSC in developing ROV's and Robotics Equipment designed to be used in space. One such example is the “OM3” project, otherwise known as “Robonaut”.



The Robonaut Hand

While “The OM3™ can be controlled via spaceball, joystick, or RS-232 computer commands” this package is also packed with advantages and features that are designed to “position tools better than the most skilled human hand”.

It is research and development such as this that keeps this company, and others in the Greater Houston Area on the very cutting edge of this new developing technology. This is where the careers are growing, now and in the future.

Indeed, this is where the two last unknowns are being explored.

Sources:

http://robonaut.jsc.nasa.gov/
http://www.oceaneering.com/oilfield/rov/oilfield_magnumrov.htm
http://www.oceaneering.com/adtech/space/adtech_space_robonaut.htm

Acknowledgements

The MATE ROV 2005 Team wishes acknowledge the following companies and individuals for their help and support.

Kalsi Engineering, Inc
745 Park Two Drive
Sugar Land, TX 77478-2885

College of the Mainland
1200 Amburn Road
Texas City, TX 77591

Texas A&M University at Galveston
P.O Box 1675
Galveston, TX 77553

Technical Consultants Service
702 19th Ave N
Texas City, TX 77590

Reynolds Advanced Materials
2001 Karbach
Suite 5
Houston, TX 77092

Wilkinson Supply Co.
P.O. Box 2457
Texas City, TX 77590

TNT Paintball Shack
1836 Algoa Friendswood Rd.
Alvin, Texas 77511

Kim Page
Friendswood, Texas

John Gerami
La Marque, TX