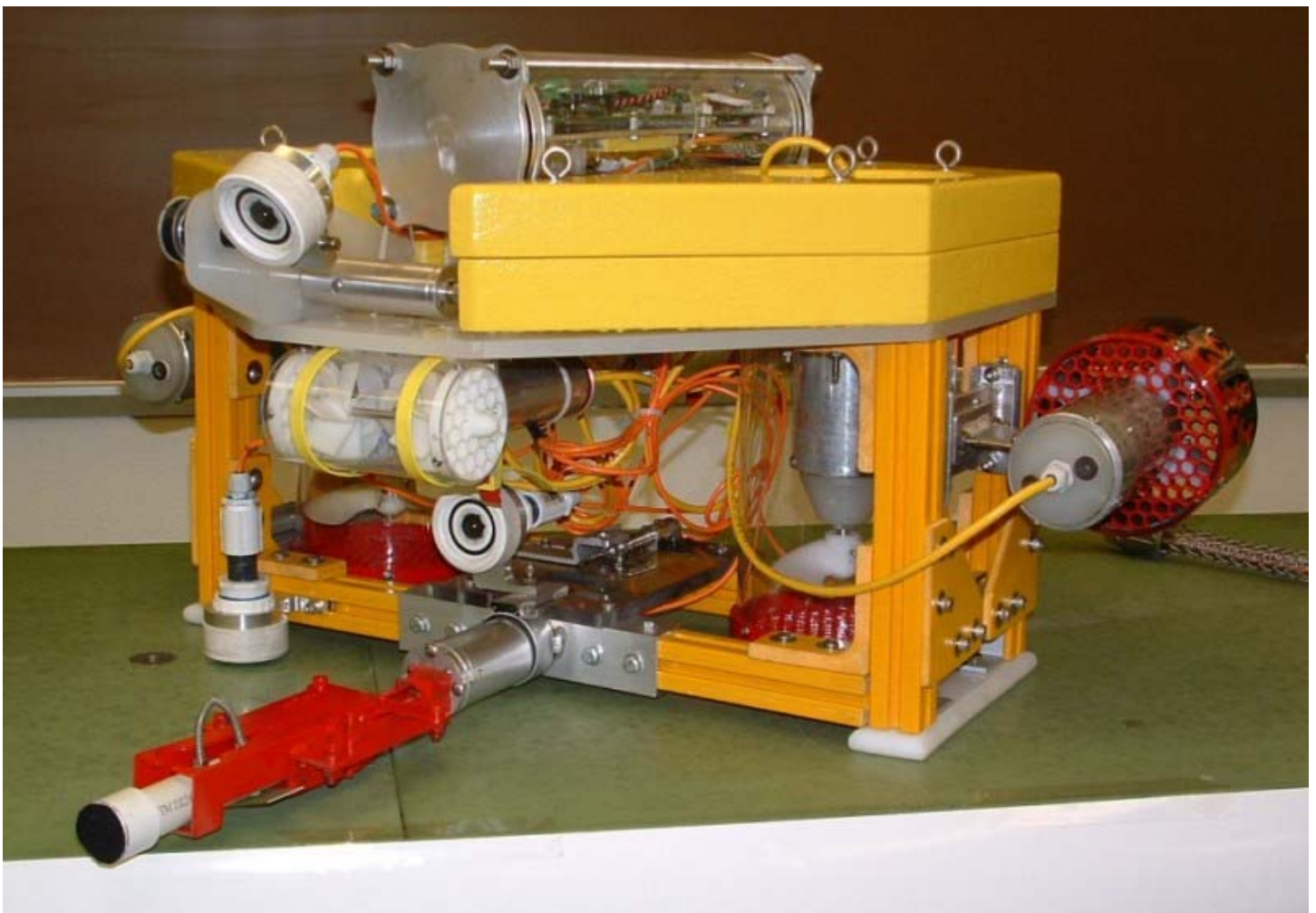


Technical Report
Long Beach City College ROV Team
Long Beach City College
Long Beach CA
Viking Explorers
ROV Name: VEIII (Vicki 3)

**5th Annual
International ROV Competition**

*Ocean Observing Systems:
Tools for Tomorrow's
Science & Technology Workforce*











ABSTRACT

The Viking Explorer III ROV (Vicki-3) constructed by Long Beach City College robotics team is a salt and fresh water capable robot designed specifically for light duty submersible applications. This ROV (Remotely Operated Vehicle) has a design limitation of 90 meters due to the thruster seals and the crush depth of the electronics housing. It is currently limited to a depth of 30 meters due to tether length. The ROV measures 97cm x 107cm x 56cm with six 24 Volt DC thrusters that are divided into two thrusters for forward/reverse propulsion, two thrusters for vertical, and two small crabbing thrusters for small side to side movements. The main thrusters each provide a peak thrust of nearly 2kg. The vertical thrusters are located on the sides so that the generated thrust will not be blocked by the payload. The ROV has four color video cameras with two providing views of the gripper and two providing downward looking views of the payload. The system voltage is 48 volts DC and all video and controls are sent between the ROV and the surface over a single fiber optic cable. Most of the frame is PVC, ABS or fiberglass. Aluminum is used for the electronics housings, grippers, and thrusters. All of the cabling between the control unit and the ROV devices is done with IP68 rated sealed cables with connectors. With a mass of 51kg, the required buoyancy is provided by four sections of copolymer foam with a density of 200kg/m³, a depth rating of 250 meters in sea water and a provided lift of 18kg.

The Viking Explorer Team

(The Long Beach City College mascot is the Viking)

 <p>Herson Alonzo - I am currently finishing up my sophomore year in electrical technology. I plan on expanding my education by transferring to a four year college, and receiving a bachelor degree in electrical engineering. I plan on working in the field as soon as I am finished with the four semesters of Long Beach City College electrical program.</p>	 <p>Felton Anderson is an electronic technology major that graduated 06/01/06 from Long Beach City College. He currently works for a company in Costa Mesa, CA called Ceradyne Inc. as a quality assurance inspector for military armor components.</p>
 <p>Steve Berry - Steve's field of study is in Construction Technology. Steve is attending Long Beach City College taking robotics, and attending Orange Coast College taking plumbing classes. Steve already has his bachelor's degree in Business Management. Steve has been employed at Costco Wholesale for nine years and his current position held is Senior Manager.</p>	 <p>Bryan Bischoff - I am a student of Long Beach City College who just finished a two year Electrical Technology Program. I currently work for MGM Transformer Co. as a design engineer. My interests are in electronics, robotics, photography and the outdoors. I plan to go on to a four year college and study mechanical engineering.</p>
 <p>JoLeeAnn Boston is an archaeology student and spring 2006 was her first semester in the electrical program. She works at a coffee shop and will be transferring to the University of California at Berkeley this fall to continue with her upper division coursework.</p>	 <p>Francisco Canul - Currently employed at Performance Sheets Div. of Temple Inland as a Maintenance Technician Class A. My job duties include troubleshooting AC/DC drives, PLCs, used in the corrugating industry, electrical power distribution systems and all mechanical aspects of the related field, including hydraulic and pneumatic systems. Job skills required: welding, machining, and working from blueprints and schematic diagrams. Would like to work in the robotic field especially in the ROV design and development.</p>
 <p>Cuauhtemoc "Temo" Cardenas - My name is Cuauhtemoc Cardenas. I am twenty two years old and I attend Long Beach City College. I am currently finishing the electrical program at Long Beach City College. I plan to one day become an electrical engineer and graduate from CSU. I am currently employed with Shultz Steel Co. in South Gate CA, and there I work as an electrician fixing heavy industrial equipment.</p>	 <p>Clifton "Woody" Colella - I am a sixteen year old student at Long Beach City College. I go to college full time (at least 18 units per semester) and I work (Internship) part time at Ocean Institute. I graduated from Oxford High-School in Cypress in 2004-2005. I started working with robots when I was about ten years old and ever since then robotics has been my primary field of study. I hope someday to work for a private or large company studying under sea life or sunken ships with a ROV.</p>

Long Beach City College 2006 MATE ROV Competition Technical Report



Joshua Ford - My name is Joshua Ford and I am a student at Long Beach City College in the Industrial Electric program. This is my second semester and I plan on getting my certificate. I am taking the robotics as an elective but am interested in the field. I already have my BS in business from Cal Poly Pomona and am currently working at Costco Wholesale as a manager.



Pedro Granados - My name is Pedro Granados, I'm currently studying my 4th semester in Long Beach City college. Right now I'm completing my general education even though I just started taking some classes relating to my field of study which is electronics/robotics. I'm planning to transfer to a 4 year college, but I am still undecided which one.



Sean Harrington - I am currently enrolled in the electrical program at Long Beach City College and work full time as an electrician. I have been working in the electrical field for the past seven years and going to school at night for the past 4 years. I will be finishing this summer of '06. I am also currently signed up to take my C-10 contractors license test. I am interested in getting a job at the docks as a crane electrician, which requires both certifications.



Jason Hindersinn - I am currently enrolled in the PLC and Robotics class. I am employed by Crockett Container, my title is maintenance mechanic. I plan to finish the program at Long Beach City College and then maybe pursue a degree from this college and transfer to Long Beach State. My plan is to continue at my present employer and to further my education.



Pheak Phoeun is a full time student at Long Beach City College. He is majoring in electrical and he is now finishing his second semester in electrical. Right now he is just planning to get his 'AS' and will be looking for employment in the electrical field.



Jan Reside - I am student at Long Beach City College majoring in Engineering and plan to transfer to California Polytechnic University San Luis Obispo to major in Mechanical Engineering. I was able to put my five years of CAD use to oversee the computer modeling of the ROV parts and assemblies. I enjoy taking a project from paper to completion and hope to continue this in my career.



Julio Rivas - is an electrical technology student at Long Beach City College. He is hoping to transfer to California State University, Long Beach to finish his degree. Currently he works for Fullerton Culture Specialty as a maintenance mechanic.



Eric Sandeen - Hello my name is Eric Shannon Sandeen and I'm currently enrolled in Long Beach City College. My current field of study here at LBCC is electricity and I'm now ending my second semester of the program. I'm currently not planning to transfer to any other college, but in the future I might go to a tech college. I'm currently working at a family run grocery store called Spring Farms as a courtesy clerk (a grocery bagger).



Steven Tatum - I currently work as a Telecommunication Technician. I am currently employed by Teksystem and I am contracted to Spenser Communication Incorporated as a field technician. I have worked in Telecommunication Industry for over 10 years, but I like to get more involved in the field of robotics. I would use my knowledge of telecommunication and robotics for the remote control of robots over the internet. I feel that these could be used to help in search and rescue in hazardous situation such as mine collapses and nuclear reactor. After I receive my AS in Electrical Technology I plan on transferring to Cal Poly Pomona and my Major will be Electronics and Computer Engineering Technology.



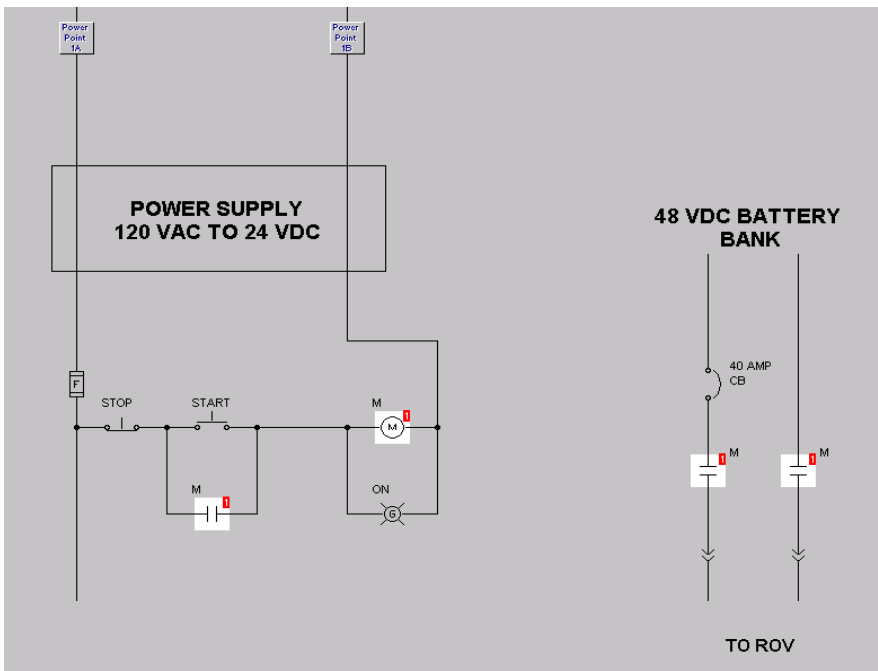
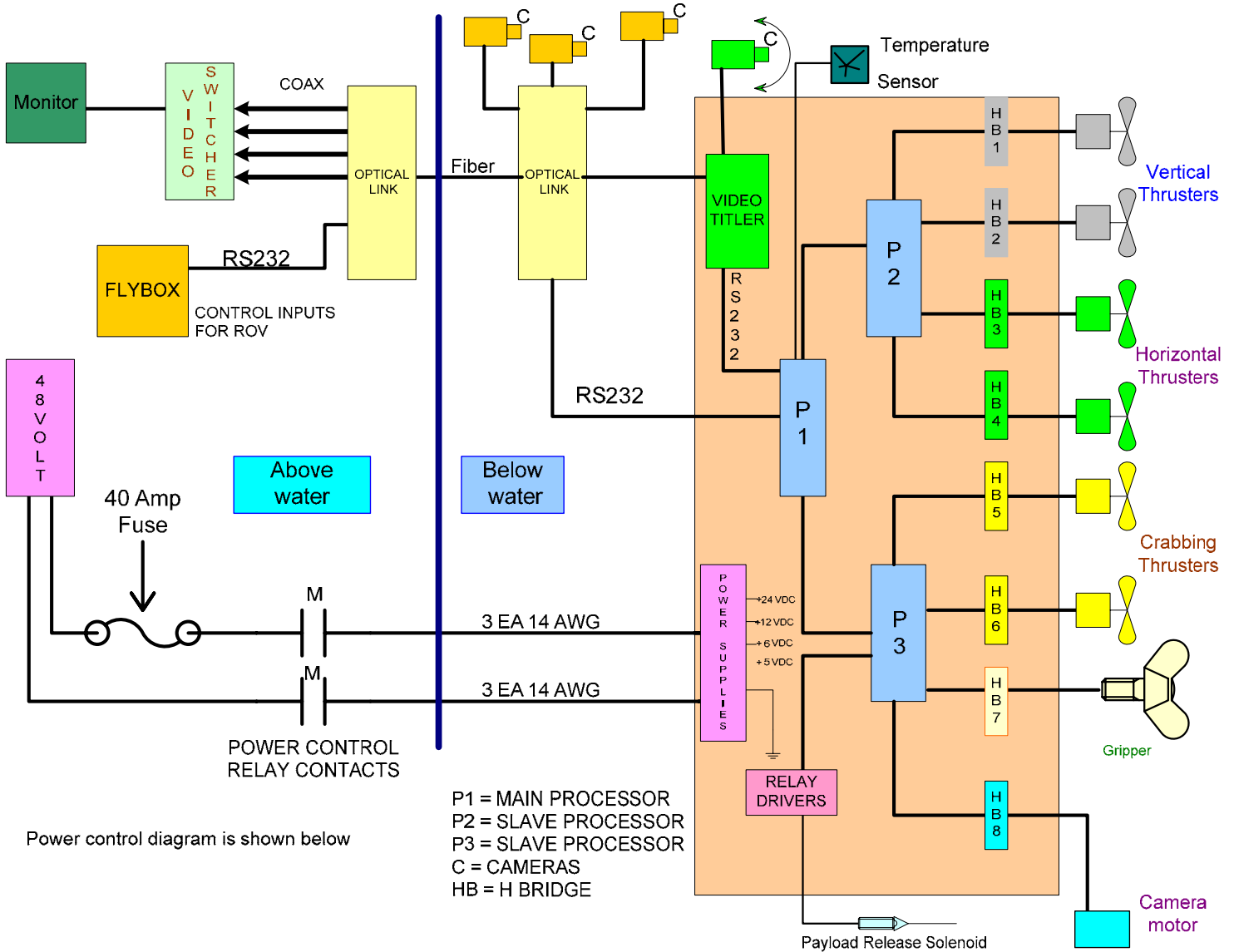
Jesus Zavala - My main field of study is electrical technology; I would like to start working in the electrical field at least a semester before completing my electrical program at LBCC. Once done with this program, I would like to work with an electrical union. Having become as permanent union worker, I would return to school to finish my Bachelors Degree in Electrical engineering. Having my BS in electrical engineering would allow me to expand my electrical career.

Budget/expense sheet

LBCC ROV TEAM EXPENSE REPORT AS OF 6/2/06

Item Description	Source	Donated	Cost
Fiber Optic Video Link	Optelecom-nkf	\$ 3,100.00	\$ -
CoPolymer Foam	CRP Group	\$ 876.00	\$ -
Foundation Grant	Long Beach City College Foundation		\$ (700.00)
Student Versions of SolidWorks	GoEngineer.com	\$ 500.00	\$ -
Waterjet Services & Aluminum Stock	Standard Metal Products	\$ 500.00	\$ -
Polyurethane Reinforced Tubing	New Age Industries	\$ 370.00	\$ -
IP68 Rated Cabling & Connectors	Lundberg	\$ 350.00	\$ -
Plastic & PVC sheets	MesaWest	\$ 300.00	\$ -
Aluminum Billet and Stock	Boeing	\$ 280.00	\$ -
Thrusters (4)	2005 ROV	\$ -	\$ -
48V to 24V 20Amp Power Supply	2005 ROV	\$ -	\$ -
48V to 12V 5Amp Power Supply	2005 ROV	\$ -	\$ -
solenoid (5)	alltronics.com	\$ -	\$ 18.12
14AWG wire	DeepSurplus.com	\$ -	\$ 86.60
Electronic Components	DigiKey	\$ -	\$ 244.65
Motors (4)	Ebay	\$ -	\$ 80.00
Motors (2)	Grainger	\$ -	\$ 164.54
PVC Camera Housings	Home Depot	\$ -	\$ 21.65
Fiber Optic Cable	LBCC CISCO Program	\$ -	\$ -
ABS RapidPrototype Parts, thruster grills, propellers, camera housing	LBCC Drafting Program	\$ -	\$ -
CNC work for aluminum parts	LBCC Machine Tool Program	\$ -	\$ -
IP68 Rated Cabling & Connectors	MagTrol Long Beach	\$ -	\$ 512.33
O-Rings, shaft seals & sealant	McMaster-Carr	\$ -	\$ 66.03
Stainless Fasteners	McMaster-Carr	\$ -	\$ 81.19
Acrylic Tubing	McMaster-Carr	\$ -	\$ 83.35
Fiberglass Extrusions	McMaster-Carr	\$ -	\$ 189.44
Pulleys (2) and cog belt	Stripped from a broken copy machine	\$ -	\$ -
Video Cameras	Synetlink	\$ -	\$ 92.01
Printed Circuit Boards (4)	www.4pcb.com	\$ -	\$ 132.00
	Total donated parts	\$ 6,276.00	
	Total Cost		\$ 1,771.91
	Donation		\$ (700.00)
	Balance covered by LBCC Electrical Program Supplies		\$ 1,071.91

Electrical schematic

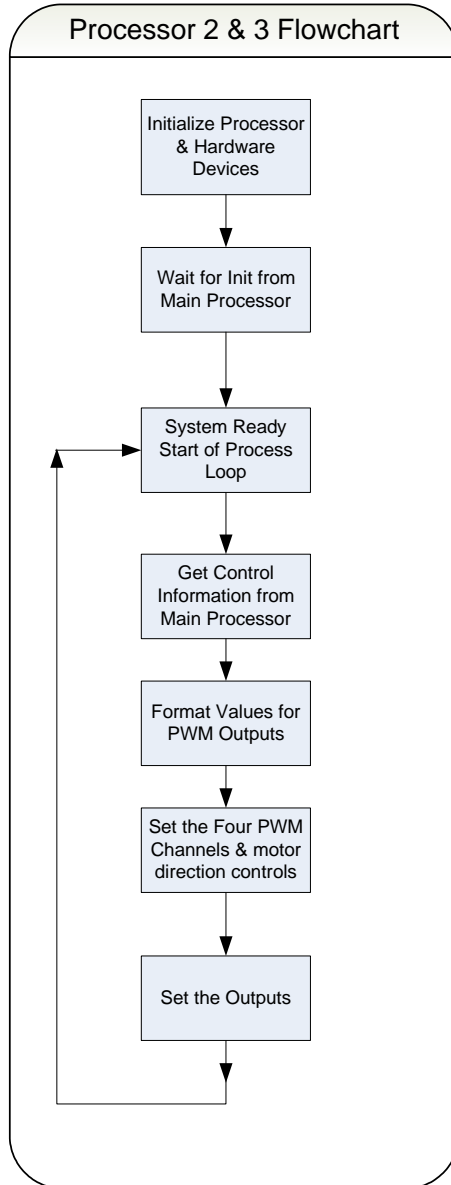
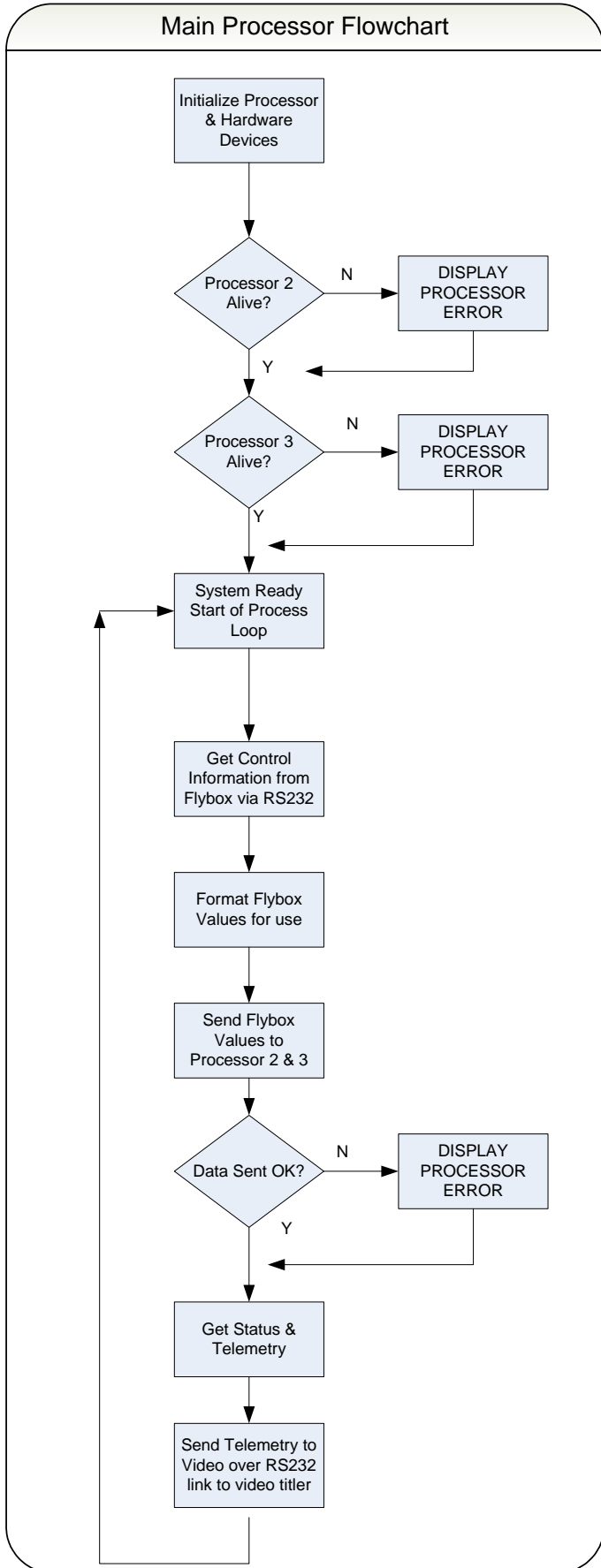


The schematic above is a one line diagram of our connections to each of the devices. The overall schematics were done in EagleCad and comprise many pages. The schematic page for the interconnection and power supply boards are included in the appendix.

The diagram to the left is a line ladder diagram for the ROV power control. It is relay operated from the operator's console. The 50A power relay contacts are located in the battery cart and the controls are located in a console mounted enclosure.

Page one of the schematic above was done with Visio and page two to the left was done with a motor control design and simulation program called Constructor.

SOFTWARE FLOW CHARTS



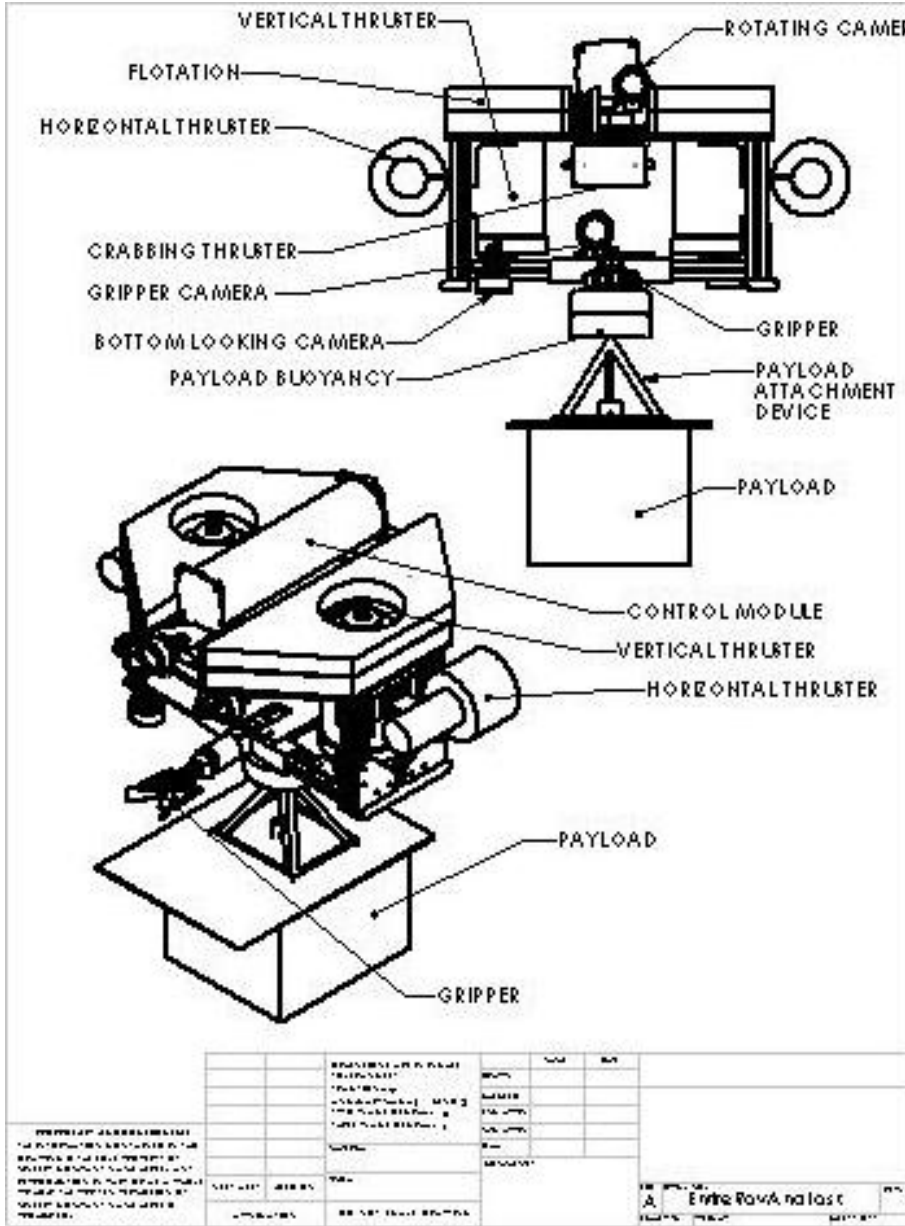
The software development for this project was done with MicroEngineering's PIC Basic Pro compiler and assembler for the MicroChip PIC18F4431 Processors.

There are three processors on the control board, one main and two slave processors.

Communications between the processors was implemented using a synchronized RS-232 serial transmission. The main processor signals that it is ready to send new data, the slave acknowledges that it is ready and then stands by to receive the data from the main processor. This allowed the coding to be done entirely in Basic without having to resort to interrupt service routines.

Much of the software is new this year, with some pieces being reused from prior years. The Flybox control and parsing software was reused and the Temperature sensor software was reused.

Design rationale



Our ROV is an underwater robot that is designed by students at Long Beach City College. Through the lessons learned from our previous underwater robot, we have been able to redesign our ROV to incorporate a newer frame, a totally sealed and encased circuit control housing, tether, buoyancy and cameras.

Our frame is constructed primarily of rigid fiberglass extrusion with angle slots running on all sides which allow us to inter-connect pieces together to construct our frame. The top of the frame is a sheet of flat plastic and is cut and anchored to the frame as designed on a computer program (Solid Works) by our team. Our frame is a very important because it houses our six thrusters and cameras.

At the front of the frame is an aluminum mounting fixture which is used to attach the mechanical gripper.

Our tether was designed to be strong but still flexible enough to allow our ROV to maneuver in the water. The polyvinyl tubing contains our fiber-optics feeding our remote control station above the sea floor. We also have power cables that lead to the head unit from our remote control station and power supply. The tether is 30 meters long and was tested for its neutral buoyancy in fresh water.

During fabrication, a 3 meter section of the tether was built and all of the cables were installed for buoyancy testing. The outer diameter of the tubing displaces enough water to render the tether neutral in fresh water. The entire tether is stored in a plastic garden hose reel.

Our control unit is housed in a 13cm diameter x 50 cm clear acrylic tube with aluminum end caps. Inside the control unit are circuit cards that control our four video cameras, six thrusters, gripper and camera motors. The electronics boards were built by Advanced Circuits and then the entire component soldering and testing was done by this team, including every surface mount part. The housing was also manufactured by the students. The housing was drilled, so that the circuit card could be securely fastened. All resistors were soldered on as well as contacts and completely wired by the students in the Robotics class.

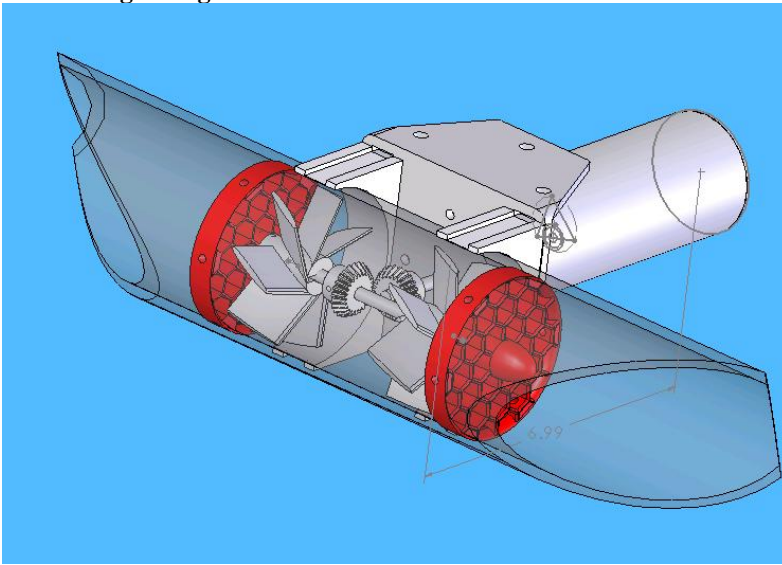
The ROV is constructed and designed by the students of Long Beach City College. All the manufacturing was done at the facilities at Long Beach City College. This allowed the students of the Robotics class to participate in every aspect of building the ROV. Students drilled using mills to mount various pieces to aluminum housings, brackets, and some motor plates. Other skills were applied when soldering the resistors, reading the resistor's color band and size, mathematics and advanced knowledge of mathematics were all used to construct this ROV.

The following pages provide details on all of the ROV systems.

Thruster Design & Characterization

Our goal with this ROV was to design it using six right angle thrusters. These thrusters were designed, built and finally fabricated. Due to the length of time it took to accomplish this task we were unable to test the thrusters until well into the build phase of the ROV. The goal of this design was to put the motor at right angles to the propeller shaft and keep the motor out of the water flow. Initial testing showed generated thrust well below expectations. A rapid system redesign was needed. We discarded the original configuration (see the lessons learned section) and came up with a new configuration. A few of the team members created the new configuration using SolidWorks and it provided the team with immediate visuals so that the entire team could approve of the modifications. The modified ROV still uses the right angle thrusters, but only two of them as crabbing thrusters for simple side to side movements. The remaining four thrusters were salvaged off of last year's ROV and incorporated into the new ROV. The red circle ROV turned into a yellow octagon ROV almost overnight.

Right Angle Thruster with Motor Out of Water Flow

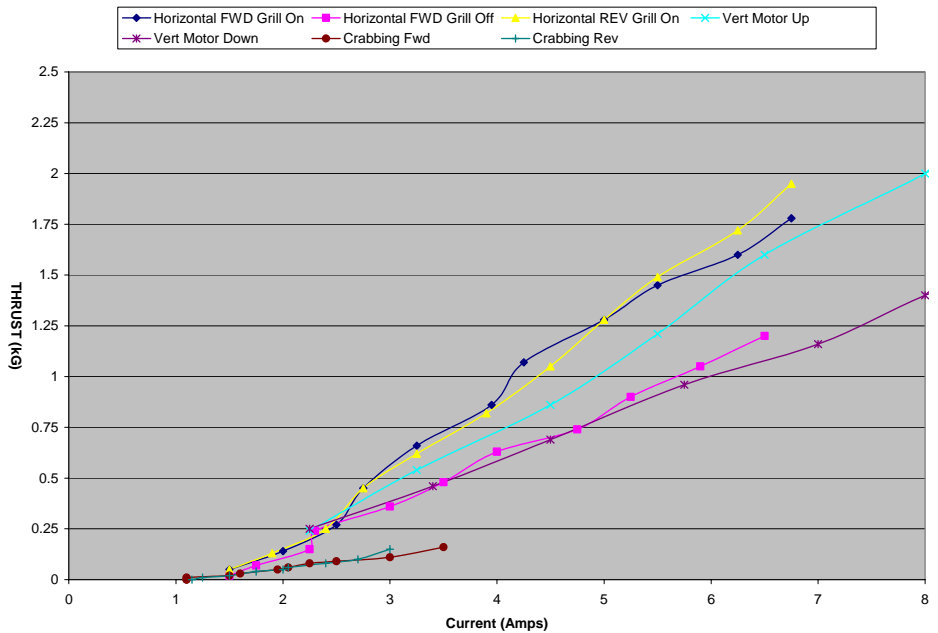


Our thrusters can be characterized many different ways, for example: resistance, current, voltage, horse power and thrust. We looked at three important characteristics of our thrusters, amps, volts and thrust. The voltage and amps were measured with our power supply and the thrust was measured using a strain gauge. Our ROV uses six 24VDC thrusters, in three sets, vertical, forward/reverse and crabbing (side to side). To measure the generated thrust, we built an aluminum assembly that fits over the opening of our 1900 liter water tank. The frame includes a digital meter that we calibrated to measure thrust in kilograms. The meter is connected to a pressure sensitive device (load cell) that generates a voltage proportional to the generated thrust. We tested each thruster by mounting it onto a swinging arm. One end held the thruster under water and the other end pushed against the load cell. The arm pivoted at the center on bearings. We were able to directly read generated kilograms of thrust off the readout. At each measurement point, we also recorded the

amps and voltage applied to the motor. In addition to the amount of thrust generated, we were able to determine the upper limits of the thrusters to keep from overloading our motor drivers. All of this information told us if the motor was efficient enough for us to use.

With all six thrusters in place, the ROV should operable in all directions and give us the benefit of being much more flexible in our movements underwater. The motors are sealed at the motor shaft using a pump seal and are housed in an aluminum housing to protect the electrical wiring and motor from getting wet. The aluminum end caps are sealed to the housing with double o-ring seals. The cable coming into the thruster is sealed with a cable gland that is IP68 rated to a depth of 46 meters.

To protect all living species in the water, we guarded the propellers. These grills also worked to increase the output and efficiency of the thrusters. The chart to the right shows the difference between the thrusters and shows the same motor with and without the thruster grills. The grills were designed in a manner that results in straightening of the water flow at the same time increasing its exit velocity. Permission was received from Innerspace Thrusters of California, to adapt their patented thruster grill design for our use. Using SolidWorks we designed the grills to fit our applications. The grills increase in thruster output from a low of 48% to a high of 150% was seen with the average being a thrust increase of 71%. Compare the Dark Blue line with the Pink Line in the chart to see the difference with and without the thruster grill.



Gripper Design

The most challenging task of our gripper design was to design the gripper to be able to pick up the connectors that will be placed inside the electronics module and to open the door. The main idea was to make an electrically operated gripper using one of the motors from our small thrusters. The housing was already designed and we did not have to start over for a motor housing. The motor was attached to an aluminum and stainless lead screw assembly to provide the forward/backward motion. At the front of the lead screw, the gripper shell was attached. The gripper shell was made out of a piece of square aluminum tube. The connectors that we have to pick up are not that complicated but they will be lying on the ground and will be supported by a small foot. To adjust for the foot, we cut a hole on the bottom of the gripper shell. By doing this when the gripper closes, the foot will be avoided and the gripper will be secure around the connector. When the gripper is closed, the foot will keep the connector secure. The top of the connector has a loop that can be used to pick it up. Even though we are not using the loop for its purpose, we had to compensate for it. We machined a small groove in the top of the gripper shell so that the loop would protrude through the top of the gripper. This will help to keep the connector stable inside the gripper. Finally, a large hole was put at the forward end of the gripper shell to allow it to clamp down around the trawl resistant frame door handle.



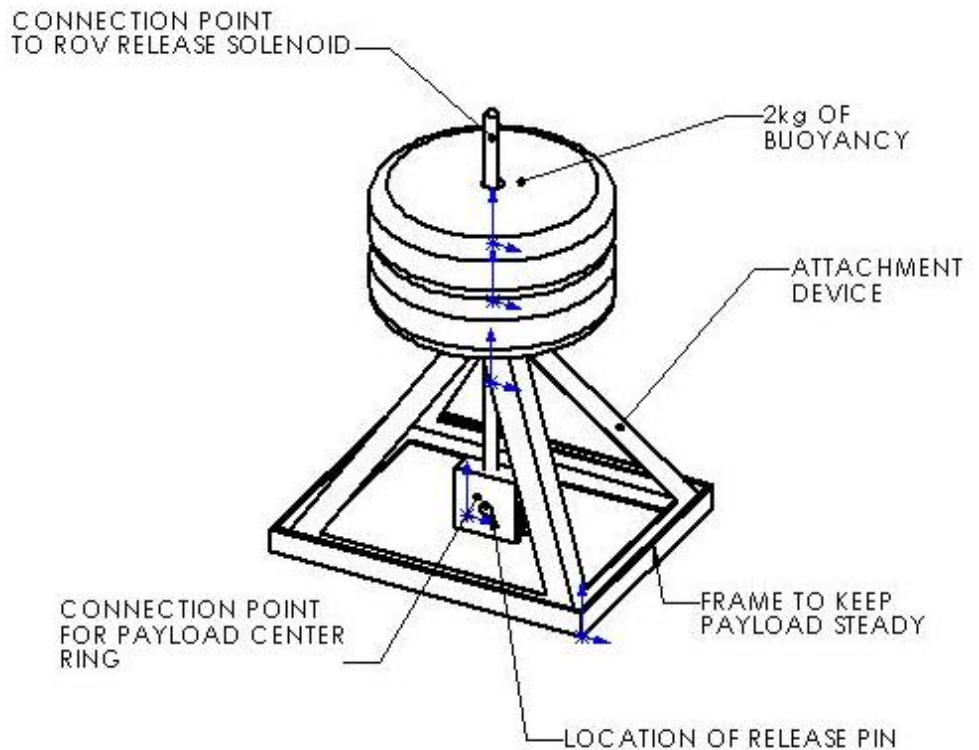
Payload Attachment & Release Device

The purpose of the payload attachment and release device (PARD) is to provide a means for the ROV to transport and situate the payload. It consists of a solenoid, an aluminum frame, buoys, and a payload attaching/release pin. The solenoid's use is in the form of a locking pin at the top of the PARD which attaches the device and payload to the ROV. When energized, the solenoid detaches the device and payload from the vehicle.

The PARD is connected to the payload via means of PVC block which encapsulates the center loop of the payload itself and a connecting pin which joins the clasp and PVC block. This block in turn is connected to the aluminum exoskeleton of the device that surrounds the PVC Block in the shape of a pyramid. At the base of the pyramid is a rectangular base that characteristically both stabilizes the load when submerged and prevents it from rocking while under way. At the top of the aluminum frame are two essential buoyancy modules that provide neutral buoyancy for the payload and PARD. The floats each provide 1kg of buoyancy and were made from the thruster holes that were cut out of the main buoyancy floats.

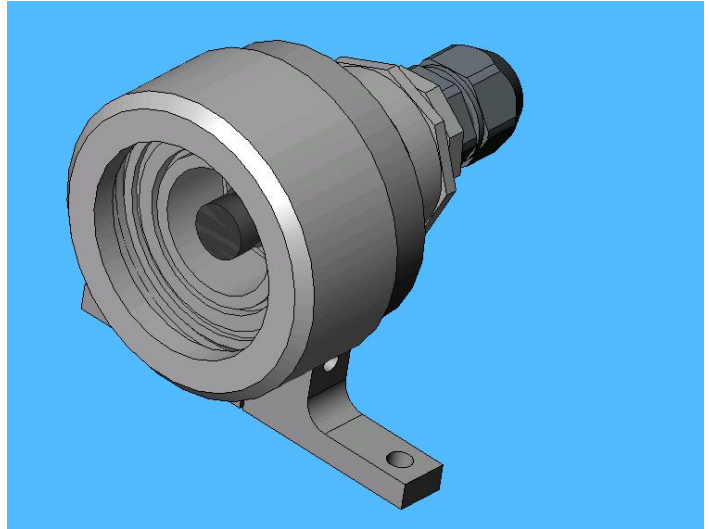
When the payload is delivered, the ROV detaches from the PARD by energizing the solenoid. Once free, the ROV can then be piloted to the side of the enclosure and locate the connecting pin joining the payload and the device.

The device can be released by means of having the ROV pressing a button located on the side of it. The buoyancy modules in turn allow the device to rise to the surface for collection and reuse.



Cameras and Locations

Our camera housings utilize PVC couplings and an acrylic lens to house the cameras. Our design is modified from the one used by the Falcon ROV Team. The housings were constructed to allow connection of a low voltage chord to come out of the back of the housing for connection to the control box. The cabling exits the housing through another cable gland IP68 rated for 45 meters. This was done to waterproof the cameras and keep them from being damaged when submerged. Once built, we then tested them on the monitors for operation. We were able to see the differences of using a wide-angle lens as opposed to a normal lens. The wide-angle lens was determined to provide the best range for close-up and far-away views. These sub-assemblies were then mounted to the ROV.



The ROV in terms of video components is comprised of four cameras. The first is a stationary camera situated in the front of the ROV above the gripper to allow for sighting of any targets or obstacles and working with the gripper. The second camera is situated atop the ROV and is used to enable a larger view of the forward direction, and is motorized for vertical motion to change viewing direction to a higher or lower point of perspective. This provides the operator with a second and higher angle view of the gripper. The last two cameras allow viewing of anything situated under the ROV and are specifically placed for the positioning of the payload. One is on the right front side and the second is on the left rear so that all four sides of the payload can be viewed as its being placed into the housing.

Buoyancy Design

The floats of the ROV are made from a sheet of XL200 copolymer foam donated by the CRP Group. The foam has depth rating of 250 meters in sea water. Each float provides a buoyancy of 4.5 kg for a total amount of added buoyancy of 18kg. Each float is painted with a simple polyurethane paint to shield the foam from UV exposure. The foam is closed cell and the paint is only for added protection. The floats were designed with SolidWorks which allowed us to enter the physical characteristics of the foam and calculate the lift generated. The foam has a density of 200kg/m³. Each float has a volume of 5629.7cc and a mass of 1.12595kg. SolidWorks also allowed us to email the design to one of our sponsors (Standard Metal Products) where they took the design file and sent it to their water jet cutter and in literally a matter of minutes cut the foam pieces exactly to specification.



Tether Design

The ROV tether is shrouded in a polyurethane hose and designed to enable operation of the ROV via the transfer of control and video signals and power. Designed to be neutrally buoyant, the tether contains a six fiber optic cable and six 14AWG copper wires. The copper wires are used to power the ROV while the fiber optic cable is used to transport video and control signals. Testing was done with a three meter mockup of the tether and placed into our 1900 liter test tank to verify neutral buoyancy. The chart below shows the calculations we performed in designing the tether.

Tether Buoyancy Calculations

Wire	0.123 kg per meter
Fiber	0.021 kg per meter
Tubing	0.234 kg per meter
Total Weight	0.378 kg per meter
Tubing	2.223 cm OD
	3.879 cm ²
	387.948 cm ³ per meter
	0.388 kg lift per meter
Total Weight	0.378 kg per meter
Buoyancy	0.388 kg lift per meter
	0.010 Buoyancy per meter



Design Tools & Processes

SolidWorks - Throughout the robotics course, the team has been tasked to design and construct parts and assemblies of the various robotic systems using SolidWorks. This began with the initial design of caps and housing for the main motors. After this, there was further development in design for the various parts to complete the system within the limited space in the ROV.

We also worked as a team with more experienced members in SolidWorks helping those with no experience with the program to build parts. Changes were made and work continued until a satisfactory design was created. SolidWorks is easy enough to learn that some team members with no experience with Computer Aided Design (CAD) were able to actually make significant contributions to the project.

EagleCad & Electronics Modules - Using another CAD program, EagleCAD schematic capture and board design, the 24/12/6 VDC power supply was designed. The board was designed to provide all necessary on board power for the main board, thrusters, video cameras, switch relays and future additional equipment. The power supply is designed to take in 48VDC and output 24 VDC, 12VDC or 6 VDC to the various pieces of equipment. The design was checked for errors and then gerber fabrication files were automatically generated by the CAD program. These files were sent electronically to Advanced Circuits in Aurora Colorado where they built the bare printed circuit boards (PCBs). When the PCBs were returned to us, we assembled the required parts and hand soldered all components to the board. There are a total of three circuit cards in our control unit.

1. Power Supply Card – holds the 48V to 24V converter, 12V linear regulators and 6V linear regulator (Designed, laid out and assembled by the team)
2. Electrical Distribution Card – located inside the fiber box, distributes power to the thrusters, solenoids and cameras (Designed, laid out and assembled by the team)
3. Main Control Card – holds the three processors, relay drivers and video titling unit.
(The main control card was laid out by our instructor to our specifications and 100% assembled by the team, including soldering the *tiny* surface mount components)

Under Pressure Version 3.0 - Using the housing analysis program provided by DeepSea Power & Light of San Diego, CA., we ran an analysis of the electronics housing. It was a concern of ours about it withstanding the pressure at depths up to 30 meters (the length of our tether). After running the analysis, the results show that our housing will not collapse until a depth of approx 90 meters, three times our design depth. We also ran an analysis of the housing, substituting the acrylic tube with an identical aluminum tube and found a new crush depth of 2000 meters!

TUBE CONFIGURATION (External Pressure)	Tube distortion values					
	Pressure (Kbar)	Depth (m)	Stress (Kbar)	delta ID (cm)	delta OD (cm)	delta length (cm)
Inner Diameter: 12.7000 cm	0.0010	9.8	0.0105	0.0041	0.0041	0.0018
Outer Diameter: 13.9700 cm	0.0020	19.7	0.0210	0.0081	0.0081	0.0037
Wall Thickness: 0.6350 cm	0.0030	29.5	0.0315	0.0122	0.0122	0.0055
Tube Length : 48.2600 cm	0.0040	39.4	0.0420	0.0162	0.0162	0.0073
Weight in air : 1.53 kg	0.0050	49.2	0.0525	0.0203	0.0203	0.0092
Weight in water : -6.06 kg	0.0060	59.0	0.0630	0.0244	0.0244	0.0110
Failure mode: Thin wall collapse	0.0070	68.9	0.0735	0.0284	0.0284	0.0129
Collapse pressure 0.0091 Kbar (89.9m underwater)	0.0080	78.7	0.0840	0.0325	0.0325	0.0147
Thick wall crush at 0.0479 Kbar (471.0 m underwater)	0.0090	88.6	0.0945	0.0366	0.0366	0.0165
	0.0100*	98.4	0.1050	0.0406	0.0406	0.0184

* = after housing failure

Manufacturing Process – Aluminum Parts Most of the aluminum parts that were designed by our team were manufactured for us by students in the Long Beach City College Machine Tool Program on our other campus. The parts were designed by the team and documented using SolidWorks. The designs were emailed to the other campus for review. Suggestions were made to improve the manufacturability and performance of the part and these suggestions were folded back into the design and final build plans were sent to the students. The following parts were made by the LBCC Machine Tool Program students.

Electronics Enclosure end caps (2), Fiber-Box (box to house the wiring interconnect board and the fiber optic link card), Small motor mount flanges (6), the small motor mount end caps (6) and the small motor housings (6).

The LBCC Welding Program providing welding services for the few parts that required aluminum welding.

Manufacturing Process – Plastic Parts The ABS parts on the ROV were again manufactured using the Rapid Prototyping machine in our Drafting Program. Our students designed the parts, uploaded the SolidWorks STL files to the machine and hours later, we had the parts. This year the new parts were the camera cup housings, the crabbing thruster propellers and the crabbing thruster grills.

CHALLENGE DESCRIPTION

By far the overwhelming vote for the biggest challenge was what to do when the thruster design failed. We had put so much time and energy into designing a nice neat compact ROV around these thrusters, it seemed like everything was lost when they didn't generate the needed thrust. Looking back, we were expecting too much out of the thrusters and should have tested much earlier in the year. When the problem was discovered, ideas were tossed back and forth, for many aspects; we were starting from scratch back at the end of March 2006! It was a little scary. The ideas were compiled and presented to the entire team at the next class meeting. Most of the team jumped right in and contributed to the new design and within a week we were off refocused and building again. It was great to see all the ideas going back and forth. The final result has the ROV in a new configuration, we salvaged the thrusters off of last year's ROV and we are using the new thrusters we designed as crabbing thrusters. Not all was lost, but the entire team feels we made a good recovery in a very short period of time.

Explanation of Troubleshooting Technique used to overcome technical problems.

One problem we ran into when hooking up the camera and video system controls was our voltage output. Originally, the output voltage feeding the video/fiber link on the ROV was 7.5 volts, which was 1.5 volts too high. The operating voltage for the link is only 6 volts. In order for it to function properly we had to shed the extra 1.5 volts.

We were able to accomplish this by using a voltage divider circuit. A voltage divider circuit allows us to adjust our output voltage by changing the resistance value of the resistors connected to the 3-terminal adjustable regulator. The formula we used showed that one of the resistors we were using needed to have a lower ohm value. The 1200-ohm resistor needed to get lowered by a value of 300 ohms. We also found by rearranging the formula a little bit that using a 909-ohm resistor gave us a calculated voltage of 5.9 volts, which is within tolerance.

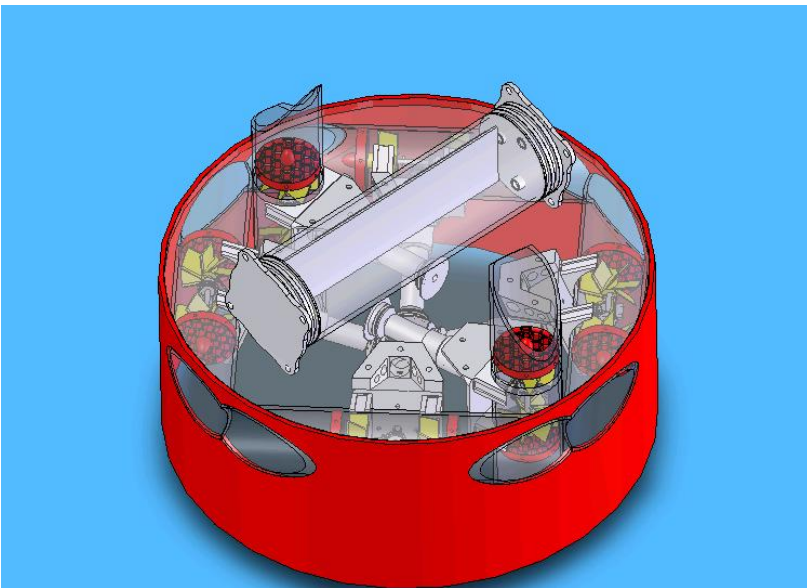
To mechanically fix the problem was very simple. We just used the soldering tools to remove the 1200-ohm resistor connected to the circuit board and replaced it with the 909-ohm resistor. Not much there. After testing the circuit, our voltage readings showed that our calculations were right on the money.

Description of at least one lesson learned during the design and building process.

The team has 100% agreement on the following point;

TEST A NEW DESIGN BEFORE IT IS USED TO BUILD AN ENTIRE SYSTEM AROUND!

ORIGINAL DESIGN CONCEPT



The rendering on the left is our original ROV design concept. Red and Round. The outside diameter is a 24" cylinder and was to be fabricated from a cylindrical water container and happened to be red. The right angle thrusters were located for forward/reverse, side to side (crabbing) and two for vertical. A platform and frame assembly was to be built on the bottom half to support the grippers and mission related items. The buoyancy was going to be installed in the top area.

We did do some initial tests early on with the thruster, but did not connect it to instruments to measure exactly the amount of thrust generated. That came later after it was a bit too late.

Discussion of future improvements

The biggest improvement we would make would be to add sealed variable buoyancy modules. This type of buoyancy control is beneficial to future ROV constructs due to its design. The ability to control the change in buoyancy would enable the ROV to handle different types of payloads with ease and little to no modification of the ROV itself.

The second improvement that we would make is in our build process. We would emphasize initial testing. When creating a vehicle around an essential component, the team must first ensure the essential component can and will work within expected or minimally tolerable specifications. Doing so will reduce the chances for the need to make any significant modifications to the vehicle design. This would have kept us out of a whole lot of trouble this year.

Careers with Ocean Observatories

Oceanography is the scientific study of the physical, chemical, and biological aspects of the ocean. The description alone opens doors for many career opportunities. There are many opportunities spread throughout the world, and number in the hundreds. The ocean observatories also offer careers in the study of the weather and all aspects of the ocean environment. An example of one such person working with ocean observatories is Mike Kelly, who works as an Ocean Observatory Supervisor for the Monterey Bay Research



Institute. Mike is shown in the photo working on an observatory system. Solar panels, communications equipment and other electrical devices are shown in the photo.

The requirement for electrical and electronics knowledge in working with the ocean observatories applies to our studies here at Long Beach City College. This provides us with a way to see how our studies can be applied.

In addition to the electrical and maintenance positions for the observatories, there are two careers in particular that further expands on the course work this semester; they are data processors and cartographers. They utilize computer-aided-drafting programs and geographic information systems to produce charts and databases common to missions performed.

Finally, there is the much sought after position available for the ROV, Pilot/ Technician. This person actually maintains and operates the Remotely Operated Vehicles that are used in maintaining the Ocean Observatories. The R.O.V. operates in three dimensions; up/down, forward/aft, and sideways. This allows the pilot to maneuver the craft to best suit his mission. This flexibility allows the maintenance of the systems to be done from the surface rather than by divers or manned submersibles.

Qualifications for most of the career fields noted require a bachelor's degree, however many of them accept related experience and training as well.

Works Cited

Careers in Oceanography. Marine Science and marine Biology. <http://scilib.ucsd.edu/sio/guide/career.html>

Fugro- Worldwide <http://www.fugro.nl/careers/msdrovpilots.asp>.

OceanCareers.com http://www.oceancareers.com/profiles.php?profile_id=7&action=display

Acknowledgements

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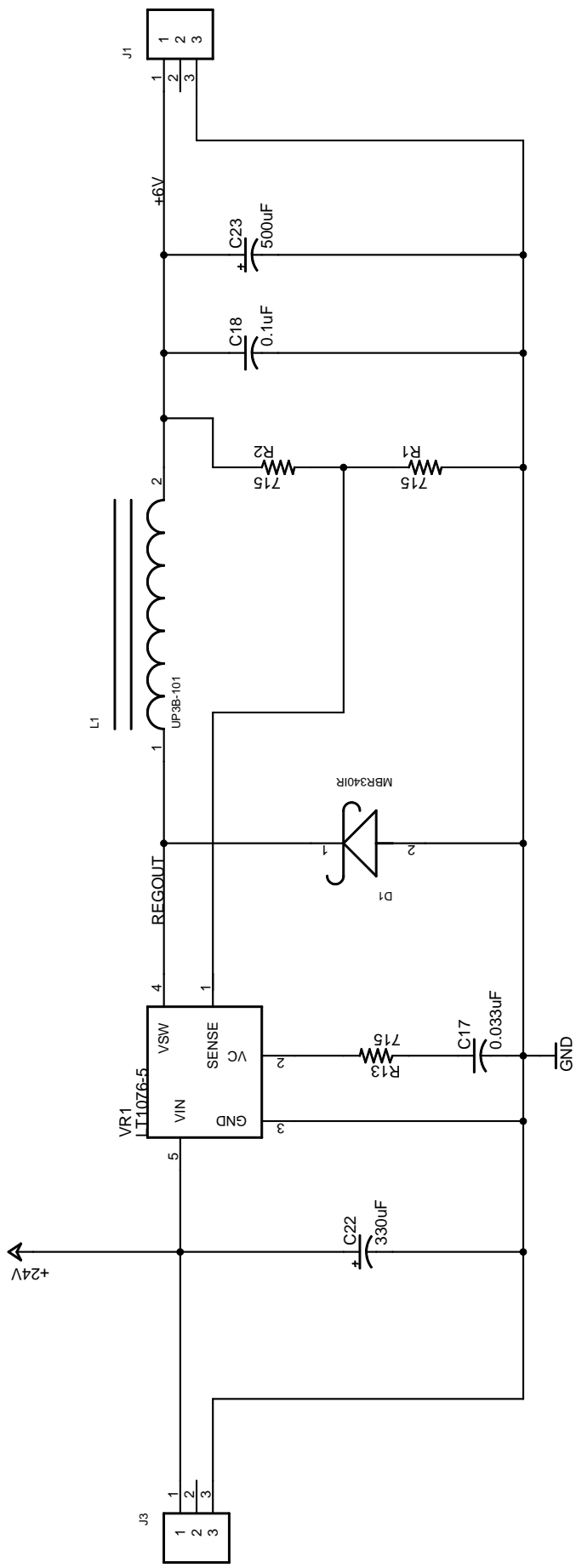
Long Beach City College Machine Tool Program
Long Beach City College Drafting Program
Long Beach City College Welding Program



APPENDIX

The following pages are attached as an appendix to the report for additional information. These are only a sample of the many pages of documentation that was kept for this project

Appendix	A.1	24VDC TO 6VDC POWER SUPPLY BOARD SCHEMATIC
	A.2	24VDC TO 6VDC POWER SUPPLY BOARD CIRCUIT LAYOUT
	A.3	FIBERBOX INTERCONNECTION BOARD SCHEMATIC
	A.4	FIBERBOX INTERCONNECTION BOARD CIRCUIT LAYOUT
	A.5	SAMPLE OF SOLIDWORKS DRAWINGS - OVERALL DIMENSIONS
	A.5	SAMPLE OF SOLIDWORKS DRAWINGS - ELECTRONICS MODULE
	A.5	SAMPLE OF SOLIDWORKS DRAWINGS - FIBERBOX



- H1 MOUNT-PAD-ROUND3.0
- H2 MOUNT-PAD-ROUND3.0
- H3 MOUNT-PAD-ROUND3.0
- H4 MOUNT-PAD-ROUND3.0

24VDC TO 6VDC POWER SUPPLY

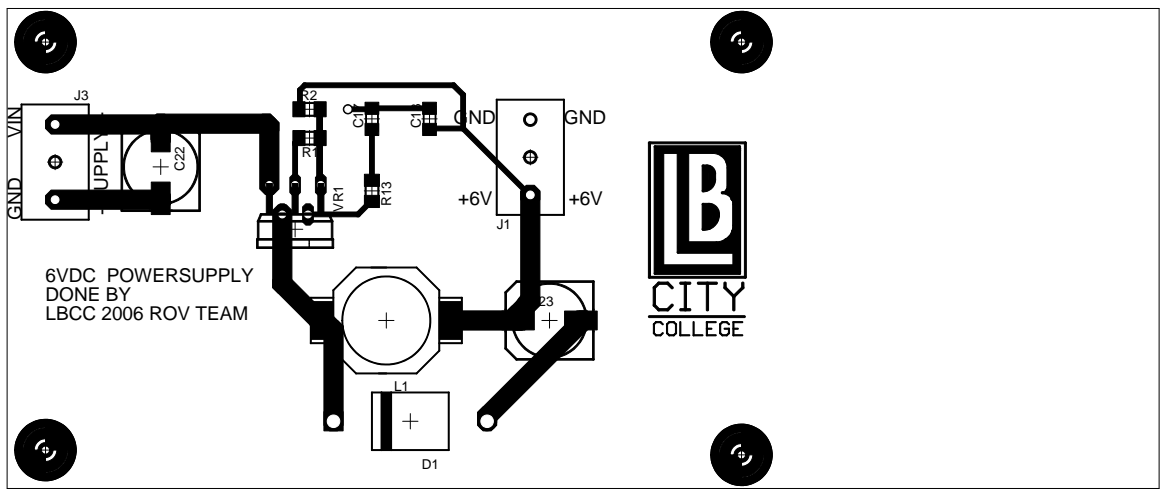
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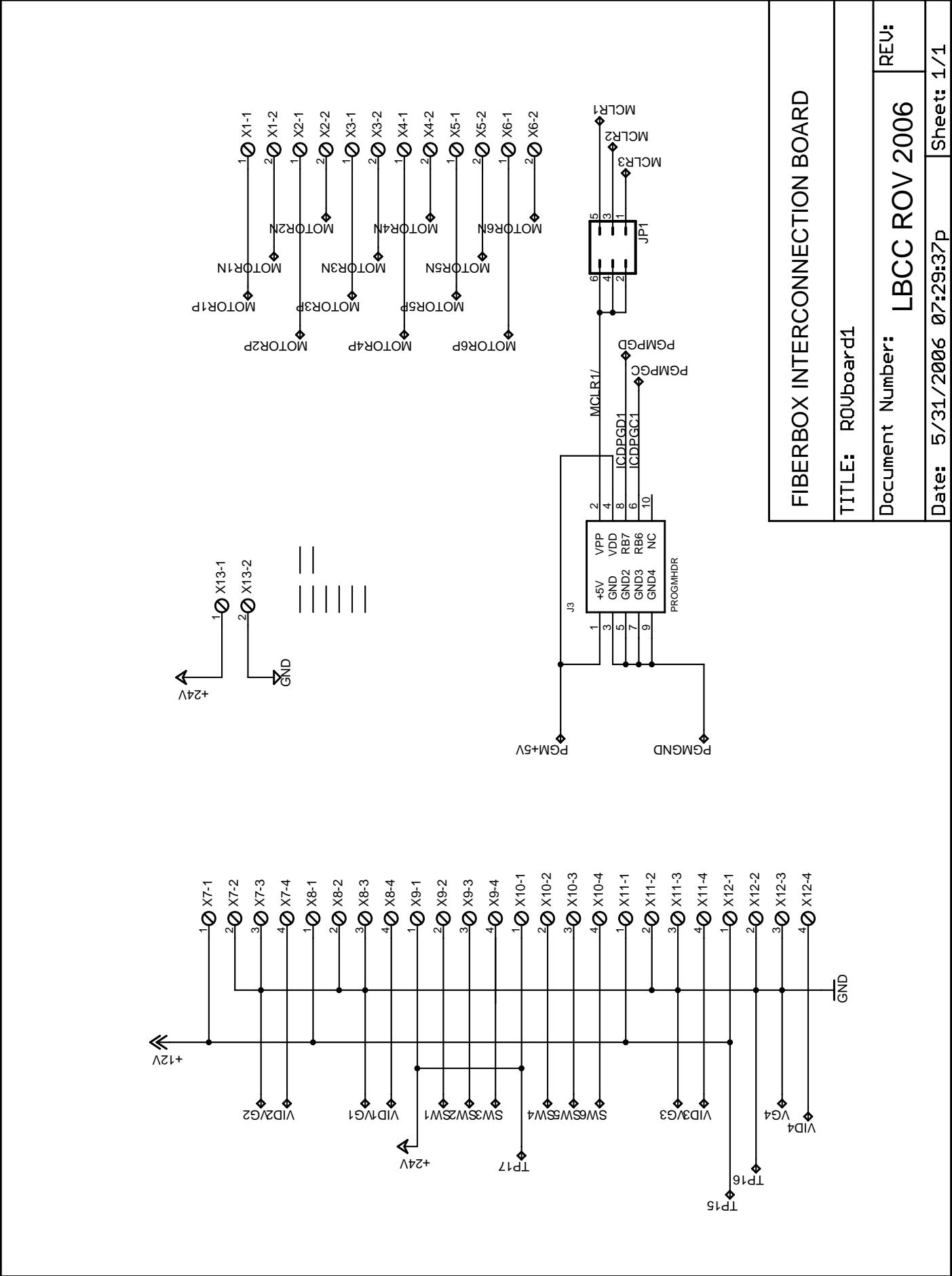
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FIBERBOX INTERCONNECTION BOARD

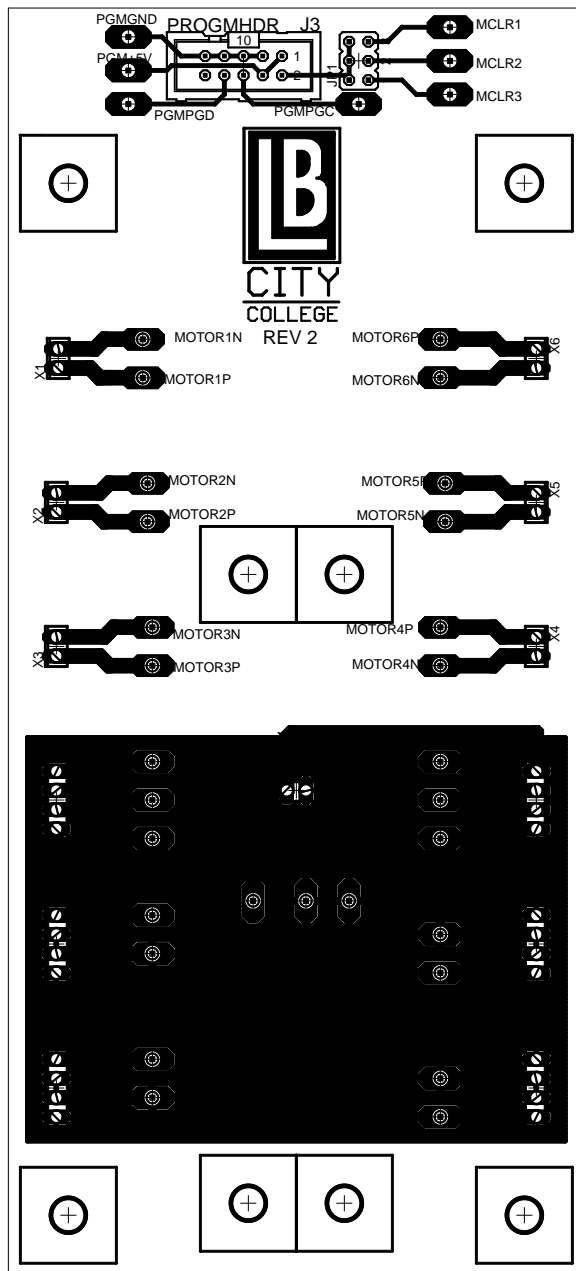
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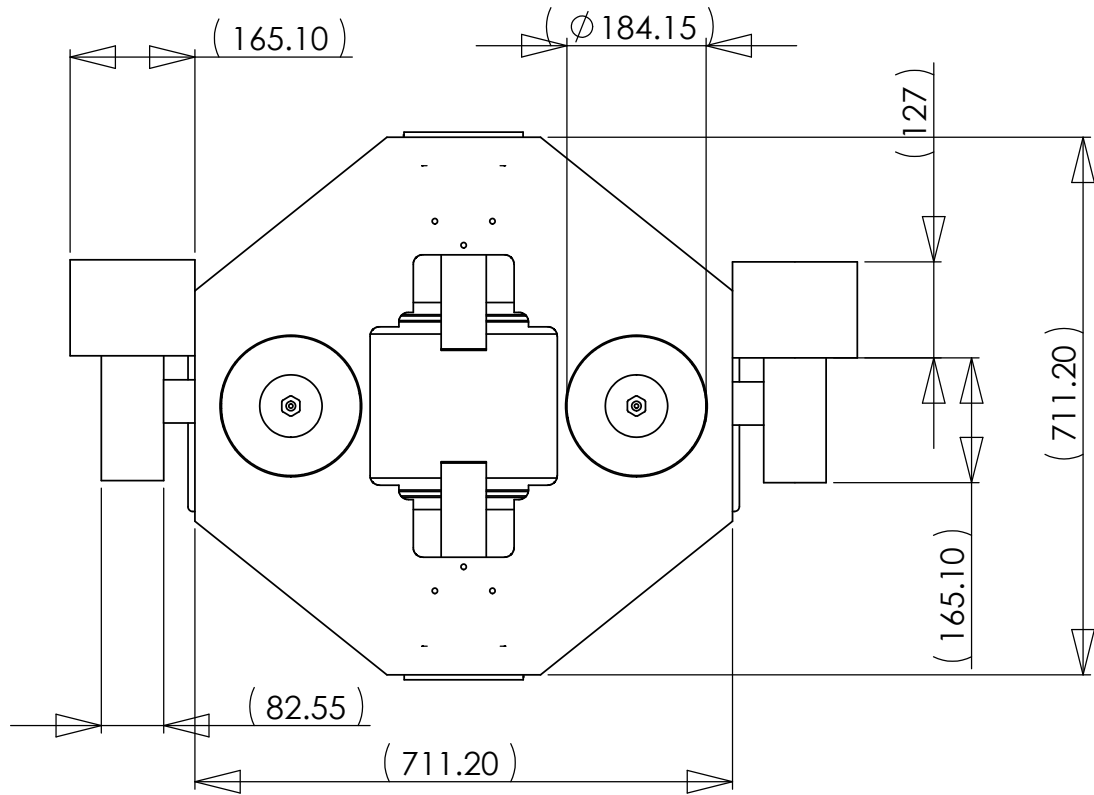
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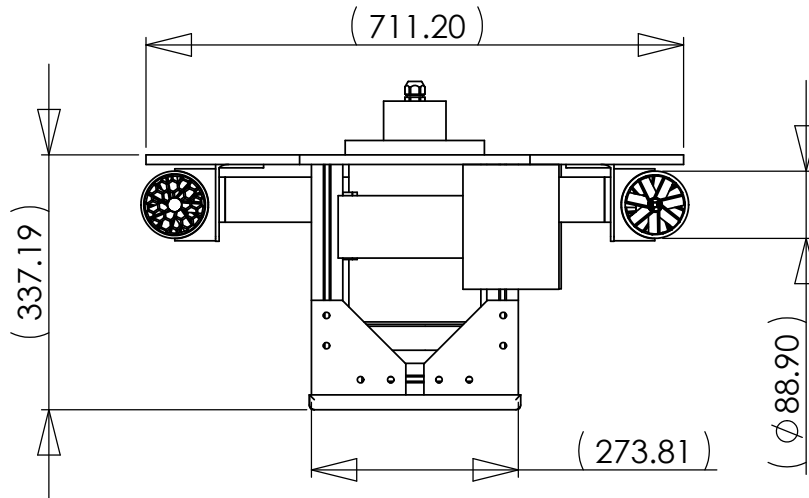
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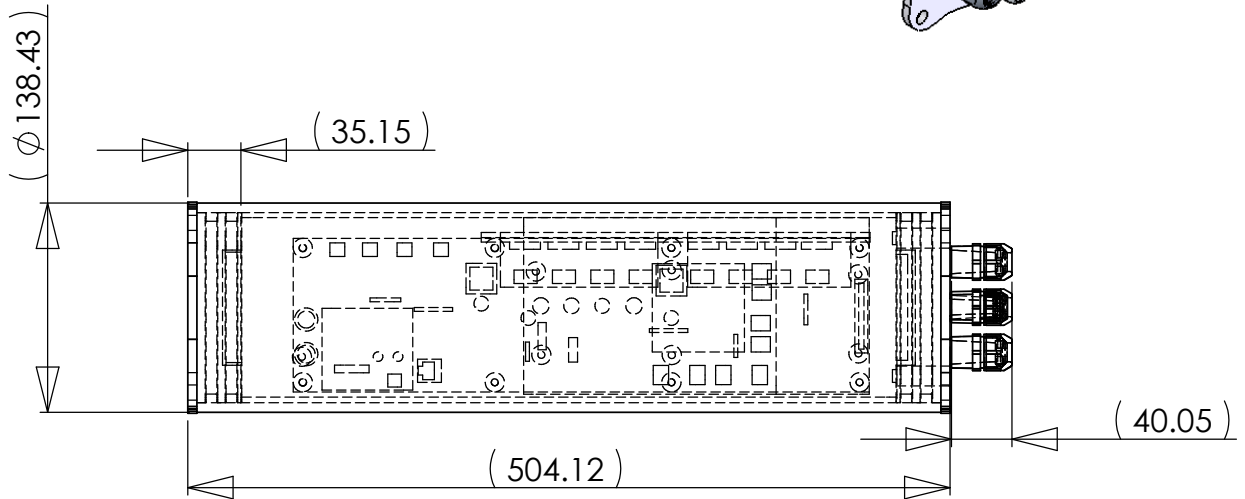
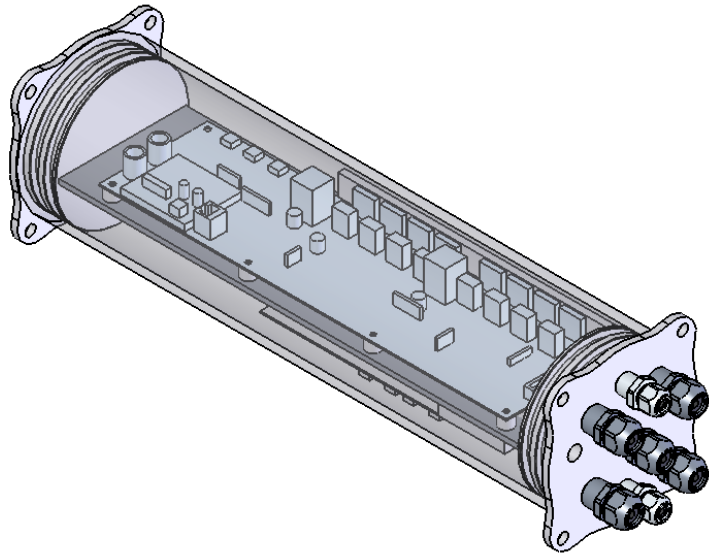


TOP VIEW

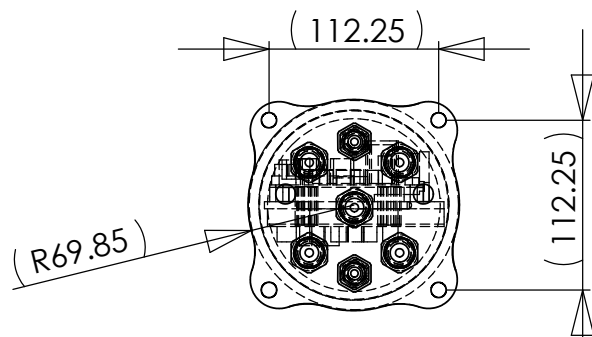


SIDE VIEW

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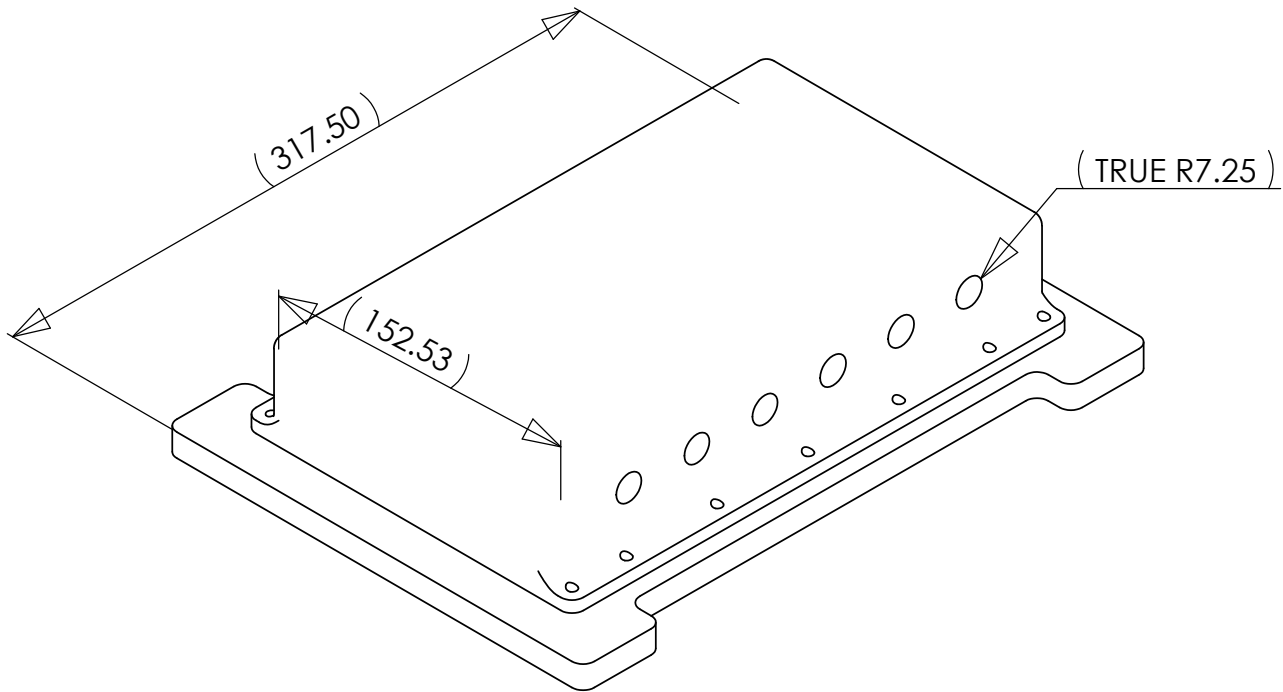


CONTROL SIDE VIEW

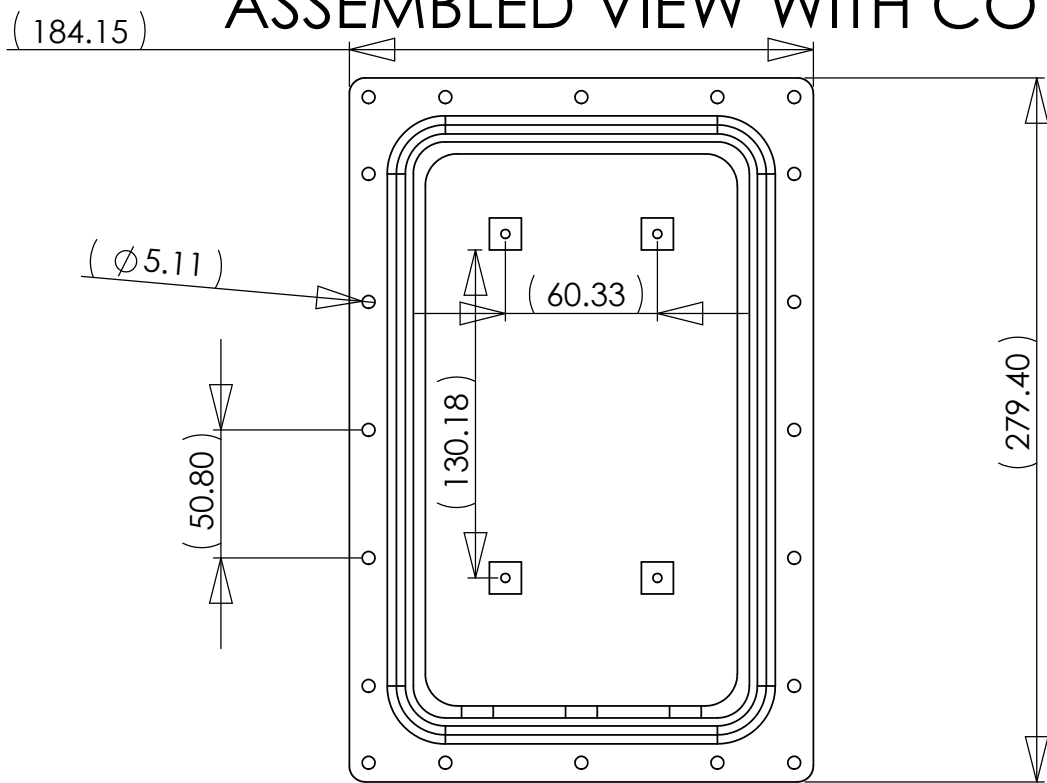


CONTROL END VIEW

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ASSEMBLED VIEW WITH COVER



INSIDE VIEW WITHOUT COVER

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