Team Monterey Peninsula College in partnership with the
Marine Science and Technology Department Presents:

Soylent Yellow

A Remote Operated Under Water Vehicle

Made primarily of other ROVs

Built and operated by:

Bernard Roth, Student of MPC majoring in University Studies

Monica Blaha, Student of MPC majoring in University Studies

Khrysta Moe, Student of MPC majoring in Marine Technologies

Joe Buffo, Student of MPC and Electronics Field Technician

David Gesinger, Student of MPC majoring in University Studies

With Instruction and support from:

Tad Masek, Adjunct Instructor at MPC

Thomas Rebold, Engineering Instructor at MPC

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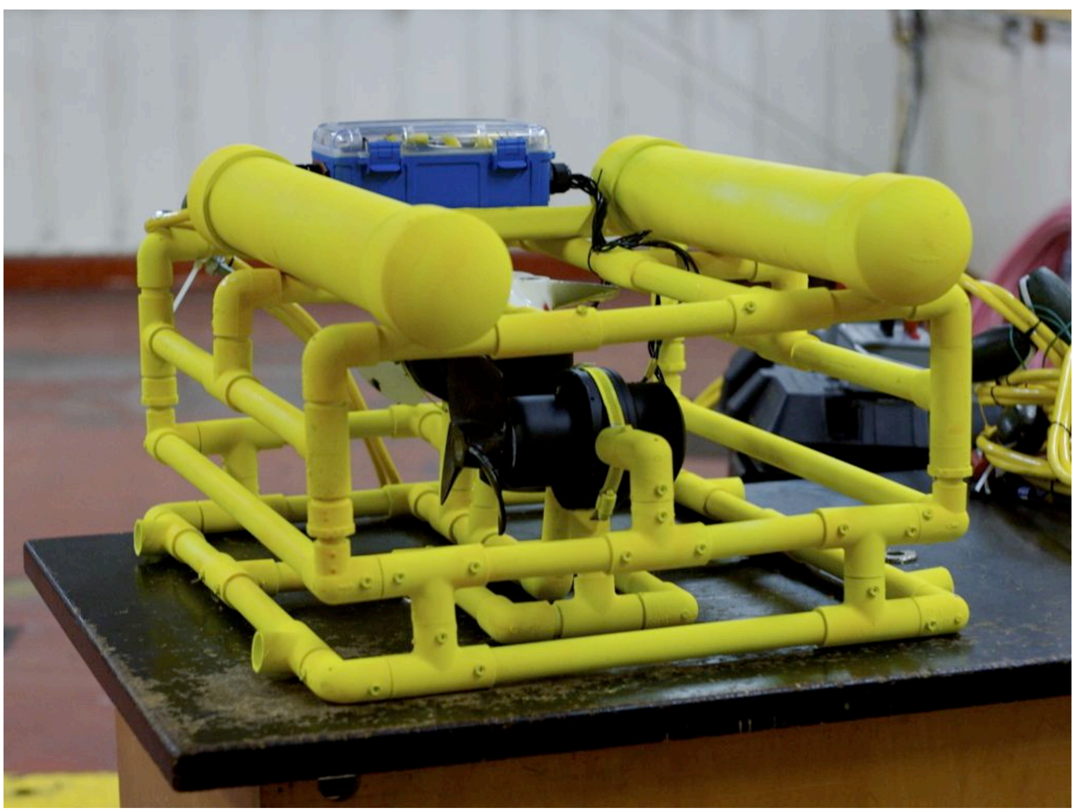
Abstract:

Soylent Yellow is a remotely operated vehicle (ROV) designed and built by Team Monterey Peninsula College (MPC) in conjunction with the Marine Science and Technology department of MPC. Much like the movie which inspired the name, the ROV is composed largely of other discarded underwater devices.

The objective of the team was to build an ROV which would qualify for competition, compete, and win the June 23-25 2006 MATE Center/MST ROV Committee ROV Competition in the Explorer Class. Additional goals for the team included: limiting the input from our instructor, keeping expenses to a minimum, allowing every team member the opportunity to learn something new, while taking advantage of their individual talents.

Team MPC was charged with creating an ROV that would be able to take a science node from the surface to a frame on the bottom of the pool. Other tasks required the ROV to be able to open containers with handles, and to pick up and "plug in" two cables. Immediately, the team got to work discussing possible designs. Several variables had to be taken into account before any building could be done. Restrictions, such as a minimal budget, available parts, scheduling, and the individual skills each member was able to offer, were all limiting factors. The decision to keep the structure simple while still being able to perform the multiple tasks was unanimous. Team members made a simple, cost-effective ROV. The following is the evolved design process of Soylent Yellow.



Budget:

ROV Expenses 2006

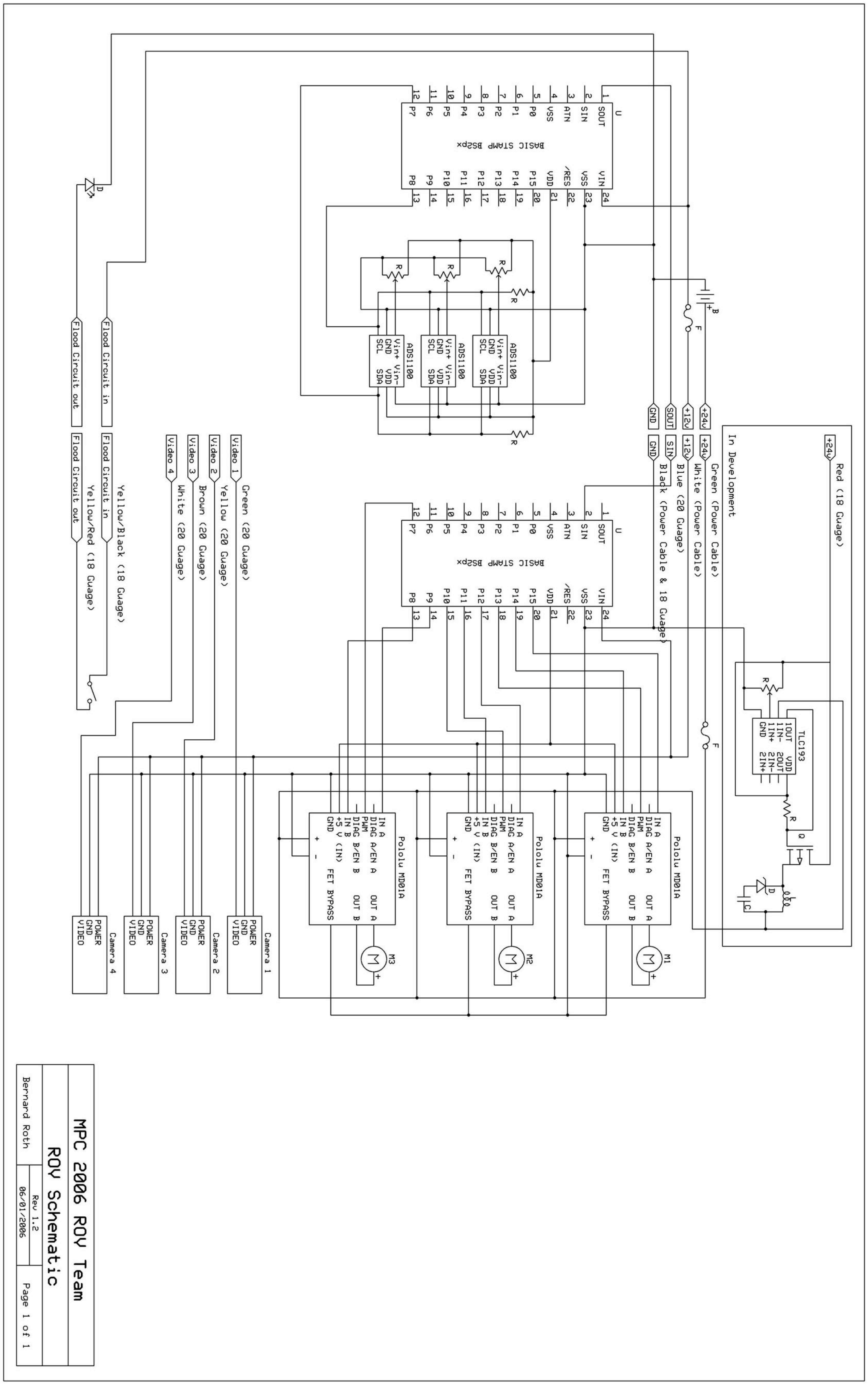
Date	expense type	costs	total funds
			$1,827.16
2-Feb-06	**Structure**	$ 17.21	$ 1,809.95
3-Feb-06	**Structure**	$ 22.50	$ 1,787.45
4-Feb-06	**Structure**	$ 10.69	$ 1,776.76
5-Feb-06	**Mock test devices**	$ 31.86	$ 1,744.90
6-Feb-06	**Structure**	$ 9.77	$ 1,735.13
7-Feb-06	**Cameras**	$ 5.58	$ 1,729.55
8-Feb-06	**Structure**	$ 21.17	$ 1,750.72
9-Feb-06	**Structure**	$ 10.72	$ 1,740.00
10-Feb-06	**H-Bridge**	$ 89.85	$ 1,650.15
11-Feb-06	**Tether**	$ 11.63	$ 1,638.52
12-Feb-06	**Cameras**	$ 22.49	$ 1,616.03
13-Feb-06	**Cameras**	$ 1.08	$ 1,614.95
14-Feb-06	**Tether**	$ 52.66	$ 1,562.29
15-Feb-06	**Buoyancy**	$ 39.33	$ 1,522.96
16-Feb-06	**Buoyancy**	$ 16.31	$ 1,506.65
11-May-06	**Cameras**	$ 13.89	$ 1,492.76
12-May-06	**Cameras**	$ 3.21	$ 1,489.55
13-May-06	**Cameras**	$ 0.74	$ 1,488.81
14-May-06	**Cameras**	$ 2.45	$ 1,486.36
15-May-06	**Cameras**	$ 15.98	$ 1,470.38
16-May-06	**Cameras**	$ 5.58	$ 1,464.80
17-May-06	**Cameras**	$ 14.16	$ 1,450.64
18-May-06	**Cameras**	$ 61.97	$ 1,388.67
19-May-06	**Cameras**	$ 18.73	$ 1,369.94
20-May-06	**Structure**	$ 28.02	$ 1,341.92
21-May-06	**Tether**	$ 23.14	$ 1,318.78
22-May-06	**Cameras**	$ 2.54	$ 1,316.24

Total costs for elements of the ROV

H-Bridge	$ 89.85
Structure	$ 77.74
Cameras	$168.40
Tether	$ 87.43
Mock test devices	$ 31.86
Buoyancy	$ 56.24
Total	$511.52

Monterey Peninsula College 2006 Explorer Class Remote Operated Vehicle

Soylent Yellow



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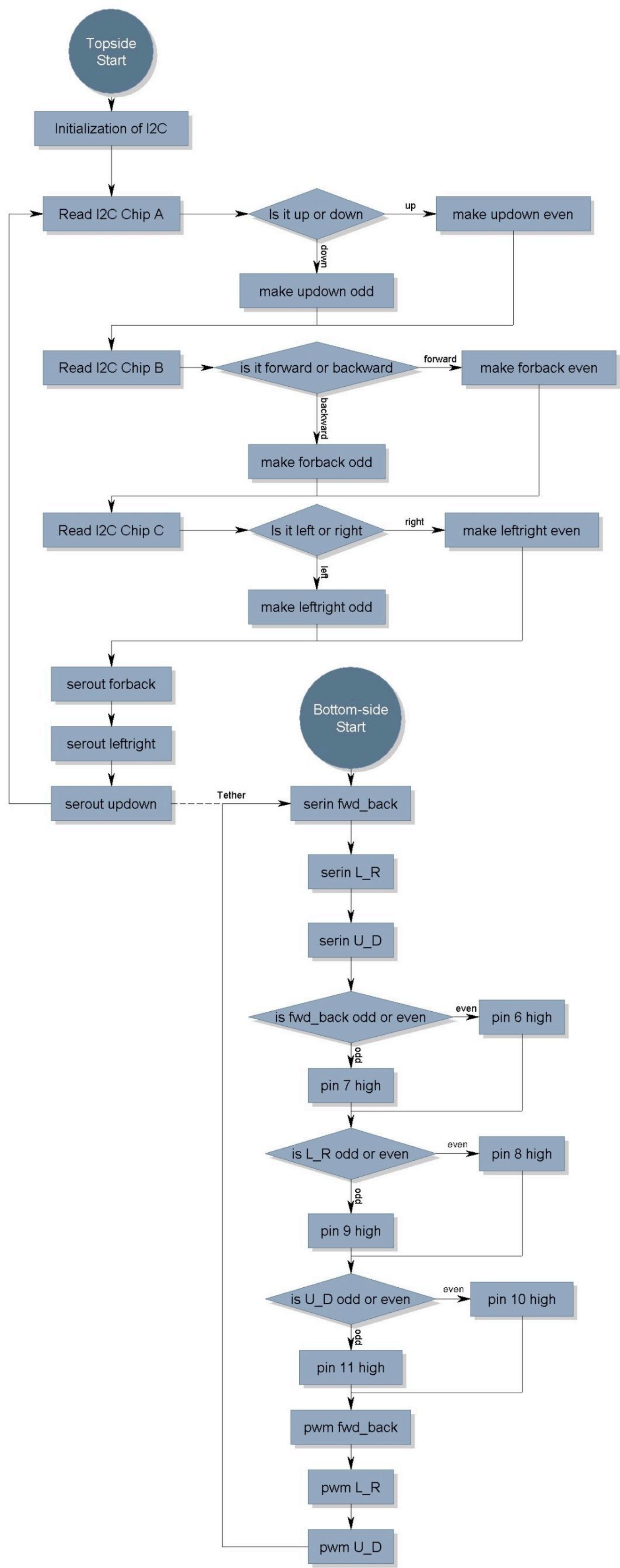

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Design Rationale:

During the first two weeks of the course the team reviewed the rules and limitations of competition and decided to make simulated test devices to visualize challenges and develop a strategy of how to do the mission. The team took an inventory of existing parts not being used from a “junk pile” of parts discarded from other classes. The team also discussed their individual talents and knowledge and motivations, this allowed for a division of labor based upon individual needs and abilities. The individual categories which were delegated included:

1) Electronics
2) Frame construction
3) Motors
4) Buoyancy
5) Cameras
6) Tether
7) Programming

After much discussion of how the team could perform the various tasks, it was decided that the first priority should be the development of a structured frame, which could be quickly modified as needed. In this way, the team was able to offer flexibility to the various members who were going to be responsible for their individual elements of the project.

Power, buoyancy, and thrust, were all established using standard formulas and/or mechanical tests; however, due to the complex physics of fluids, the frame and final motor configuration had to be determined after the instrument box was attached to the ROV and placed in the water and functioning.

It was decided that a PVC-framed ROV with three motors, one at each axis of movement, would be the basic design. A structural frame shape, which could be quickly modified to change motor configuration and replacement of motors, if needed, would have to be maintained in the design. Frame modification to accommodate a load carrying payload, and cameras, was also a consideration.

The water pressure at 10 meters, being approximately equal to that of standard residential plumbing, allowed all of the seals to be developed from existing standard plumbing technology. Maintaining mechanical integrity in the construction of the watertight components allowed the team a number of benefits, which greatly improved the number of the available options in the design. Cost and availability of parts were the deciding factors.

Other factors lead to a prolonged discussion about tether options. The team reviewed tether options by listing the pros and cons of the three options proposed:

1) The “Old Way”: send power down the tether.

PROS	**CONS**
Simple to design	Large tether
Inexpensive	Power loss

2) Batteries: Buy 12 volt batteries and place them on the ROV

PROS	**CONS**
Simple	Low power
Small tether	
Inexpensive	

3) DC/DC converter: send Voltage down to a converter board

PROS	**CONS**
Small Tether	Complicated
Good score	Expensive
Offers greater motor control	

The team tested the available motors to determine the voltage needed to lift the box without installing an adjustable buoyancy system. The team’s goal was to create 4.5 kilograms of lift. After testing, it was established that 12 volts of power was only going to provide 3 kilograms of lift. After discussing the benefits of greater motor control, the decision to proceed with the DC/DC converter tether option was pursued with the alternative of sending power down the tether if the DC/DC option proved too time consuming or difficult.

The team then developed a theory for how the coding of controls was going to be converted to digital form, which offered the greatest amount of control with the simplest tether. Two microprocessors were programmed, one for the topside control and one for the bottom-side control. The topside information would be transmitted in three bytes; each byte would have 255 potential combinations of speed and direction.

Direction would be established by the last digit of the byte. Odd or even bytes would equate to positive or negative direction. This allowed for a variability of 128 separate power levels for each motor direction. The three bytes would then go down the tether and enter the bottom-side controller where it was first determined if it was an odd or even byte. After that, the bytes were divided by ten for speed issues, which lowered the resolution of 255 potential combinations to about 25, while speeding up the sending process. Next, a pulse-width modulation (PWM) loop was created. This enabled the motors to continue spinning while waiting for the next instruction from the topside control. Throughout the entire design process the three main points of focus were flexibility of design, cost effectiveness, and durability.

Challenge:

The communication between the two microcontrollers became the most time consuming problem the team faced in the evolution of the ROV. Once the two controllers were finished they had to be timed. The bottom-side controller had to be able to receive the bytes sent to it by the topside, determine where the information needed to be routed, and send them where they needed to go, all in time to receive the next byte of topside code. If the bottom-side was unable to place the first byte of topside information prior to receiving the second byte of topside information, the routing and magnitude of electrical impulses to the motors would be uncontrollable. Simply put, bottom-side circuitry had to run faster than topside.

To time the codes an oscilloscope was used, and it was determined that the bottom-side was slightly slower when allowed to operated unimpeded. The topside was actually faster than the bottom-side, which was the opposite of what was needed for the motors to run properly.

The options proposed to resolve the problem were to program timed pauses in the topside code, or to find a way to make the bottom-side faster. Tests were conducted to determine if there was any measurable difference between the topside Basic Stamp and bottom-side Basic Stamp. The results indicated that the problem could be resolved by simply switching the two Basic Stamps. The results were much improved and the codes were able to communicate successfully.

Troubleshooting:

The most common problem was the interruption of power to the motors. The following is the troubleshooting technique used to isolate the problem:

1) Verify the motors are free from obstructions.
    a. With the power disconnected try to turn each motor by hand
2) Ensure the batteries are charged and the power is connected to the batteries.
    a. Place a volt meter on each positive electrical line and measure voltage.
3) Verify power is being supplied to the topside and bottom-side Basic Stamps.
    a. Look for a light on the bottom-side circuit
    b. Perform voltage test to the 9 volt power adapter
4) Verify that each directional control is sending an electrical signal to the bottom-side stamp.
    a. Insert a test light into the appropriate pin and operate the corresponding topside control.
5) Verify each H-bridge is sending the signal received to the appropriate motor.
    a. Measure the voltage of the electrical line between the H-bridge and the motor.

6) Isolate the H-bridges for all three motors and ensure the H-bridges are receiving an electrical signal from the bottom-side Basic Stamp.
    a. This test would require the use of a volt meter.

By using the listed troubleshooting procedure the team was able to quickly isolate the problem of major components.

Future Improvements:

One improvement for the ROV would be two-way communications between the topside controller and the bottom-side controller. Adding two-way communications would make it easier to add sensor packages like depth, heading, and temperature sensors for future missions.

Lessons Learned:

As much as Team MPC tried to maintain the KIS (keep it simple) principal, things didn't always go in that direction. There were only two components of the ROV that the team feels may have been too complicated. The first was building waterproof housings for the cameras. The idea was to create a better-looking design, which allowed the team the ability to repair the cameras. Of the time it took to finish Soylent Yellow, the housings required at least one person dedicated to them throughout the entire evolution of the project. Now, after reviewing the time used to develop individual ROV components, the idea should have been abandoned after the third failure.

Another lesson learned was communications between the two different controllers. A lot of time was spent trying to write code and getting the two separate controllers to communicate. The major reason this was a challenge was because of the fact that the members creating it had never done this type of thing before. However, once it was finished, these same members realized how easy it was to write and manipulate code. The lack of experience was the factor that made this more difficult and complex than it actually was. In the future trying to keep to the team members' existing knowledge may prove to be a more efficient use of time.

Description of an Ocean Observing System:

The majority of the surface of our planet is covered in water. The majority of these waters are unexplored. We are dependent upon our oceans for the air we breathe, for the stability of our climate, and for its abundance of natural resources as well as its current and potential uses for transportation. If a change occurs in, on, or around these waters, it could greatly impact the global eco-system.

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An Integrated Ocean Observation System (IOOS) [1] is being established to provide us with a better understanding of our oceans. Southeast Atlantic Coastal Ocean Observing System (SEACOOS) [2] is one of many observing systems that, when combined with other observing systems scattered throughout the United States and its territories, will provide us with data to help better predict changes that may affect our nation and by default all other nations on Earth.

SEACOOS consists of in-water stationary and mobile data collection components located in the coastal oceans of North Carolina, South Carolina, Georgia and Florida. Together with observations taken from space, the information gathered is used to develop models that will be analyzed and studied to advance our understanding of our ocean changes and their effects. All of these systems require further developments in the type of technology that we are attempting to develop and explore through this competition. [3]

Acknowledgements:

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VideoRay, for donating the great tether- www.videoray.com;
And the MAST 55 class for permitting us to use parts from their ROV
Friends and family for their continued love and support

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[2] http://seacoos.org/General%20Information/Folder.Origins/
[3] http://www.ocean.us/Products_and_Services