



2015 MATE International ROV Competition

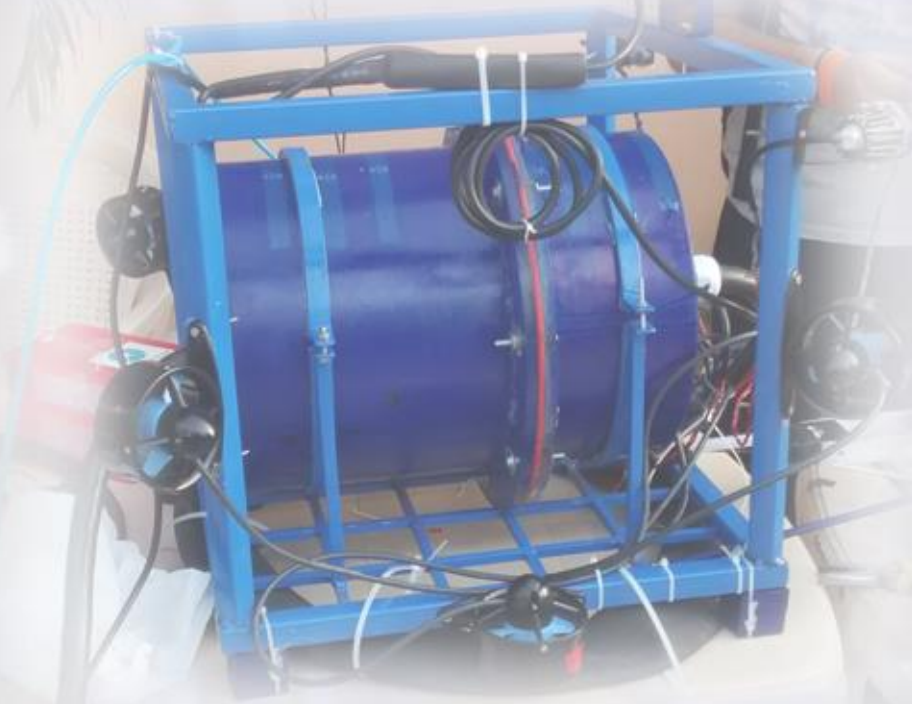
SVKM's NMIMS Mukesh Patel School of  
Technology Management & Engineering



"TEAM SCREWDRIVERS"

# VIKRANT

## EXPLORER CLASS



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**Mumbai, India, 2015**

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# ABSTRACT

“Teaching is Arrogance, we believe in creating a Learning Environment”

We at TEAM SCREWDRIVERS are proud to present VIKRANT, an underwater ROV meant to carry out explorations in the extreme weather conditions of the Polar Regions. We feel proud to represent India internationally and strive to innovate and bring forth the best of what we have learnt.

This report gives a detailed understanding of how we designed, developed and tested the various ROV subsystems. Apart from that, it also highlights our efforts as a team to promote knowledge of marine science amongst school children, general publics and others, through our various “TS Outreach” programs.

We have inculcated the learnings of our MATE 2014 experience and made improvements in this year’s design accordingly. Our focus this year during designing was on weight and easy maintenance of the ROV. Inspired by the “Make in India” fervour gripping our country, majority of the components used were sourced from national vendors.

This year, we have used mild steel for the frame and designed a mounting bracket for every component. A rotating base system helps provide storage on the ROV. For the propulsion system, 4 out of the 8 thrusters have been developed in-house using bilge pump motors. The program for controlling the ROV has been designed using C++ Language. The ROV was designed using CAD software. Use of an aesthetically designed GUI simplifies the job of piloting the ROV.

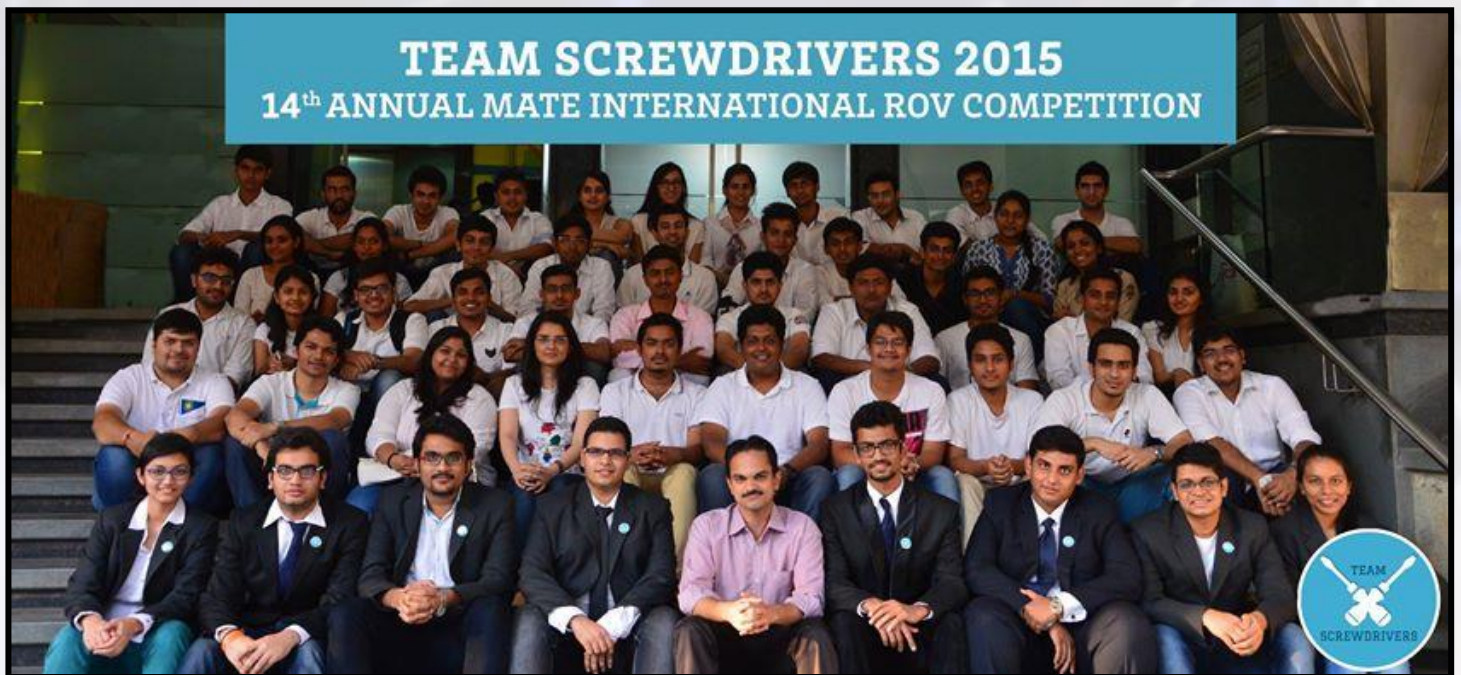


Figure 1: Team Screwdrivers

# DEVELOPMENT OF VIKRANT

## INTRODUCTION TO TEAM SCREWDRIVERS

A screwdriver is an integral tool in a mechanic’s toolbox. It is that force that locks the screw that holds the entire machine together. We at TEAM SCREWDRIVERS are here to fix together our research, expertise, passion and knowledge to create a unique solution for today’s problems. Founded in 2011, our team has participated in NASA’s Lunabotics, Human Explorer and Great Moonbuggy Race competitions in previous years. This is our second year at the MATE International ROV Competition. Our faculty mentor, Mr. Sawankumar Naik, has guided us through our various endeavours. The team consisted of the following departments along with core members like CEO, CTO, CFO, etc.:

- MARKETING**
- LOGISTICS**
- EDITORIAL**
- OUTREACH**
- ELECTRONICS**
- PROGRAMMING**
- DESIGN**
- MANUFACTURING**

## PROJECT TIMELINE

TEAM SCREWDRIVERS has followed a systematic approach in formation of the company. Last year’s core team members and our faculty mentor, interviewed the interested students and allotted them to different departments based on their calibre. The project kick-off meeting had senior members talking about the competition, its nature, our objectives and expectations from the members.

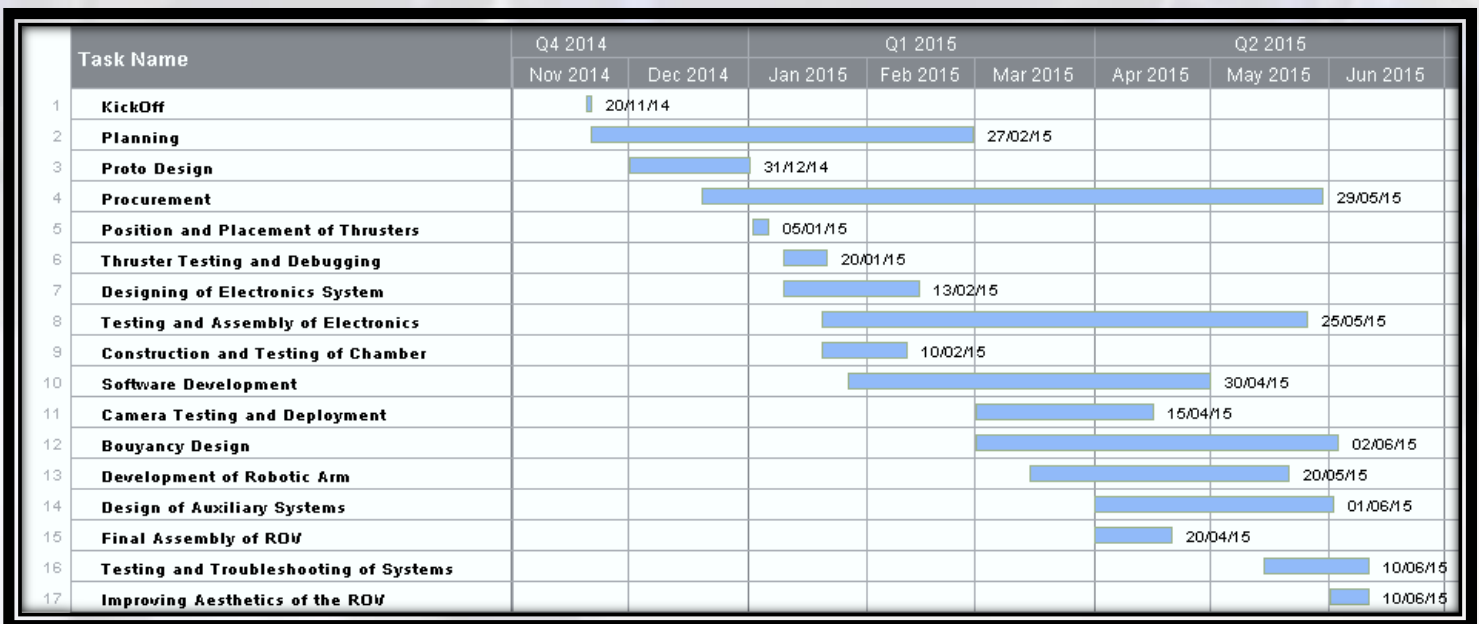


Figure 2: Project Gantt chart

## SAFETY PHILOSOPHY

### Company safety Motto

*“Be safe, don’t rely on fate, It’s the only way you’ll make it to MATE!”*

At TEAM SCREWDRIVERS, we like to believe in a “Better be safe than sorry approach”. Safety is something that cannot be compromised upon, so all members were clearly instructed to follow the guidelines as mentioned in the safety checklist. However, to avoid creating an atmosphere of rigidity, a motto with a sense of humour was made, so the message of safety is passed clearly, but in a light hearted manner.

At every step of the development process of our ROV Vikrant, we have ensured that there were adequate measures taken for safety purposes. Precautionary measures have been taken to prevent any possible injury.

A few of the safety protocols are discussed as follows –

- ➔ The tasks were done systematically, after ample planning. Enough time was dedicated for each operation so as to complete it in one attempt.
- ➔ The team members working with mechanical tools wore protective gear and fully covered shoes. They used hand gloves, safety goggles and masks to cover their noses and mouths.
- ➔ Waterproofing was done precisely, to prevent any chance of damage to the parts due to leakage. It was ensured that all the team members working on this aspect of the ROV wore gloves and protective gear.
- ➔ All members had to follow all the points mentioned in the company developed Safety Checklist (Appendix B).
- ➔ A Job Safety Analysis (JSA) document was also developed. Members had to refer to the safety guidelines given for the various job tasks, before beginning work on the ROV.
- ➔ No electronics components were tested without attaching an appropriately valued fuse to it.
- ➔ Our ROV has all the potentially dangerous/harmful parts color coded in yellow and black stripes.



**Figure 3: Tool Safety**



**Figure 4: Drilling Safety**



# DESIGN RATIONALE

## FRAME

Weight and Easy Maintenance have been at the core of the designing process. Incorporating the learnings from the last year's experience, we have made several modifications to the frame of the ROV. Firstly, Mild Steel has been used for the frame. The shape of the ROV is cuboidal, allowing us maximum volume for the components. The dimensions of the ROV are 450mm x 420mm x 400mm.

The pillars of the ROV have been mounted at a 45° angle to get the best effect of thrusters. The side plates have been designed using polypropylene. We have designed mounting brackets using mild steel for individual components such as the electronics chamber.

The designing of the frame was done using the SolidWorks software. The software allowed us to perform stress analysis of the frame, apart from helping us choose the best possible structure.

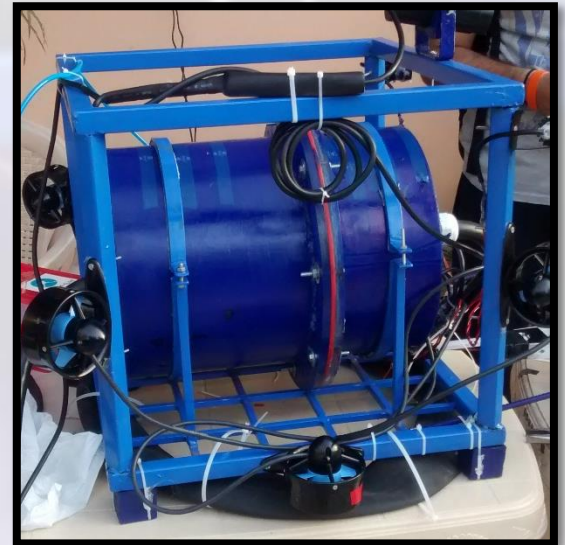


Figure 5: Frame Structure

### WE CARE ABOUT SAFETY!!

Care was taken to ensure that all the end joints with the possibility of sharp edges were properly ground off, chamfered or coated with Rubber/Silicone gel.

## SYSTEM INTERCONNECTION DIAGRAM

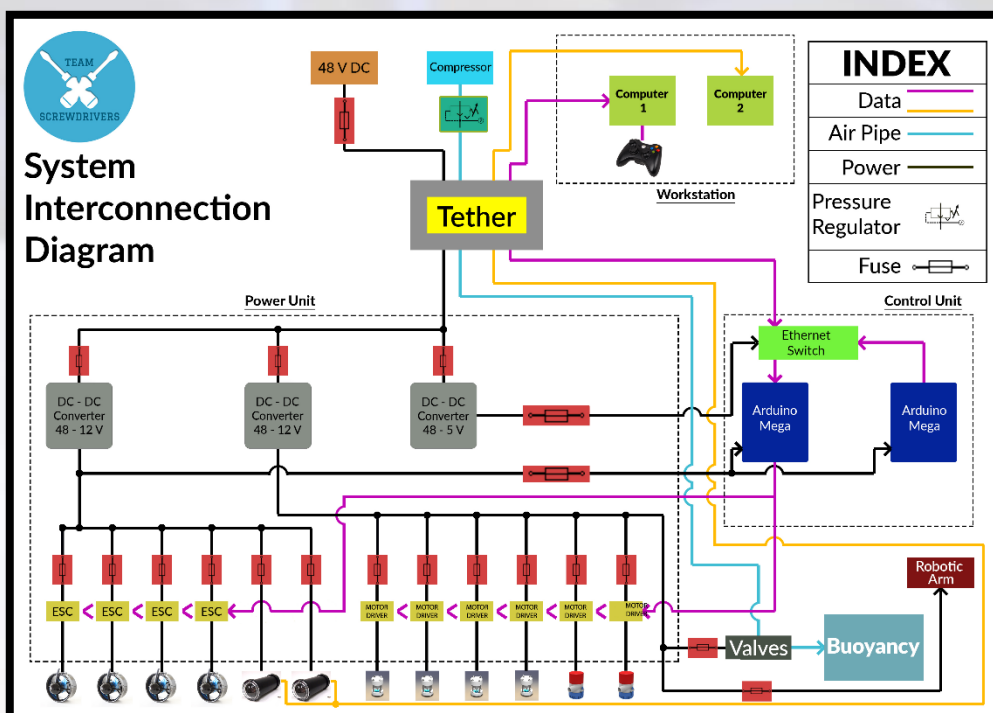


Figure 6: System Interconnection Diagram

The system interconnection diagram illustrates the control logic for the ROV. It explains the various interconnections between the components as well.

The main power supply of 48V DC is given as input to 2, 48V-12V, and 1, 48V to 5V DC to DC converters, procured from Proxim Asia Ltd.

The ROV will be maneuvered by a USB joystick controller, connected to a laptop. The software program will convert it to UDP packets and send it via Ethernet (CAT6 cable) to the ROV. An ethernet switch on board will send the control signals to 2 Arduino Mega 2560 microcontroller boards, attached with ethernet shields (without PoE). One Arduino board will be used to receive signals from the controller, and the other will be used to relay sensor data back to the workstation.

Four Blue Robotics T100 thrusters are used for turning the ROV around. At any point of time, only 2 thrusters will be operational. These brushless motors are controlled using 30amp DYS ESC's (Electronic Speed Controller's), that are flashed with SimonK software. The other 4 thrusters, used for the vertical motion of the ROV, are made in house. Locally sourced fully submersible bilge pumps were modified to create them. For operating them, 20A, Dual DC Motor Drivers will be used.

The buoyancy system gets air supply from a compressor at the work station, via a pressure regulator that maintains the air pressure at the specified psi value. A relay switch board and solenoid valves are used control the buoyancy. The relay switch is controlled by the Arduino Mega.

The main camera mounted on the front face of the ROV, is connected to a laptop at the workstation via an EasyCap USB converter. This allows us to view live video feed from the ROV. Secondary cameras are connected in a similar manner.

## **SAFETY IS IN OUR HANDS!!**

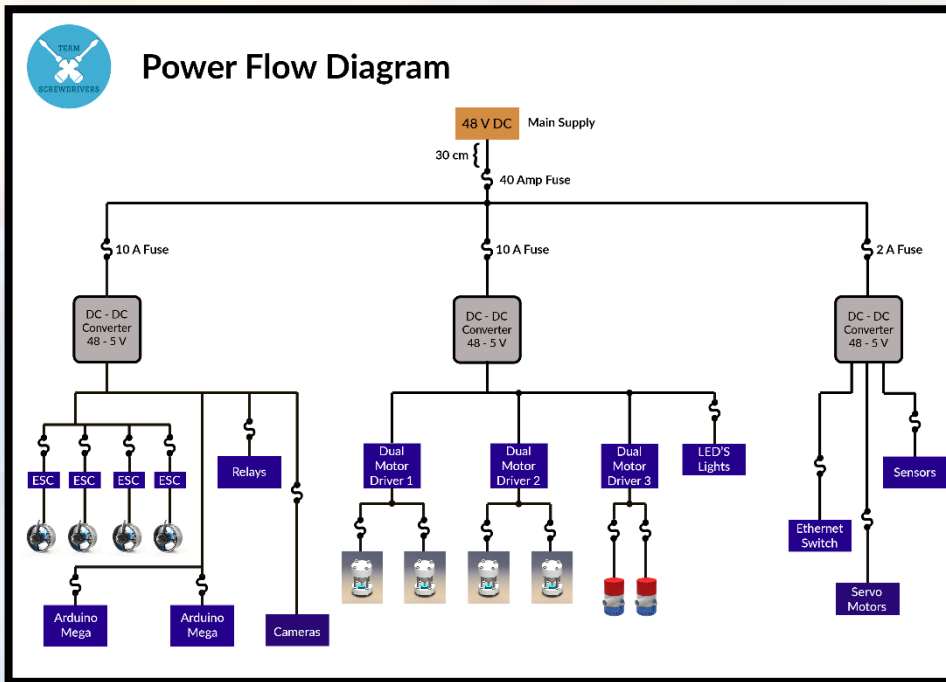
### **Safety characteristics of DC – DC Converters:**

Output Over Voltage Protection	➔ Present
Output Short Ckt Protection	➔ Present
Input High Voltage Protection	➔ Present
Safety Standards	➔ UL 60950 Recognized & conforming to IEC1000-3-2 Compliance
	➔ CUL 60950 Recognized
	➔ TUV EN60950 Licensed
Input-Output Isolation	➔ DC-500V

### **Safety features of dual DC motor drivers:**

They have a braking feature that can guarantee immediate halt on the shaft of motors in most high power applications and also includes protection circuitry to avoid any electrical fluctuations affecting the normal operation of a microcontroller.

# POWER DISTRIBUTION DIAGRAM



**BE SAFE THAN SORRY!!**

Fuses:

Current (A)	Location
40	Main Supply
10	48 – 12 V Converter
2	48 – 5 V Converter
15	ESC
1	Arduino Mega
2	Ethernet Switch
6	Motor Drivers
5	Servos
2	Lights
2	Camera

Figure 7: Power Distribution Diagram

The main DC power supply of 48V will have a 40 Amp fuse connected within 30cm of the power connection. This line is then extended to the ROV, where it provided as input to 2 48V-12V DC to DC converters and 1, 48V-5V converter.

The 12V output of the first converter will be used to power:

- ➔ 4 ESC'S (i.e., 4 T100 thrusters)
- ➔ 2 Arduino Mega boards, through DC jacks.
- ➔ The primary and secondary cameras.
- ➔ The relay board that controls solenoid valves for the buoyancy system.

The 12V output of the second converter will be used to power all dual DC motor drivers and LEDs. These drivers will in turn power the DC motors.

The output of the 5V converter will power the Ethernet switch, servo motors used for robotic arm and base plate and various other sensors used.

## TETHER

The tether of the ROV is 25 metres in length. This length was calculated keeping in mind the various tasks VIKRANT has to perform underwater. The tether consists of 4 cables. The first one is a 2-core cable for power supply. The second cable is a CAT6 Ethernet cable, which will be used for data transfer to and from the ROV. The other two are co-axial cables, meant for transmitting composite video signals from the cameras. The tether will also include air pipes which form a part of the pneumatics system. Floats are installed at various points along the tether, to give it strength and a positive buoyancy.



## BUOYANCY

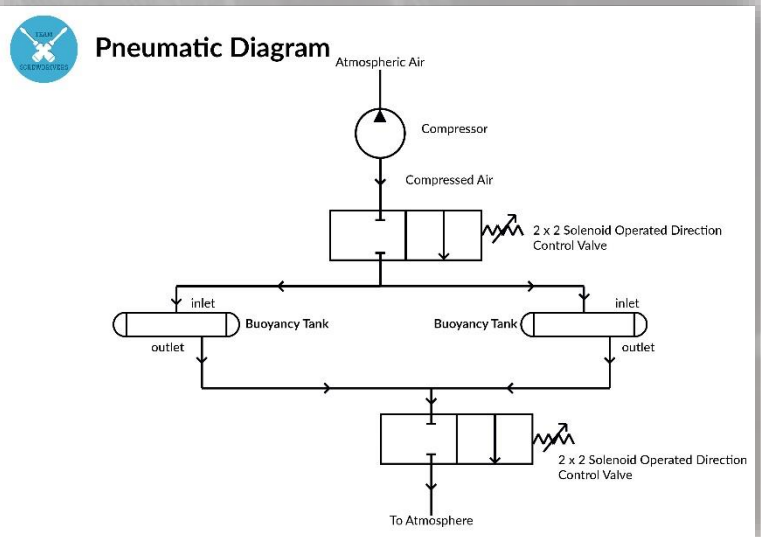
Our buoyancy system was initially designed to provide the ROV a positive buoyancy and neutralize the weight of the frame and components. However, the shape and volume of our electronics chamber (explained later) provided unprecedented positive buoyancy to the ROV, and the nature of our problem reversed. Thus, few changes were made, and the following design was fixed.

2 cylindrical tanks of diameter 100mm and length 400mm each have been used as buoyancies. PVC has been used for the buoyancy tank, as it is strong enough to withstand the pressure difference inside the pool during the tasks. Each buoyancy tank utilizes two of 2/2 solenoid valve in normally closed position – one valve for air inlet and the other for air outlet. The valves are connected to the distributors, and then to the tanks, with the help of  $\phi 6\text{mm}$  flexible tube pipes and then to the tanks.

### SAFETY FIRST!!

- ➔ The pipe connections are made in such a way to ensure that there is no chance of air-leakage from the connection joints.
- ➔ The parts were assembled and permanently fixed to ensure that there was no scope of loosening or air leakage.

Figure 8: Pneumatic Diagram



## CAMERA AND LIGHTING

The main camera mounted on the front face of the ROV, is an SCD-008 underwater camera, manufactured by Ocean River and Atmosphere Technologies. It is a fixed focus color video camera that has a composite PAL video output. The housing material is made from Delrin plastic and the camera lens has an acrylic view port. It operates on a 12V DC supply, weighs 0.4 Kg (in air) and has an FOV of 58 degrees.

The camera has an electronic iris, with a resolution of 800 TV lines. It provides an underwater view range from 150mm to 20 meters. IP cameras will be waterproofed and used as secondary cameras.

The ROV is equipped with 2 LED lamps of 12W each, which point in the forward direction. Additionally, there are 2 strips of LEDs on the ROV to provide ambient lighting.



Figure 9: USB converter for camera

### PROTECT YOURSELF!!

- ➔ Camera is reverse polarity protected.
- ➔ The LED lights are properly waterproofed so as to avoid any safety related hazards.

## PROPULSION SYSTEM

We have used 8 thrusters in the propulsion system. 4 of them are T100 thrusters manufactured by Blue Robotics and are used for horizontal movement. T100 is a brushless electric motor and can be controlled with an ESC. Its main advantages are high performance (about 5 pounds of thrust), compact design and corrosion resistance. The ESCs have inputs coming from the Arduino board and the power supply (as illustrated in the SID). We have reprogrammed the ESC's to make the thrusters operate in both clockwise and counter clockwise directions.

The remaining 4 thrusters have been developed in-house and are used for vertical movement of the ROV. They are made out of bilge pumps. The pumps were broken down, and the motor base is used. A coupler is attached to it with a threaded rod. This rod is then connected to the propeller with the help of nuts. The shrouding is a self-machined nylon ring and is rested using 4 threaded rods.

Our thrusters produce up to 1.5kg of thrust. This construction showed good results in the previous competition, and we decided to reuse them. However, we have added a couple of minor improvements in construction and propellers.



Figure 10: T100 Thrusters

### **PROTECTING THE MARINE LIFE!!**

The thrusters are perfectly shrouded so as to prevent anything from touching the propellers

Electronic components of the thruster have been insulated properly so that no wires or components are exposed.

The in-house thruster bilge pumps are rust and corrosion protected, and have:

- ➔ Moisture tight seals
- ➔ Ignition protection
- ➔ Anti- airlock protection
- ➔ No burn out when run dry

## ELECTRONICS CHAMBER

The electronics chamber houses all the electronics and ROV control systems, and keeps them waterproof. It is cylindrical in shape, as it is inexpensive to waterproof this shape compared to a rectangular shape.

It is made out of acrylic, which makes it lightweight. Inside the chamber, the electronics components are mounted on square plates (non-shaded area). The diameter of the cylindrical chamber is the diagonal of the square mounting plate (approx.). The plates are made out of bakelite, dipped in borax solution and dried. The plates are mounted on a frame that allows the distance between the plates to be adjustable. The shaded area is available for passing all wires required for connections between the plates. The plates are arranged in a way that cross connections and wiring length is minimized. Connectors are used on one face plate of the cylindrical chamber, for both input and output connections. The chamber has is ID of 11.5 cm and OD of 12cm.

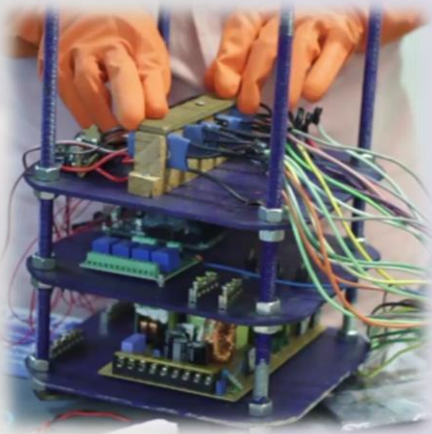


Figure 11: Electronics Mounting

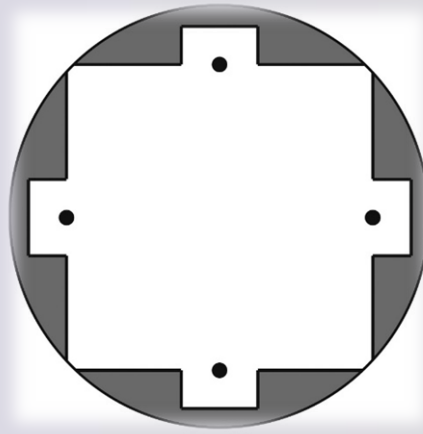


Figure 12: Modified Plate



Figure 13: Chamber

### SAFETY TIP!!

Borax solution makes the plates fire resistant.

## CONNECTORS

The connectors are primarily used to make a connection between the motor and the motor drivers. The biggest challenge was to waterproof these connectors. Although commercial waterproof connectors were available, they were expensive. We hence decided to make it ourselves.

We have used an innovative way to form the electrical joints this year. We have formed those using Glue Stick, Heat Shrink Tube and Rubber disks. Two rubber disks were placed at the two ends of the joint. A small tube of glue stick was placed between them. Then a heat shrink tube was slid on covering the rubber disk and glue stick. When heat is applied to the heat shrink tube, it shrinks and the glue stick also melts to form a proper coating on the connected joint. The rubber disk ensures uniform spreading of the glue and correct positioning of the joint. The shrunk heat tube ensures a strong and permanent waterproof joint.



## SENSORS

### IMU

The ROV is equipped with an Inertial Measurement Unit in the form of GY-80 IMU. This IMU has a 3-axis Gyroscope, a 3-axis Accelerometer, and a 3-axis Magnetometer. The combined output from these sensors can be used to calculate the heading of the ROV and its relative displacement from a reference position. The reference position for this task will be the location from where the ROV is inserted into the pool. The distance calculated from the reference position will allow identifying at which position the iceberg is located along with its heading. The distance can then be calculated between the iceberg and oil rigs and subsea assets to identify which danger zone the assets lie in.

### CONDUCTIVITY SENSOR

The conductivity sensor consists of 2 metal plates connected to a current measurement sensor, and also to an LED in parallel. This construction will help us in checking redundancy. If one mechanism fails, the other will help complete the tasks.

### FLOW METER

The flow meter will be excluded from the ROV. The entire sensor will be deployed into the pool separately coupled with an Arduino UNO and a memory card to make a log of the flow rate.

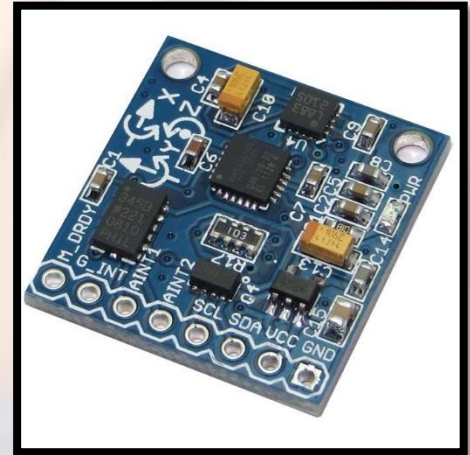


Figure 14: IMU



Figure 15: Flowmeter

## ROBOTIC ARM

The robotic arm is designed in such a way that it can perform various tasks, such as attaching the lift line, inserting a hot stab etc. It is made by 4-6 mm thick aluminium plates with three joints in it (i.e. one shoulder, one elbow and one wrist). The entire arm is mounted on a 360 degree rotating turntable. The other 3 joints are provided with three 180° servo motors. All motors were dismantled and waterproofed. They were then fixed on each joint with the help of motor brackets. The clasper contains the last servo motor that will enable the arm to hold onto objects. The total length of the robotic arm is approximately 40 cm which can be folded by its joints so as to maintain the ROV size constraint.

For controlling the robotic arm under water, a joystick controller will be used, that will connect to a laptop and transmit the signals to the Arduino Mega on board the ROV, via the Ethernet cable. The following flowchart shows the working of the control of robotic arm.

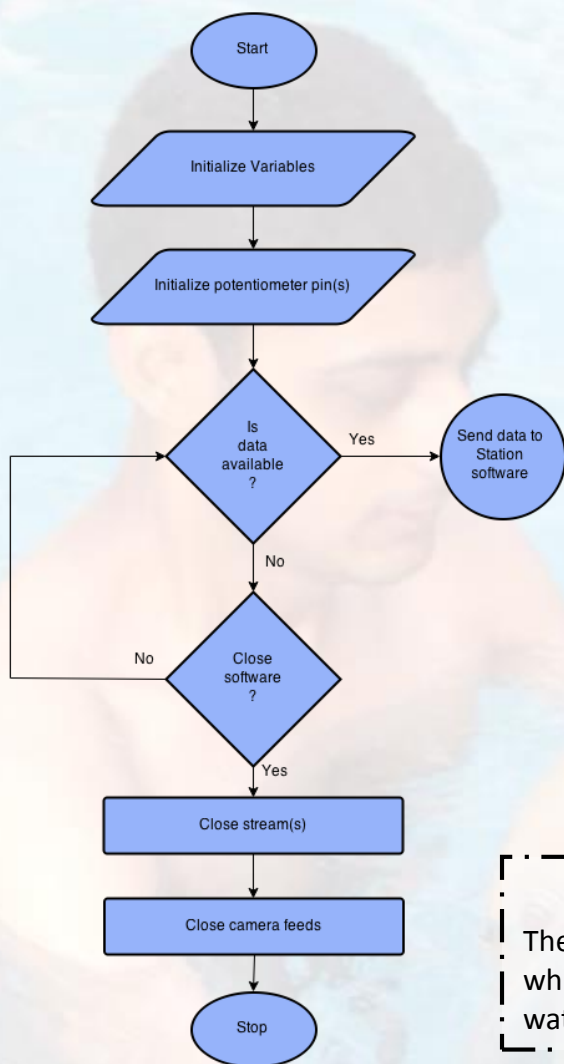


Figure 16: Robotic Arm and it's Algorithm

### BE SAFE!!

The motors were dismantled and waterproofed by marine grease which is highly efficient while working underwater. The electronics waterproofed by using a coating of Silicone.

## WATERPROOFING

Waterproofing is a must when it comes to electrical equipment's being used underwater and hence we have employed the best possible, affordable and fool proof methods.

Instead of purchasing waterproof servo motors, we opened up the normal ones to waterproof them. Grease helps to repel water and enables smooth functioning of gears. So we filled the internal parts of the motors which consisted the gear mechanism also with marine grease. We put a gasket on the output shaft inside the casing near the shaft opening to make it watertight. To ensure that there is no chance of leakage, we sealed all the possible openings of the motor on the outer casing with silicon sealant.

For the Electronics Chamber, we have used silicon and araldite around the flange area to try and prevent leakage through it. The holes through which the tether is supposed to enter and leave the chamber are covered by PG Glands to ensure that water doesn't enter, and for other waterproofing purposes, we have used Marine grease, gaskets, silicon and araldite.

# SOFTWARE AND ALGORITHMS

## GUI

Our main GUI is built using Java, using the java fx libraries. On the surface, two monitors run this application. The main monitor “A” displays our main camera’s feed, along with details of the thrusters, heading & specific readings obtained from the Arduino under water (from the ROV). Screen “B” displays the remaining two camera feeds for the co-pilot to use as reference.



Figure 17: Pilot Screen

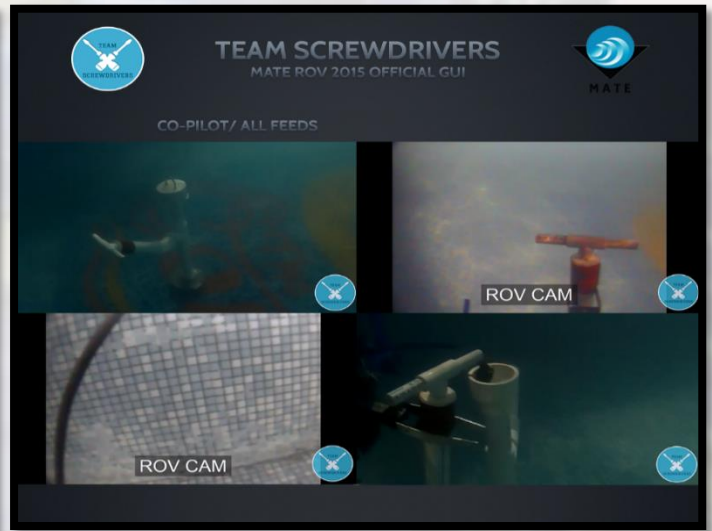


Figure 18: Co-Pilot Screen

This GUI also contains separate scripts made to accomplish various mission tasks. They have been written in Python using OpenCV. These scripts run on the main screen (A) and can be used for solving tasks that require Image Processing.

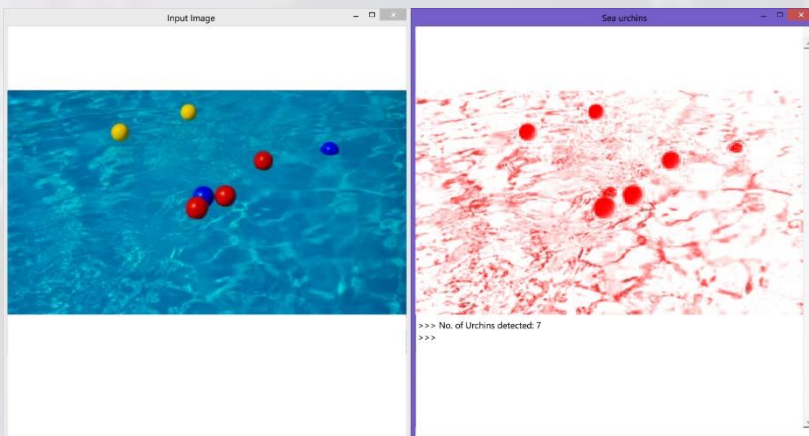


Figure 19: Sea Urchin

### SEA URCHIN:

Collecting the sea urchin requires us to have a better vision for the pilot, so that he/she can “collect” a sample easily, using the robotic arm. The program provides a binary or threshold feed from the camera, along with its default feed. This helps the Pilot/Co-Pilot to better visualize the environment.



### SEA STARS:

Since this task not only includes counting, but also identification of the sea stars, we decided to use Image Processing to count the number of sea stars in a single frame taken by the camera. Later, the program automatically calculates the number, and type (color) of the sea star. But, since color detection under water won't be exactly perfect, the Pilot/ Co-Pilot has the option to see the frame while it is being processed (to minimize error).

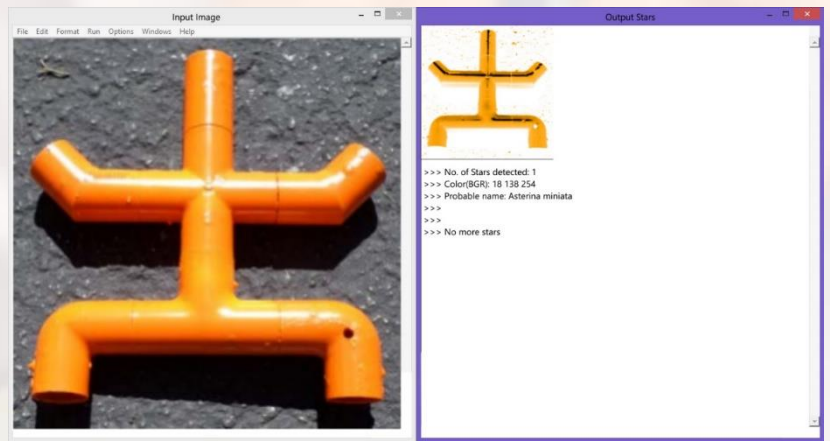


Figure 20: Sea Star Count and Identification

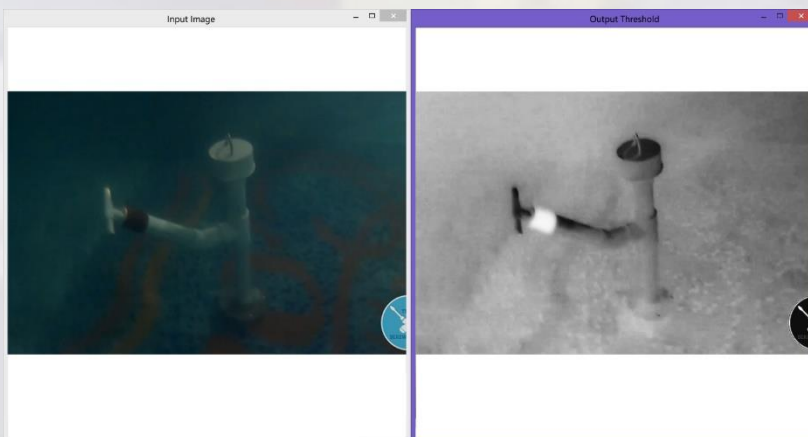


Figure 21: Corrosion Identification

### CORROSION DETECTION:

Detecting of corrosion, is also automated by the same method that was used for Sea Urchin identification. The program automatically searches for the threshold value, and it is easier for the Pilot/ Co-Pilot to detect corrosion, since two feeds are displayed again.

The figure shows how the script can detect the darker part of the pipe and highlight it in the adjacent image, making carrion detection process simpler and faster.

### DETERMINING LENGTHS IN VARIOUS TASKS:

Determining the length of the wellhead pipe, and then calculating the angle of inclination was a difficult task for the team. Our software solves this task by using simple mathematical formulas to calculate the unknown length of the wellhead pipe, and subsequently the angle. The software works as follows:

- ➔ Pilot marks an object with a known length (on a frame captured by the camera feed).
- ➔ Pilot also marks the object with unknown length.
- ➔ Known length is the input to the software.
- ➔ The software itself calculates the unknown length, and the angle of inclination.

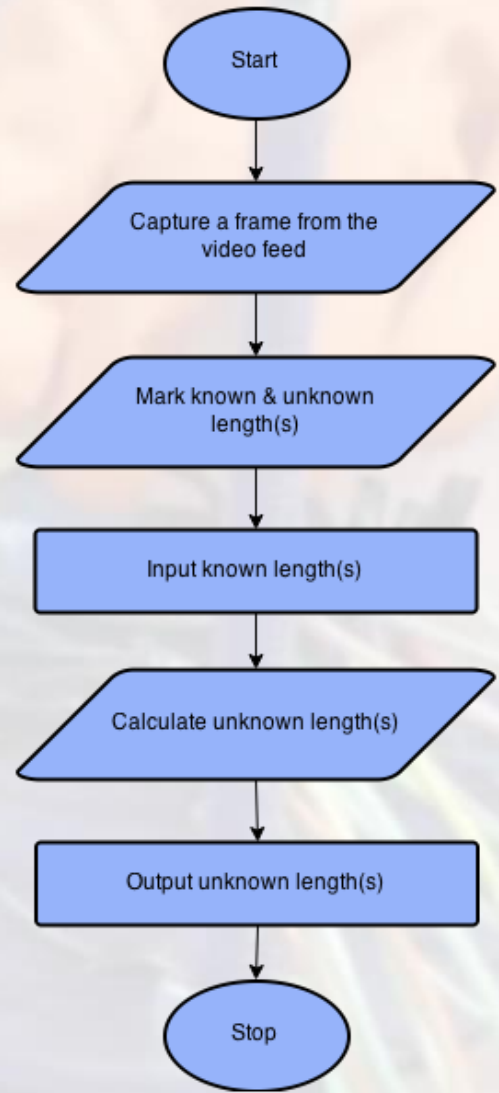


Figure 22: Length Algorithm

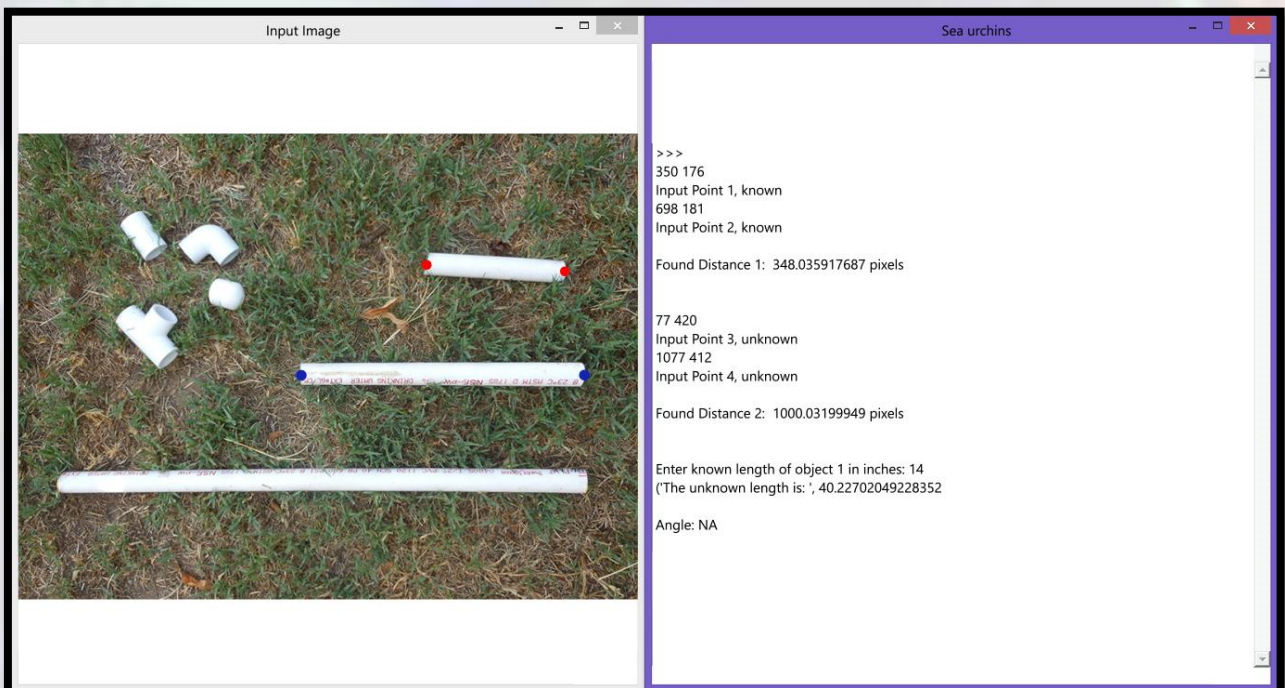


Figure 23: Finding Lengths

# DESIGN OF SPECIAL SYSTEMS

## SCIENCE UNDER THE ICE

### **Collecting a sample of algae from the underside of the ice sheet:**

For this task we will be using a funnel whose mouth will be connected to a bilge pump. When it is powered, it will suck the ball into a storage space, designed to ensure the sample remains in it.

### **Collecting an urchin located on the seafloor:**

This task will be done with the help of a rod having a hook attached to it, which will lift the O- ball representing a sea urchin.

### **Deploying a passive acoustic sensor in a designated area:**

For this task, we will tie the acoustic sensor to the base plate of the ROV, with a special type of knot. The robotic arm will hold one end of the knot, and pull it to release the knot and deploy the sensor in the designated area.



**Figure 24: Algae Sample Collection**

## SUBSEA PIPELINE INSPECTION

### **Conducting a CVI (close visual inspection) of an oil pipeline for corrosion:**

Detection of corrosion on the pipeline would first be done using image processing (as explained in the previous section). However, in case it fails or yields ambiguous results, an alternative method is to use the camera mounted on robotic arm accompanied by plastic mirrors which will give a close view of underside of the pipe for a more detailed inspection.

### **Turning a valve to stop the flow of oil through the pipeline:**

To accomplish this task we will use a separate mechanism that is a Rotating Plate, situated at the bottom centre of the ROV. It will freely rotate using servo motors that will turn the valves.



### **Attaching a lift line to the corroded section.**

Lift line mechanism is inspired by rope callipers used by mountain climbers.

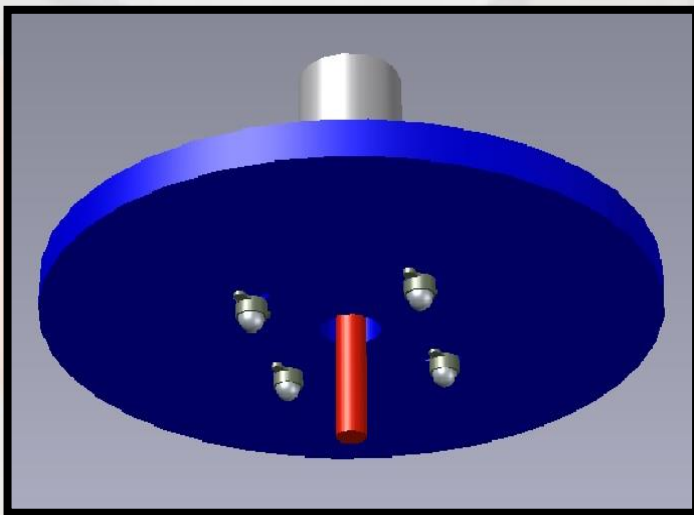
Callipers mounted on a rod will be carried by the robotic arm of the ROV. Callipers will be having air bags in it which will give a firm grip while lifting the pipe.

### **Cutting (simulated) the section of corroded pipeline:**

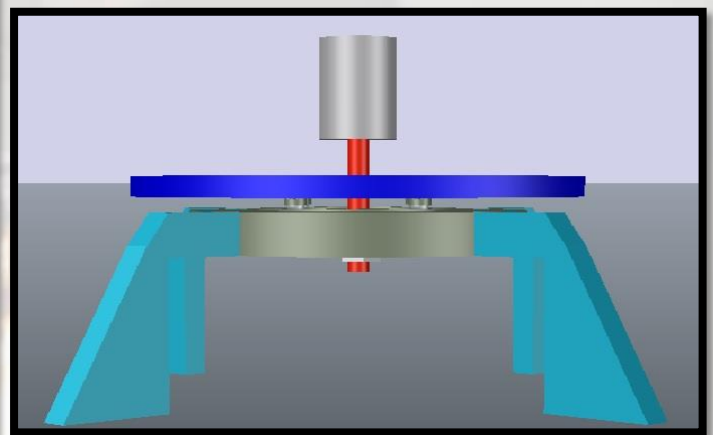
For this task the rod which was used for collecting the sea urchin will be used to pull out the U-pins from pipes which will simulate cutting of corroded section of pipe

### **Removing the section of corroded pipeline and return it to the surface:**

Callipers holding the pipe in position will be pulled by the lift line holder standing outside the pool.



**Figure 25: Base Plate + Motor + Castor**



**Figure 26: Rotating Base Sub-Assembly**

## **OFFSHORE OILFIELD PRODUCTION & MAINTENANCE**

### **Moving water through the pipeline system to verify that oil will flow through the correct pathway:**

With the help of a bilge pump, water will be pumped inside the pipe.

### **Determining the average flow rate of the water current:**

A flow rate sensor will be developed and deployed separately to gather the flow rate data of up to 5 minutes.

## CHALLENGES

In the course of this project, we have come across many challenges, and overcoming them has given us some valuable experience.

**Budgetary Constraints:** One of the biggest challenges for us was that we were falling short of funds. Purchasing the necessary materials started becoming a difficult task. This prompted us to focus our search efforts on Indian manufacturers only. The end result is a highly cost efficient ROV, as we saved money on shipping, customs duty and other additional charges.

**ROV Manoeuvring:** As per our initial design, we were using 6 Blue Robotics T100 thrusters to manoeuvre the ROV. However, after some initial tests, one of the thrusters stopped working. Analysing it revealed that its motor was damaged. Ordering a new one would not only be costly, but also time consuming. Thus, an alternate design was developed, that uses 4 of these thrusters and 4 thrusters made from bilge pumps.

**Buoyancy:** The initial buoyancy design made use of two plastic bottles that received air supply from a compressor. However, upon testing it was found that the air tank of the compressor was small and didn't fill up the buoyancy tank fast enough. Also, the plastic bottles dented due to pressure at higher depths underwater. Subsequently, an alternative compressor was used and PVC was chosen as the material for the tanks.

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### Websites:

<http://www.marinetech.org/>

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## AREAS OF IMPROVEMENT IN FUTURE

Although we overcame most of the challenges that we faced, some areas of improvement that we should focus on the next time we participate are:

**Managing excess manpower:** There were an unprecedented number of young enthusiasts who wanted to join our team and have a great learning experience. While we tried to take in as many of them as we could, handling their learning and managing the project simultaneously proved to be cumbersome. We would want to make better use of these inquisitive minds in the future, to ensure a win-win situation for both.



Figure 27: Human Capital Management

**Risk management:** The procurement of Blue Robotics T100 thrusters that we ordered from U.S.A met with an unexpected delay. Due to this, valuable time was lost and the project plan was impacted. Although we did manage to recover the lost time, it is felt that better preparedness for such contingencies should be observed.



Figure 28: Risk Management

**Design features:** Our focus for this year's ROV is weight and easy maintenance. While we have incorporated these to a significant extent, the feature of compactness can also be improved upon. Our major limitations are costly overseas procurement and bulky nature of components



Figure 29: Design Improvements



## OUTREACH

The zeal towards Underwater Robotics and Marine Engineering was transferred through focused outreach activities to school students who were mentored by Team Screwdrivers to take the initiative further. In the very first event we at Team Screwdrivers associated with a socially active chapter “ADAPT” to organize a drawing competition and Sports Day for disabled students with the theme “Swachh Bharat” to spread awareness about cleanliness. We continued our collaboration with Nehru Science Centre this year too.

On account of celebrating National Science Week at Nehru Science Center, an art competition called as “Sit and draw Contest” was organized centered around science related themes. On the occasion of National Science Day, we volunteered with Nehru Science Center to organize an education filled day for the students present to celebrate science. The highlight was a Skype lecture given to the students by Nobel Laureate Dr. John C. Mather, Goddard Space Flight Centre, NASA, on “From the Big Bang to Now: Observing the Universe with the James Webb Space Telescope.”

The team conducted one of its largest outreach activities by participating in the three days long Innovation Festival organized by Nehru Science Center. The event was graced by Padma Vibhushan Dr. Anil Kakodkar, Chairman of the Atomic Energy Commission of India and the Secretary to the Government of India. The team used visual aids and a working prototype of the ROV to explain the technology involved in the ROV. The team was presented with a certificate of appreciation by Mr. Shrikant Pathak, Curator and Head Education Cell for its efforts put thus signifying the success of the event for us.

We had a rewarding experience for themselves when we conducted outreach programs for the students coming from all over the country. We were not only able to devise technological solutions for daily life for different sections of the society, but also generate interest to work towards them. Through all these outreach activities we have successfully interacted with more than 16000 people that included students, parents, scientists and academicians.



Figure 30: Innovation Festival



Figure 31: Adapt

# ACKNOWLEDGEMENTS

First and foremost, we would like to thank Mr. Sawankumar Naik, our faculty mentor, for introducing us to this competition and encouraging us to push our limits and aim for the sky. This project would not have been possible without the support of our faculty members and lab assistants, who allowed us to access the various tools and machines in the college premises. Also, a special thanks to –

- ➔ MATE and Marine Technology Society ROV Committee, for organizing this year's ROV Competition and providing a platform to showcase our technical knowledge.
- ➔ National Science Foundation, for funding this year's international competition
- ➔ SVKM NMIMS's Mukesh Patel School of Technology Management & Engineering, for permitting us to manufacture the ROV at their campus.
- ➔ Chief Minister of Maharashtra Mr. Devendra Fadnavis, for his motivation and moral support to the team.
- ➔ Country Club, for letting us use their swimming pool for testing purposes.
- ➔ BlueRobotics, for providing the thrusters used in the ROV.
- ➔ Mr. K.C.V Gopal Varma, who shared with us his knowledge about underwater systems and best practices used in the industry.
- ➔ Mr. Hemant Kolame, for providing tools and equipment's required for manufacturing the ROV.
- ➔ Mr. Vedant Gandhi and Adapt foundation, for their moral support to the team.
- ➔ Nehru Science Center Mumbai, for letting Team Screwdrivers conduct outreach activities.
- ➔ JOYO Plastics, for donating plastic household articles and corporate gifts for outreach programs.
- ➔ Mr. Ramawtar Sharma and Advanced Valves, for providing funds to manufacture the ROV.
- ➔ Mr. Vivek Maurya, Mr. Rajesh Bhadreshwara and Mr. Jaidev Kulkarni, for mentoring this year's team.

Last but not the least; we would like to thank our family members, friends and junior volunteers of the team, for giving us their support and good wishes.

## APPENDIX A: BUDGET

AS OF MAY 2015	COMPONENT	TYPE	UNIT COST (\$.)	TOTAL (\$)
CONTROL SYSTEM	Controller	DONATED	45	90
	Tether	NEW	33	33
	Ethernet cables	USED		7
ELECTRONICS	DC-DC Converters - 12 V	NEW	161	483
	DC-DC Converters - 5 V	NEW	83	83
	Arduino Mega	NEW	58	117
	Ethernet Shield	USED	16	32
	Relay Board	NEW	2	2
	Motor Driver	USED	12	36
	Servo Motors	NEW	13	78
	ESC	NEW	13	80
	Thrusters	NEW	111	667
	Bilge pumps	USED	20	80
	Cameras	NEW	111	333
	EC Chamber	NEW	250	250
PNEUMATICS	Buoyancy tanks	NEW	17	17
	Compressor	DONATED	83	83
	Valves	NEW	6	12
	Regulator	NEW	10	10
WATERPROOFING	Araldite	NEW	5	15
	Marine grease	NEW	12	12
	Silicon gun	NEW	8	8
	Glue gun	NEW	3.3	3.3
	Glue sticks	NEW	0.13	2.6
SAFETY EQUIPMENT	Fuses	NEW	0.28	8
	Rubber gloves	NEW	1.2	20
	Safety goggles	NEW	1.6	28
	Insulating tape	NEW	0.17	3
	Lab apron	DONATED	1.7	33
MISC.	Arduino Connectors	USED	0.2	7
	Wires	USED		8
	Heat gun	USED	67	67
	Hand grinder	USED	83	83
	Chassis manufacturing	NEW	167	167
TRAVEL	Lodging		360	5400
	Team Travel		1600	24000
<b>TOTAL WITHOUT TRAVELLING EXPENSES (NEW Items)</b>				<b>2431.9</b>



## APPENDIX B: SAFETY CHECKLIST

### **Before beginning work on the ROV:**

- ✓ Remove any rings, watches or jewellery.
- ✓ Wearing closed shoes and lab apron is a must. Safety glasses and gloves need to be worn when working with machines and chemicals.
- ✓ Long hair should be tightly secured.
- ✓ Keep a first aid kit handy at all times.
- ✓ Ensure juniors are supervised by a senior team member at all times.

### **Before turning on power supply:**

- ✓ Always attach a fuse of proper rating while testing any equipment.
- ✓ Make sure all connections are tight and insulated.
- ✓ Ask a third person to check if connections are correct to avoid biasing error.

### **Before putting the ROV in water:**

- ✓ Check if the electronics chamber is tightly secured.
- ✓ Ensure waterproof glands are tightly secured.
- ✓ Ensure all components are in place.
- ✓ Check if main fuse is intact.

### **When ROV is in water:**

- ✓ During testing, pilot will say “We are live” before he begins to maneuver the ROV.
- ✓ When the ROV is in water, members inside the pool must observe it from a safe distance.
- ✓ Members in the pool should specifically stay away from parts painted with yellow and black stripes.
- ✓ In case anything is amiss the pilot must immediately bring the ROV to surface and shout “Mission Aborted” to indicate that it is safe to handle the ROV now.

### **After removing the ROV from water:**

- ✓ Once the ROV is on the deck, the power supply will be turned off and the tether will be unplugged by a member with dry hands.
- ✓ All members who were in the pool will not be allowed near the ROV once the electronics chamber is opened.

# APPENDIX C: SOFTWARE FLOWCHARTS

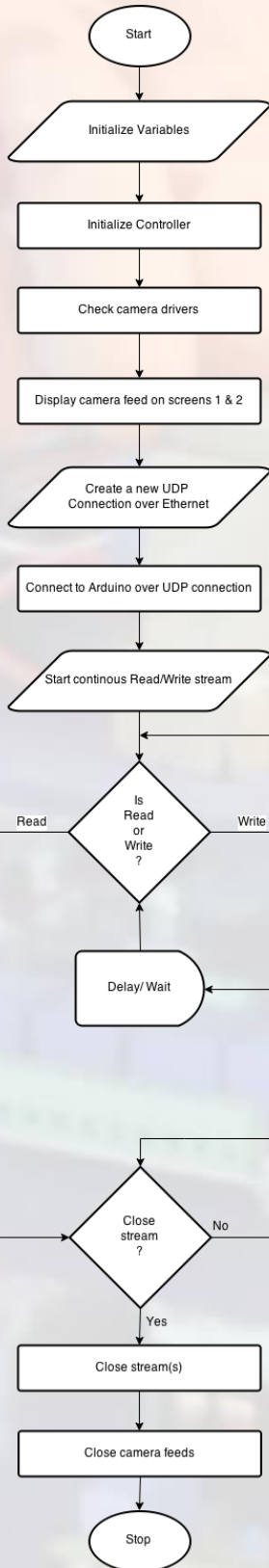


Figure 32: Deck → ROV

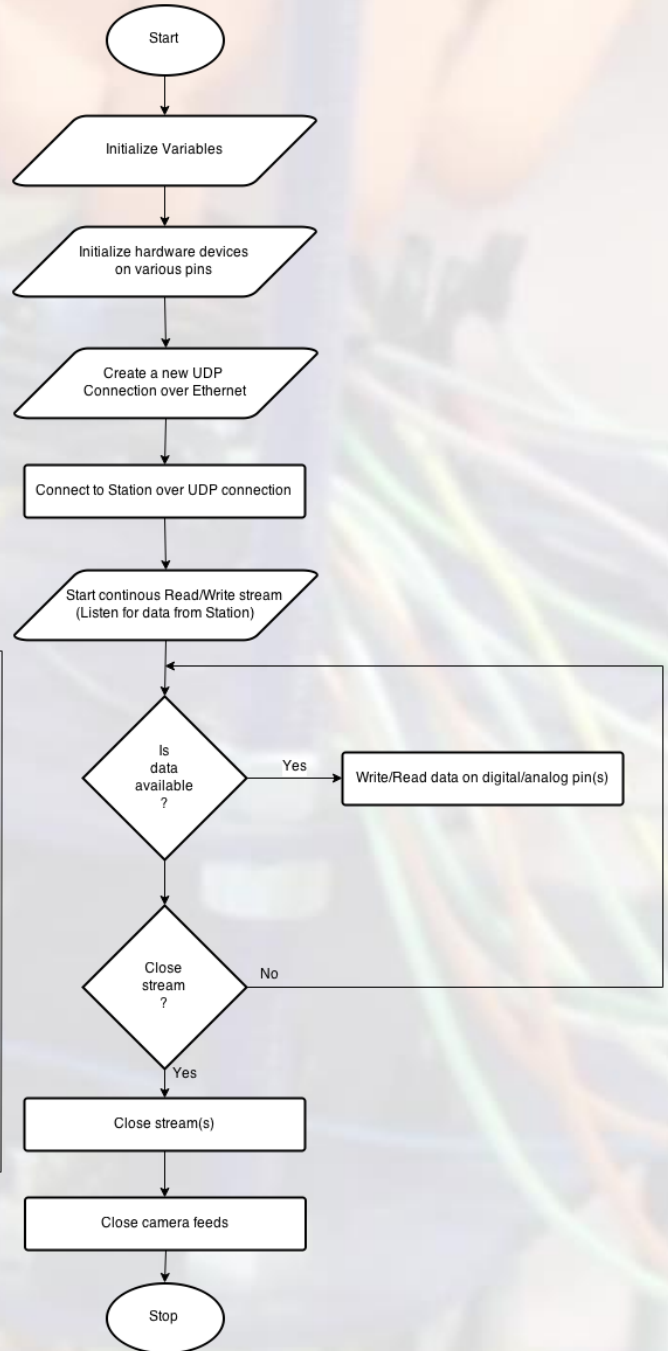


Figure 32: ROV → Deck