2016 MATE
International
ROV Competition

L.P. ROV Design Co

Liceo Ponceño, Ponce, Puerto Rico

Technical Report

Yoliann Quintana (10th grade): Chief Executive Officer; Pilot
Nicolás Loyola (10th grade): Operational Assistant
Eva Pellot (10th grade): Administrative Assistant; Co-Pilot
Adrian Ruiz (10th grade): Safety supervisor assistant; ROV Pilot
Yaidimar Pallens (9th grade): System Engineering; Pilot.
Gabriel Peña (9th grade): Propulsion, Control, Navigation Sensors, Payload; Co-Pilot-Payload controller; Media Director
Mentor: Mrs. Marlene Torres

Technical Report

Table of Contents:

I.	Abstract	2
II.	Company Members	3-4
III.	Understanding of ROV	4
IV.	Budget	
	a. Cost projection	4
	b. Project Costing	5-6
V.	System Integration Diagram (SID)	7
VI.	Mission Theme	8
VII.	Design Rationale	8
VIII.	System Design	9
IX.	Troubleshooting Techniques	11
X.	Safety	11- 12
XI.	Challenges	12
XII.	Lessons Learned	12
XIII.	Future Improvements	13
XIV.	Reflections	13
XV.	Teamwork	13-14
XVI.	Project Management	14
XVII.	Acknowledgments	15
XVIII.	References	15
XIX.	Photo: ROV part	16-17

I. Abstract

The LP ROV Design Co. specializes in building submersible Remotely Operated Vehicles (ROV). Our goal was making an efficient, capable of performing different tasks vehicle in which we can incorporate years of learning in the underwater robotics programs. This model has been designed for the competition held in NASA Johnson Space Center's Buoyancy Lab. The ROV has to complete five tasks: recover mission-critical equipment, identify forensic fingerprints and identify corals, rigs to reefs (which involves decommissioning the platform and turning it into an artificial reef) and mission to Europa (that consist of the measure of water depth and temperature). The process of designing, prototyping, building, and final testing began a year ago. Since then we aim to provide our clients with the necessary tools to accomplish this missions. This ROV is perfect for working in different and challenging areas that the human can't reach. For this we added some special features to our ROV like a mechanical arm, cameras, a total of four motors and a sensor.

II. Company Members

Yoliann Quintana:

Company role: CEO, Designer, Propulsion, Control, Payload and Tether manager: ROV Pilot
Yoliann is in 10th grade at Liceo Ponceño, Ponce. This is her first year in the MATE ROV Competition; 3rd year in underwater robotics competition.

Nicolás Loyola:

Company role: Operational Assistant, Ballast and Power; Safety Supervisor
Nicolás is in 10th grade at Liceo Ponceño, Ponce. This is his first year in the MATE ROV Competition; 3rd year in underwater robotics competition.

Eva Pellot:

Company role: Administrative Assistant, Power and Tether manager; Co-Pilot-Payload controller; Public relations
Eva is in 10th grade at Liceo Ponceño, Ponce. This is her first year in the MATE ROV Competition; 3rd year in underwater robotics competition.

Adrian Ruiz:

Company Role: Designer, Ballast and Tether manager; Safety supervisor assistant; ROV Pilot
Adrian is in 10th grade at Liceo Ponceño, Ponce. This is his first year in the MATE ROV Competition; 3rd year in underwater robotics competition.

Yaidimar Pallens:

Company Role: Design, Propulsion, Control, Navigation Sensors, Payload; Pilot.
Yaidimar is in 9th at Liceo Ponceño, Ponce. This is her first year in the MATE ROV Competition; 2nd year in underwater robotics competition.

Gabriel Peña:

Company Role: Ballast, Propulsion, Control, Navigation Sensors, Payload; Co-Pilot-Payload controller; Public Relations

Gabriel is in 9th grade at Liceo Ponceño, Ponce. This is his first year in the MATE ROV Competition; 2nd year in underwater robotics competition.

Mrs. Marlene Torres

Mentor

III. Understanding the ROV

Every member in our team was assigned to design an ROV model. After brainstorming each model, we ended up choosing two and start designing, all together, from that one. Using that two designs as a base we ended up with a quadrilateral shape. After having the design chosen, we had to choose the material. For the material we used PVC pipes, a material that we previously had used before in our ROV models. For buoyance pieces of EVA foam were used, it has low-temperature toughness, stress-crack resistance, hot-melt adhesive waterproof properties, and is resistant to UV radiation. The robot needed some specific tools like cameras and payload. The mechanical claw is powered by a servo motor, that we waterproofed. The view of the claw was possible using a rear camera and waterproof it ourselves. We decided to add a second camera, the **FP100 Fish-Phone WI-FI Underwater Camera System**, to had a complete frontal view while working with the ROV. We used the **Elite-5 CHIRP sonar** in order to complete the mission Outer Space: Mission to Europa.

IV. Budget

Cost Projection

As part of a student organization, we received the institutional support of our school in different ways, such as funds, equipment or materials, and the authorization to make fundraising activities. We estimate that we would need to spend approximately between $1,500-$2,000 to build our vehicle. We made decisions to reduce costs and request donations. Our final budget of $1,540 allow us to build our ROV.

Project Costing

Item	Amount spent(USD)	Total value (USD)	Donated/discounted/ re-used
Frame	$3.29	$6.07	
PVC PIPES (10ft)	$1.75	$1.75 ea.	-
PVC Tees (5)	-	$0.75 ea.	Re-used
PVC 3-Way Elbow (8)	-	$1.20 ea.	Re-used
PVC CROSS (2)	-	$1.60 ea.	Re-used
PVC Female adapter (2)	$1.54	$0.77 ea.	-
Flotation	$13.49	$13.49	
EVA Foam	$13.49	$13.49	-
Propulsion	$139.45	$139.45	
Johnson pump 1250 GPH Motor	$103.24	25.81 ea.	-
Shrouds	$36.21	$36.21	
Tether	$177	$193	
18/8 Wire(100ft)	$65	$65	-
6-Pin Cable	$72	$88	Discount
Speaker Cable	$25	$25	-
CCTV Cable	$15	$15	-
Cameras	$270	$270	
Rear camera waterproofed (with monitor)	$60	$60	-

Vexilar FP100 FishPhone WIFI	$210	$210	-
Control Box	$29	$699	
Trigger Fish Kit MATE Control	$0	$670	Donated
RIGID tool Box	$29	$29	-
Gripper	$12.40	$27.39	
Parallel gripper	-	$14.99	Re-used
Servo	$12.40	$12.40	-
Sonar	-	$349.00	Donated
Tooling	$479.77	$500	Discounted
Misc.	$248	$300	Discounted

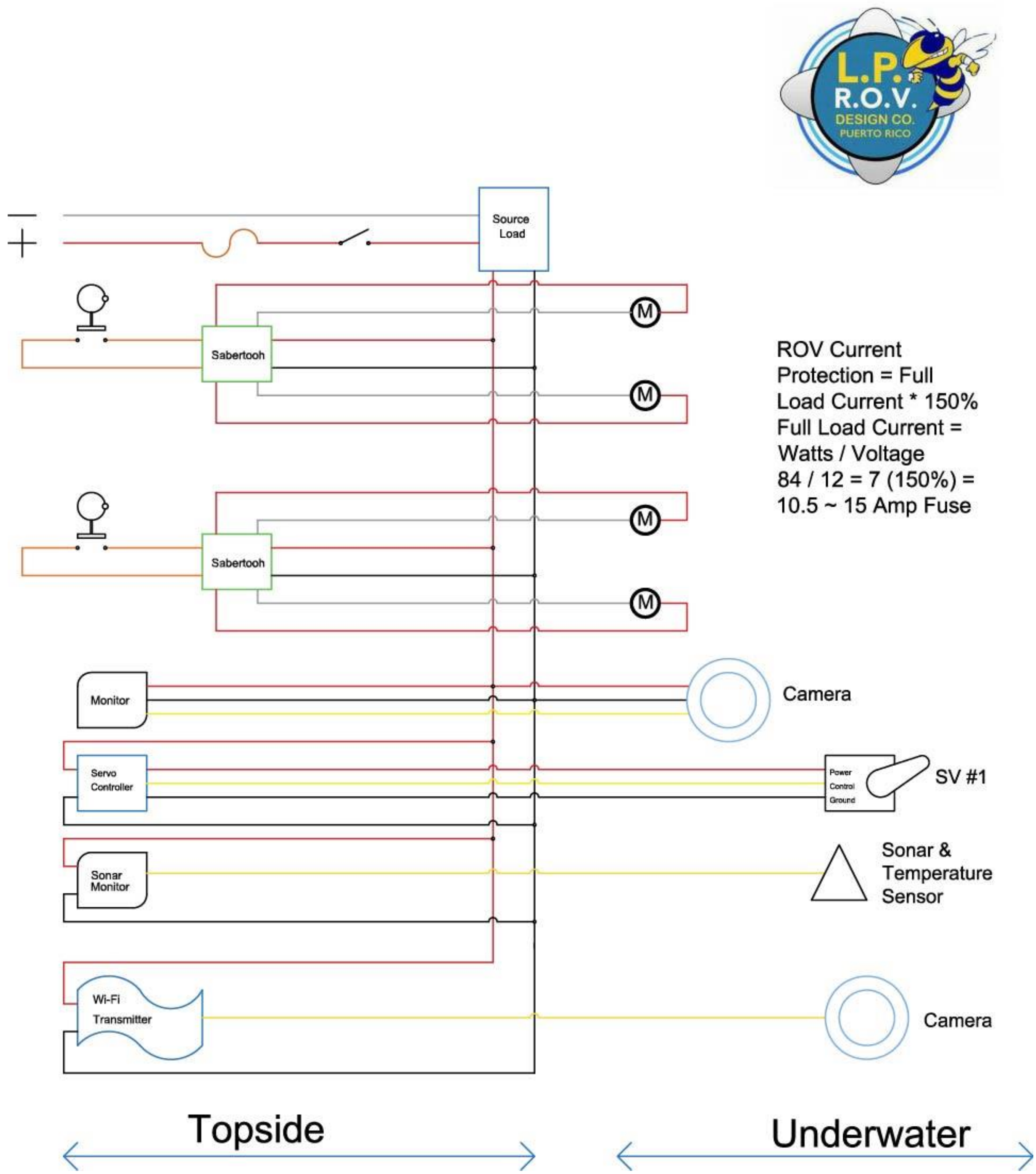
Income, donations and use of funds

Value of Donated parts	$349.00
Income (USD)	$1,540
Amount Spent	$1,372.40
Total Value	$2,497.40
Savings	$1,225

Other costs

Travel for 6 members	$2,790.00
ROV transportation	$350
Team transportation	$379.00
Hotel	1,278.41

V. System Integration Diagram (SID)



VI. Mission Theme

ROVs are tools for search purposes in this case space is our field of study. Mostly these devices are used for underwater and terrestrial investigations but ROVs now are going to be used in outer space. National Aeronautics and Space Administration (NASA) and Oceaneering Space systems (OSS) have requested for proposal (RFP) for a first-of-its-kind, dual purpose remotely operated vehicle that can operate in the harsh environments of both the deep ocean and outer space. These organizations are in need of an ROV that can:

1) Survive a trip to Jupiter's moon Europa and operate in the ocean under its ice sheet to collect data and deploy instruments

2) Find and recover critical equipment that sank in the Gulf of Mexico after a recent series of testing programs

3) Collect samples and analyze data from oil mats located in the northern Gulf of Mexico to determine to determine their origin

4) Photograph and collect samples of deep-water corals to assess their health post-Deepwater Horizon oil spill

5) Prepare a wellhead for decommission and conversion into an artificial reef.

VII. Design Rationale

During the process of designing our ROV model, some features were taken in consideration. For instance, the ROV in RANGER class, has limitations in weight and size. For example, it has to fit in a hole of 75cm and weight less than 14.0Kg, but bonus points would be awarded to companies that design smaller and lighter vehicles.

a) Frame and Flotation

The frame is made of polyvinyl chloride, commonly abbreviated PVC, of ½". In this form, it is also used in electrical cable insulation, imitation leather, signage, inflatable products, and many applications where it replaces rubber. PVC's relatively low cost, biological and chemical resistance and workability have resulted it being used for a wide variety of applications. PVC also has high hardness and mechanical properties, helping us achieve a better product. For flotation we used a kickboard made of EVA foam. We divided the board and installed it on the ROV until the desired buoyance was reached.

EVA foam kickboard used as floaters

b) Motors and Shrouds

The motors we are using in this particular vehicle are the Johnson 1250 GPH (gallons per hour). This motors were chosen because they are efficient, powerful, and have long lasting hours. It also has universal replaceable twist lock motor. Our motors are fully submersible and have 3-year warranty.

For the shrouds we used PVC strainers on the tees that holds the motors. In order to attach them we used epoxy. The PVC strainers used weren't enough for safety, we needed 2cm behind and in front of the propeller. For this we attached a PVC adapter in front of the strainer. The PVC attached to the strainer satisfied our safety expectations.

c) Control System and Tether

The control system we use for our ROV uses analog system. Using a motor-simulation board with two saber-tooth motor helps control the motor system. The motor simulation board provides information about the status and direction of the motors. The saber-tooth has shown to be reliable, versatile, and designed to accept a variety of input signals and power sources allowing us to make the perfect ROV. The saber-tooth are mapped to joysticks that are input devices consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling, also known as the control column. We have a volt/amp/watt meter for continuous system monitoring. Our control system has a kill-switch, which is also known as an emergency stop. The kill-switch is a safety mechanism used to shut off the device in any situation, it shuts down all of the systems instantly turning the vehicle off without damaging it. Our company has a blade fuse holder that connects to the battery or main source of power.

The tether contains this cables:

- 18/8 for our 4 motors
- 6-pin cable for the sonar
- Speaker wire for the servo
- Fish-Phone camera cable
- CCTV cable for camera

Speaker wire for servo

d) Cameras

The ROV is prepared with 2 cameras. One of our cameras is a rear camera used for cars. The camera is water resistant (IP67) but for safety issues is waterproofed on an acrylic tube. The acrylic tube then it's filled with non-conductive clear epoxy, sealing the electronics. This camera is directly connected to a monitor which gives the pilot a live image that is wide-angle.

The camera is pointed on a downward angle, to view objects on the ground as well as the position of the walls and the mechanical arm. The second camera is the **FP100 Fish-Phone WI-FI Underwater Camera System** that as the name implies is a camera that turns your phone or tablet in your monitor. Fish-Phone is a stand-alone, fully functional, smartphone controlled system that allows you to record video or still images. This camera creates its own hotspot that reaches out 30.48m (100feets) in all directions.

FP100 Fish-Phone WI-FI Underwater Camera System

e) Mission Specific Tooling

In order to do tasks that we were assigned, we needed to put a sensor that can measure temperature but we also needed an instrument to measure the depth according to our position in the pool. We decided to incorporate to our ROV a fish-finder that is an instrument used to locate fish underwater and the depth of the ocean by sending sound waves. We are going to use it to measure our position on the pool and the thickness of the ice crust. A modern fish-finder displays measurements of reflected sound on a graphical display, allowing an operator to interpret information as the depth and temperature of the current location.

The ROV has a mechanical arm powered by a servo. A servo is a small device that has an output shaft. This shaft can be positioned to specific positions allowing movements to the arm. The position of the servo and position of the arm is controlled by a servo tester. A servo tester can be used manually to control a servo clockwise or counterclockwise. The mechanical arm of the ROV was improved by putting a plastic servo horn and cut it in 2cm and then attaching it with a screw. In the borders of the grip we put a 5cm purple yoga mat that is made of PVC for better hold in our missions.

VIII. Original vs. Commercial

Item	Why it was selected (Make vs buy explanation)
Primary Camera	Thin and light camera with 170° of vision.
FP100 Fish-Phone WI-FI Underwater Camera (COTS)	Easy to connect to a monitor. Allows you to record video or still images.
Johnson Pump Motors (COTS)	Completely submersible, 1250 GPH for speed.

Control Box	Use and acquire knowledge on electronics. Able to manipulate completely and accommodate things to our benefit.

COTS- Commercially of the shelf*

IX. Troubleshooting Techniques

Problem	Troubleshooting technique employed
Control not turning ON	Check power plugs, and that the kill switch is ON position. Check the fuse, change if necessary.
Motors keep moving without touching the joysticks	Calibrate the potentiometer by unscrewing it and moving it up or down.
While moving the joysticks the motors don't move	Check the signal and power connection at the saber tooth and potentiometer.
Mechanical arm keeps moving automatically	Change the mode on the servo tester to manual.
Gripper doesn't open or close	Check the servo tester connection.
Monitor doesn't show image	Check the signal connection between the camera and monitor.

X. Safety

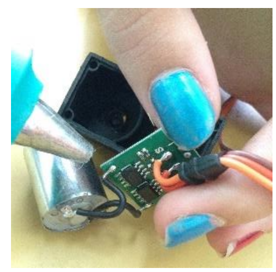
Safety is our number one priority. Safety is a crucial component for a professional vehicle. ROVs use electricity in close proximity to water, because of this we made a checklist of what we should check and follow in order to be completely safe when the ROV is being used. This year's vehicle is completely safe, it has shrouded motors, a fuse, a kill switch and no sharp edges. This are the safety features that our ROV has, but the company also followed a safety protocol which required Personal Protective Equipment (PPE). Our company's PPE includes wearing a life vest, safety glasses, masks when treating hazardous substances, safety helmets and closed-toe shoes.

The members close to the pool are wearing life vest?
Are all members using safety glasses?
Are all members using closed-toe shoes?
Is there a fuse?
Are we wearing safety helmets?
Are the two main power (Anderson power pole connectors) connected properly?
Is the switch in OFF position?

XI. Challenges

A) Technical Challenge

Our biggest technical challenge was waterproofing the servos needed for our mechanical arm. We had already used waterproof servos at a lower depth but never at the required for the competition. When using these servos at the required depth our servos stopped working, which let us know we needed to improve the waterproofing of the servos. After we did some research and tests we found that the most efficient way of waterproofing servo was by sealing the components inside it.



Company member sealing the servo

B) Non-Technical Challenge

A non-technical challenge that our company faced was to make a decision in which all company members were satisfied with the outcome. For example, in the process of designing our ROV not all of the company members agreed in the size or shape. At the end, we learned to appreciate all the ideas given by the company members and select the most efficient one.

Making decisions about safety

XII. Lessons Learned

a) Technical Lesson:

During the process of designing and making our ROV we learned that there are some features to take in consideration with advance, the specifications given to us in order to make an efficient ROV. We should build the vehicle having in mind the future improvements for the ROV and how to make it the most versatile possible. Another lesson learned was while testing our ROV, to manage and control our ROV just looking through monitors and on a larger depth than the one we had experience with. This lessons led us to a great administration of the company, as a result having a cost-effective and versatile product.

b) Interpersonal Lesson:

During this year of preparation for the competition we learned to process information and hear attentively to all team members. We learned that listening is the key to all effective communication. In the process of designing the ROV when the message was misunderstood we ended up with a complication.

XIII. Future Improvements

As a company we accomplished to be satisfied with our model and what it does but, we want to create the best and a versatile model that anyone could use. After testing our ROV we brainstormed new ideas to improve it. One of the ideas we really want to make possible is to change the material of the frame of the ROV. We would like to test the carbon fiber since it is lighter than PVC and could give us a faster and stronger ROV.

XIV. Reflections

One of our goals for this competition was to achieve a cost-effective and versatile ROV. For this we realized that simple systems worked greatly and they also helped us achieve our goal. After achieving a cost-effective ROV, we also accomplished another of our goals, that was apply our previous knowledge and gain more. We accomplished that by using the servos we used before but waterproofing them. While working with the servos we applied knowledge and gain more. In the end, we accomplished our goals and the new useful skills learned, helped us make our ROV work exactly as expected.

XV. Teamwork

The company organized each member into different groups with a different task to bring the company forward. Each group prepared with three members for better organization and development. Each member has an area of concentration, but all members have knowledge on every aspect of our ROV. These groups were made in order to begin our research on the different parts of the ROV. After the research phase, our company worked together through all the building and testing phase. Our goal always being learn as much as possible and apply our previous knowledge.

Organizational chart

XVI. Project Management

This project began a year ago. This year is our first MATE Competition, but we already had experience building ROVs. We had never built a ROV of this scale, because of this we had to do some research on MATE ROVs from past years' competitions. After the research we noticed we were able to remove and re-use parts of our old ROVs incorporating them to our first MATE ROV.

In order to achieve everything, we wanted for this competition, we created deadlines. This helped us organize our time and have a better result at the end. As the due date got closer we focused more on the ROV leading us to a design that we spend time creating, that satisfied our needs and filled our expectations for the MATE 2016 Competition.

XVII. Acknowledgments

We would like to thank the following people and organizations for supporting L.P. ROV Design Co.

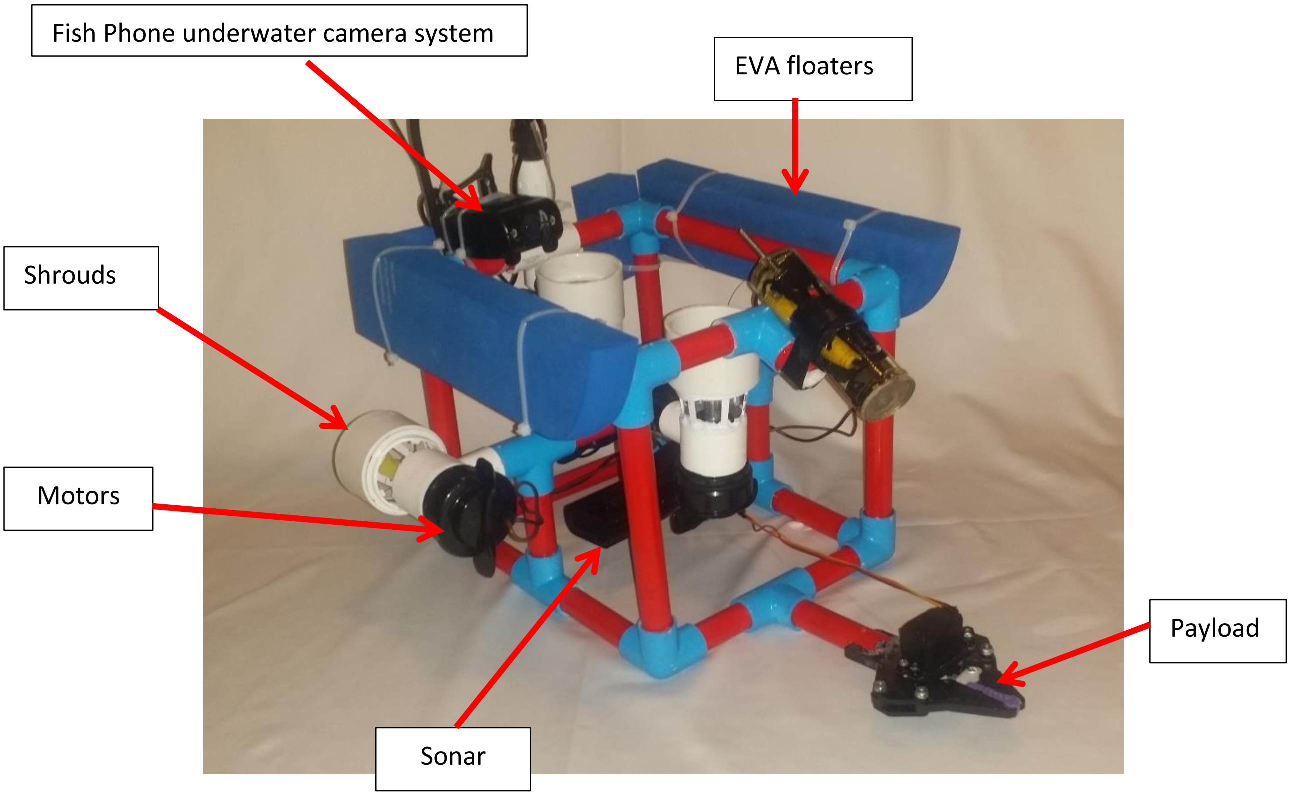
- Liceo Ponceño, Mrs. Marlene Torres; Administration and faculty
- Learning by Doing – Mrs. Aymette Medina
- Puerto Rico Top Level Domain
- Municipio Autónomo de Ponce, Complejo Acuático Víctor Vasallo
- CIAPR-Ponce- Ing. José Vera (President)
- Ing. Julio González, Ing. Anthony Figueroa
- Ing. Juan Sebastian Luz Puerta
- Angel Quintana, Yarixsa Ithier, Maria Nieves, William Pellot, Joyce Vargas, Daniel Ruiz, Carlos Pallens, Carmen Rivera, Mariceli Rodriguez, Ramón Peña, Maria Otero, Norberto Loyola, Ricardo Capriles
- All MATE Competition officials and volunteers

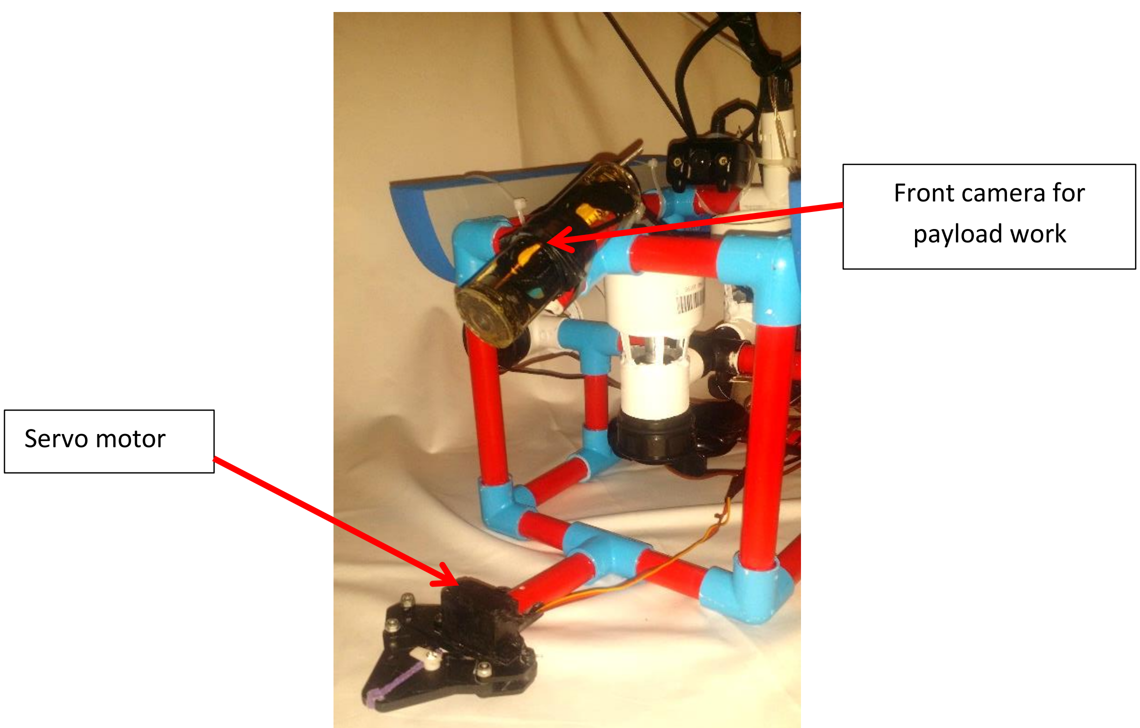
XVIII. References

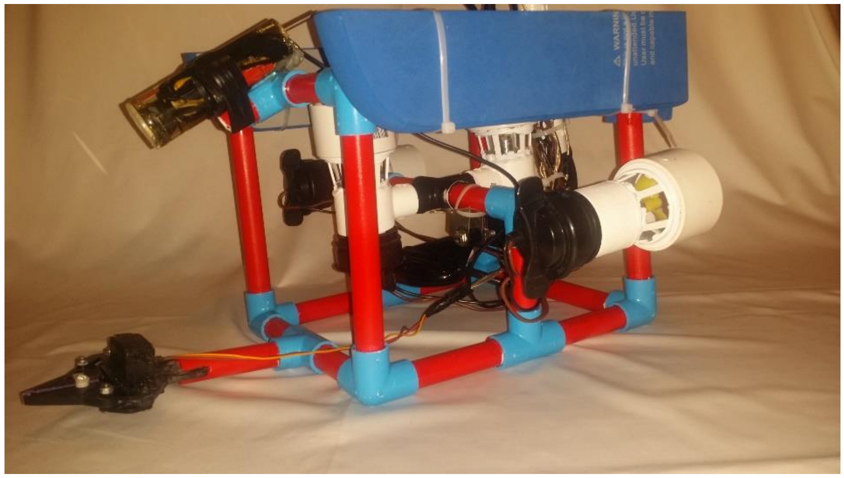
1. Deepwater Horizon oil spill:
    - http://www.britannica.com/event/Deepwater-Horizon-oil-spill-of-2010

2. Mission to Europa:
    - http://www.space.com/24926-nasa-europa-mission-2015-budget.html

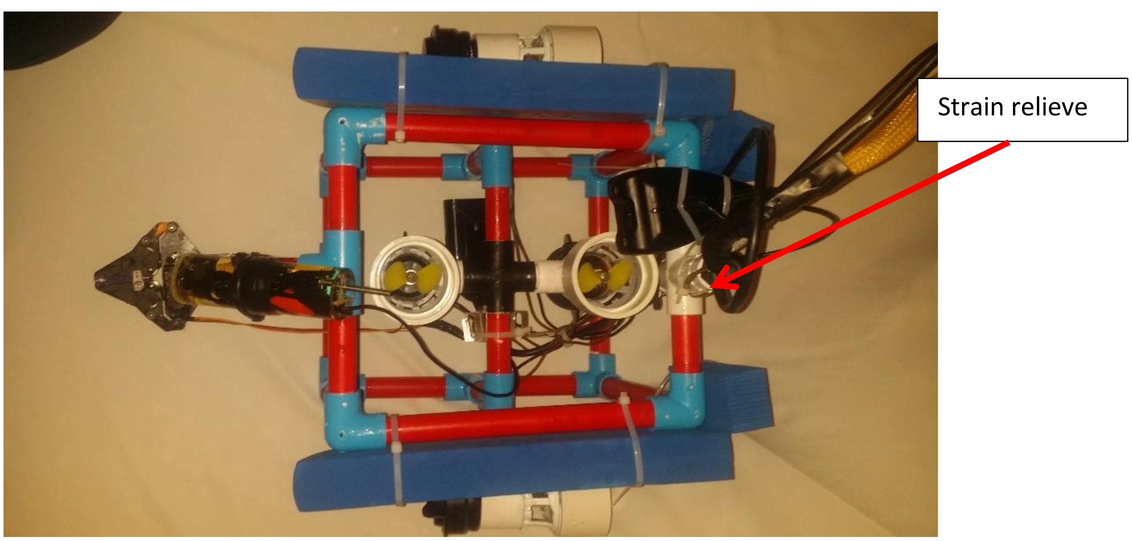
Photos ROV Parts







Lateral view



Top view