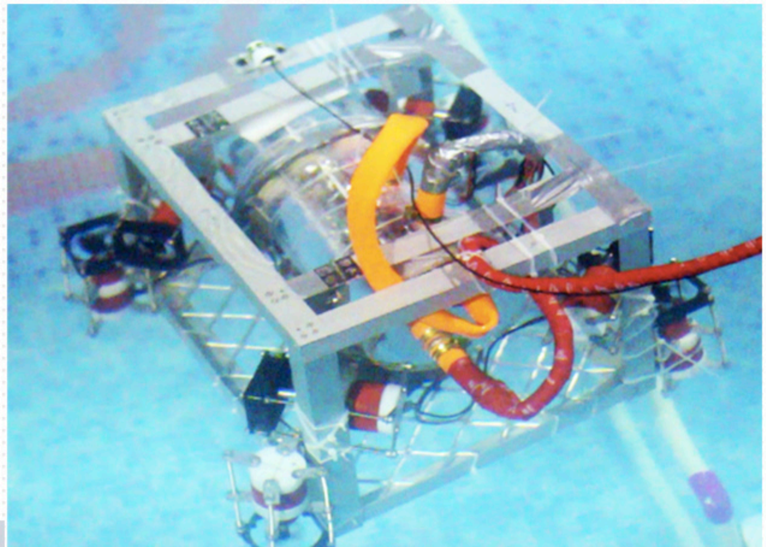
Mukesh Patel School of Technology Management & Engineering.

TEAM SCREWDRIVERS - MUMBAI, INDIA

Vikrant

Dimensions: 50mmx40mmx40mm
Total Weight: 16 KGS
Total Cost: US $ 1,922
First Time Participation



Team Mentor : Prof. Sawankumar Naik

Employee List:

Name	*Designation*	*Year of Engineering*	*Course*
Vivek Maurya	C.E.O.	4th	Computer
Rahul Krishnan	C.T.O	4th	Electronics
Gaurav Mishra	C.F.O.	3rd	Chemical
Saurabh Sharma	Chief Logistics	4th	Computer
Rajesh Bhadreshwara	Chief PR	4th	Electronics
Chetna Tyagi	Chief Editorial	4th	Electronics
Jaidev Kulkarni	Camera & Lights	3rd	Computer
Dhairya Sathvara	Social Media	2nd	Civil
Mit Vaidya	Fundraising	2nd	Computer
Rishi Bafna	Fundraising	3rd	Mechanical
Sonika Shriwastav	Fundraising	2nd	Computer

TABLE OF CONTENT

1. ABSTRACT

This report describes the main technical aspects and applications of 'Vikrant' underwater remote operated Vehicle designed by Team Screwdrivers. We the team screwdrivers are here to fix together our research, expertise, passion and guidance to create a unique solution for technological barriers. We are proud and determined to represent this project internationally. Our company comprises of few engineers, each bringing new ideas and striving to pull out the best of what they have learnt.

The propulsion system consists of 8 thrusters, out of which 4 are placed vertically and 4 vectored horizontally, with a reliable housing designed by our experts, keeping safety issues in mind.

Keeping proper buoyancy and light weight in mind, acrylic tube is designed to hold the complete electronics.

The control program is designed based on C++ programming language. Using 3D CAD system software Solid Works TM, our ROV is designed keeping in mind versatility and adaptability. The solid base built with the aluminum chassis, and stainless steel used for thrusters housing, our ROV can be easily tailored to perform various tasks mission. The ROV is equipped with 3 cameras. The top quality GUI simplifies the ROV's Pilot job.

Since this is our first year of participation, it was a completely new and learning experience for our team and we look forward to come up with more innovative and additional features to the ROV.

2. DESIGN RATIONALE:

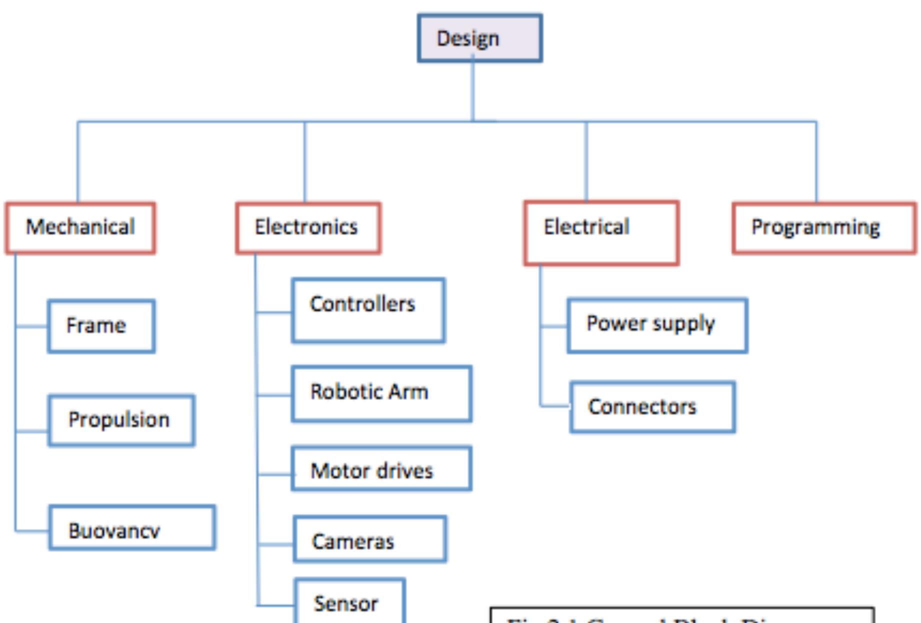


Fig 2.1 General Block Diagram

Our main aim was to design a ROV versatile yet robust to carry out deep under water tasks. Having said so, after intensive research and experiments carried by our team, we found that the most important factor was the stability of ROV. Furthermore, we required powerful thrusters in order to lift the heavy objects and come up with the resistance of water. According to the requirements we decided to use 8 thrusters, 4 to control horizontal motion and 4 vertical. We decided on using acrylic tube to hold all the electronics keeping proper buoyancy and waterproofing in mind.

3. MECHANICAL DESIGN

The design maintains a relatively compact shape and a sound structure that provides maximum space for internal components. The question of material was answered with great consideration to cost as well as effectiveness of materials

A. Frame*:*

The Engineering Team decided to use the conventional structure of an ROV frame.
Dimensions: 50cmx40cmx40cm.ROV's frame was initially designed keeping optimum functionality in mind.

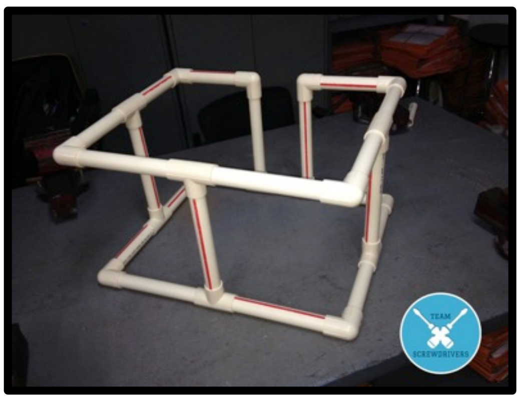


Fig 3.1 PVC Pipes Chassis

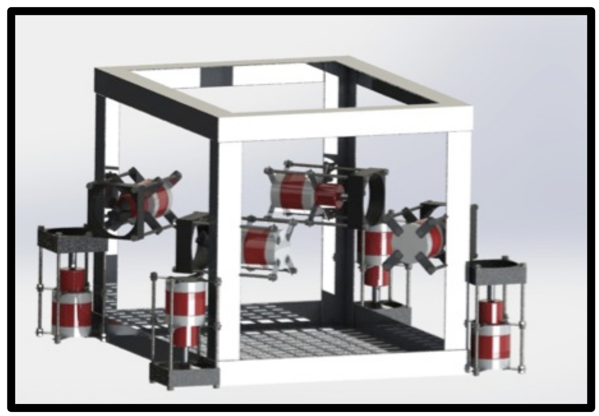


Fig 3.2: Aluminum chassis

After performing the buoyancy test we noticed the instability in the structure and hence we decided to work on the newly designed frame made from aluminum. The latter design of frame fits all components with ease; enough space is given to ensure zero interference and maximum efficiency. The frame's final design was modeled on 3D CAD System Solid Works TM which gave us the ability to decide the shape of the vehicle and the required dimensions and perform the stress analysis on the Frame.

B. Propulsion:

ROV system requires moving smoothly underwater to perform the tasks. Motors powered using a 12 V, 3 amps power supply, 1157 m3/sec thrust is provided by each thruster at this rating. Four thrusters are placed horizontally at an angle of 45° at the mid of the chassis and other four vertically.

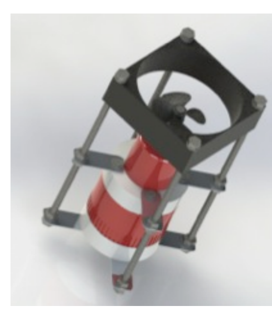


Fig 3.3 Housing for Propeller

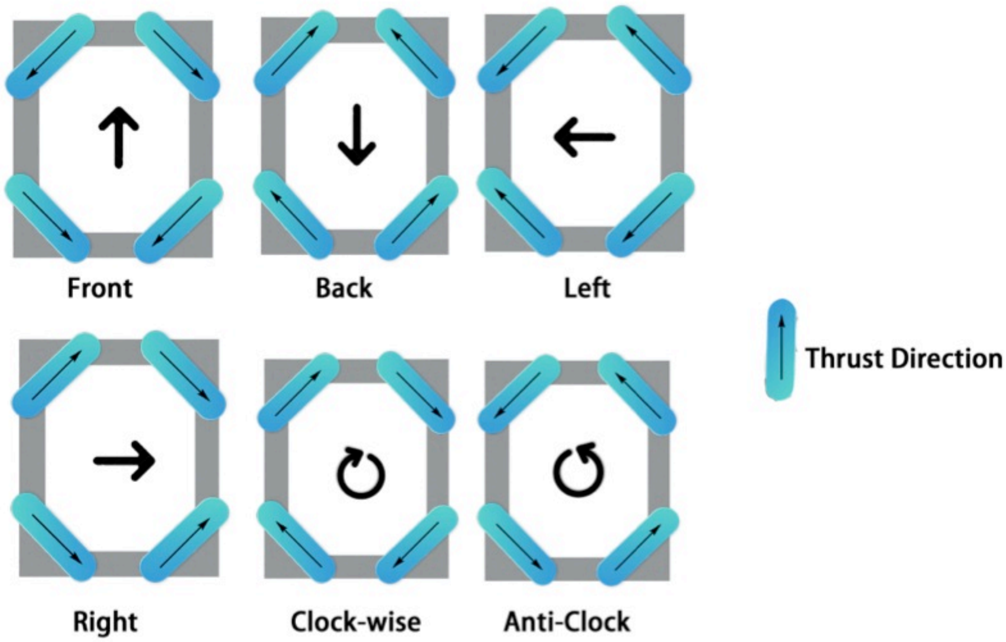


Fig 3.4 Propulsion Direction

C. Buoyancy

Its buoyancy is also easily controlled. With dimensions of 0.5 m length, 0.4 m width and 0.4 mm height our ROV relies on eight propellers, four propellers in vertex position for horizontal and lateral movement and four for vertical movement, it is also equipped with one main gripper.

4. ELECTRONICS

A. Cameras & Lighting

Fig 4.1 Primary Camera

Fig 4.2 Primary Camera Connectors

We have used **the MCV8-LED** as the primary camera for our ROV. It has a CMOS sensor & is equipped with pinhole technology having night vision as its special feature. It has a resolution of 520TVL with a 90degree view angle. The 20 metres cable is very flexible and was easily braided with the tether. Furthermore, the camera's RCA video jacks can easily link them to video cameras to record during missions. We have used a USB convertor for the RCA cable conversion of data from RCA to USB for connection to the GUI laptop. We have used two secondary cameras **Xpro IMAGE-IN** . These are basic webcams with a high quality CMOS sensor inbuilt LED & a USB output. We made a separate housing for these cameras as they were not waterproof & placed them accordingly on the ROV.

Fig 4.3 Secondary Camera

B. Sensors

Conductivity Sensor:

The Conductivity Sensor measures the conduction current capacity of a liquid.

- **<u>Design of the conductivity sensor:</u>**

  The Design consists of the following Components- EC Probe, EC shield+ Arduino UNO.

  1. **<u>EC Probe</u>:** We have used 2 conductivity probes while testing
     - **A. Nichrome wire probe (Designed and Home Manufactured)**
     - **B. Atlas-scientific Conductivity probe (Bought from ATLAS-SCIENTIFIC)**

A. Nichrome wire probe (Designed and Home Manufactured):

We have designed a conductivity probe by using the following materials, Nichrome Wire, Telephone Wire, Pen refill, Insulation tape.

- **<u>Construction:</u>**

1. Two Nichrome wires were taken and the two leads of the telephone wire were soldered to it.
2. The Nichrome wires were attached to the refill on either side such that there is an exact distance of 1cm between them.
3. The Nichrome wires were then covered using an insulation tape such that only half an inch of the wire was visible.
4. The making of the wires is shown in the following images.

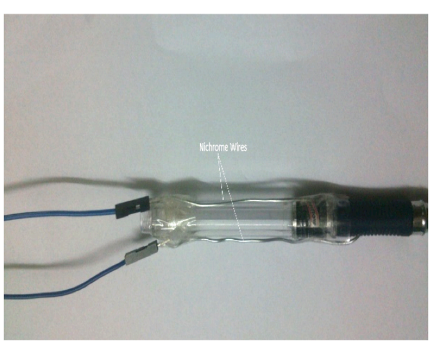


Fig 4.1 Homemade Conductivity Sensor ***Fig 4.2 Ordered Conductivity Sensors***

B. Atlas-scientific Conductivity probe (Bought from ATLAS-SCIENTIFIC)
This probe uses a Platinum Electrode and has a cell constant 10(K=10). It has been specifically designed to measure Seawater conductivity.

C. Robotic Arm

The robotic arm is used to aid the ROV in performing its various tasks. The arm has 2 degrees of freedom, which we deemed sufficient enough to perform its tasks, while keeping its design simple. The various components of the arm includes the gripper (pre-assembled), two waterproof servos (HS-646WP) and the housing to connect it to the chassis. Both the gripper and the servos were purchased from stores. The housing was designed and manufactured by us.
The HS-646 WP Hitec waterproof servos are a simple solution to operate the gripper underwater. They are IP-67 rated and have been tested underwater to check its functionality. It has been observed that these servos are waterproof but have reduced torque at larger depths. However the torque produced is sufficient to complete the tasks.
The arm has two possible movements, opening and closing of the gripper and rotation of the wrist of the arm, both controlled by the servos.

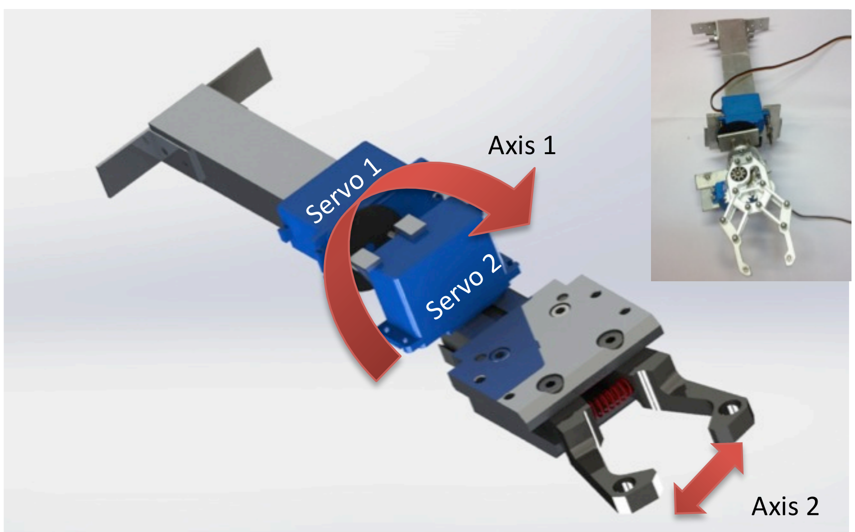


Fig 4.4 Robotic Arm

D. Motor Drivers

To ensure the proper functioning of ROV high-powered thrusters are used. Motor driver boards are used on which 4 motor drivers are mounted to control the thrusters. Motor drivers have better transistors to dissipate the heat and to handle the load efficiently without burning it.

E. Controller

Arduino boards are used to control the motor drivers, which will control the motors.

Arduino UNO Specifications: -

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Arduino DUE Specifications: -

The Arduino Due is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on a 32-bit ARM core microcontroller. It has 54 digital input/output pins (of which 12 can be used as PWM outputs), 12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, an USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button.

The board contains everything needed to support the microcontroller; simply connect it to a computer with a micro-USB cable or power it with an AC-to-DC adapter or battery to get started. The Due is compatible with all Arduino shields that work at 3.3V and are compliant with the 1.0 Arduino pin out.

5. PROGRAMMING:

This section will detail the algorithms and design of control system

Initializing:

VB.Net initializes the controller.

Set variables for joysticks & button inputs from controller.

Variable	Names	Purpose
XPos	X Position	Potentiometer
YPos	Y Position	Potentiometer
RPos	R Position	Potentiometer
UPos	U Position	Potentiometer
dwButtons	X, Y, A, B, L1, R1	Buttons
Lt	Lt (Left Trigger)	Potentiometer
Rt	Rt (Right Trigger)	Potentiometer

For the controller XY (1^{st} Joystick/ Potentiometer), values are stored in two different variables, namely XPos & YPos.

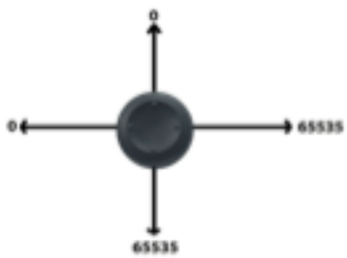
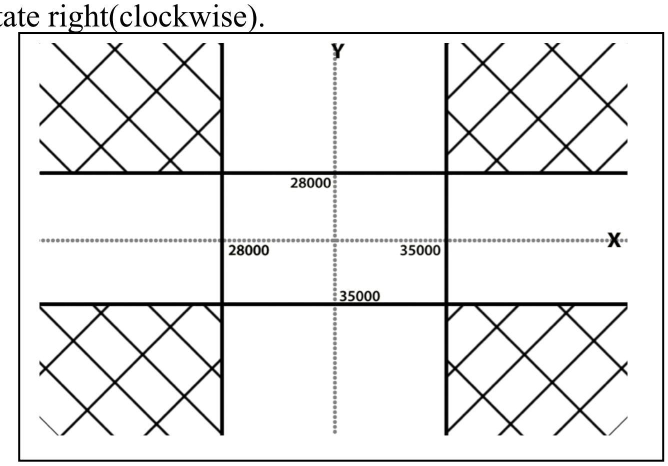


Fig 5.1 Sweep Range

Fig 5.2 Controller

The default value (idle state) is 32767 for both X & Y axes. But, since the scale is too huge (values range from 2^0 to 2^{16}) when idle. Hence, sweep range instead of a 'sweep spot'. Shaded portions are the ones where the four main (lateral) thrusters are in use (not in break/ idle mode). Also note that the values on Y axis are inverted. This is because the casual gaming joystick that we have used has its axis inverted by default. We had to change these values later. i.e. set 65535 = 0 and 0 = 65535. So that's how we choose the sweet zones, where VB directly assumes that the controller is idle, hence the thrusters would break.

This is performed with another of C++'s inbuilt functions, map. The thrusters A, B, C & D marked in blue are used for moving forward, backward, lateral left, lateral right, rotate left(anti- clockwise) & rotate right(clockwise).



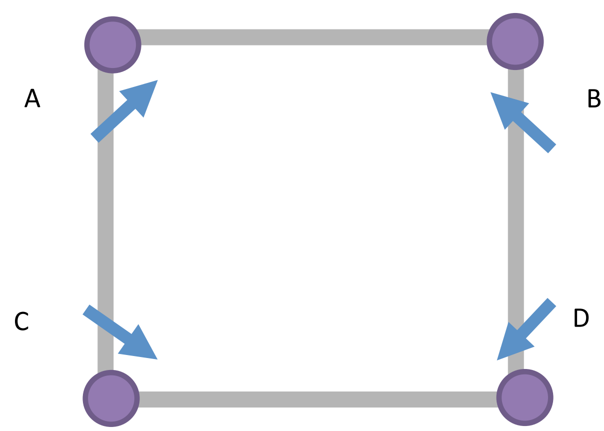


Fig 5.3 Sweep Range on Axis

Direction	A	B	C	D
Forward	0	0	1	1
Backward	1	1	0	0
Left	1	0	1	0
Right	0	1	0	1

Anti-Clockwise	1	0	0	1
Clockwise	0	1	1	0

Where 1 represents forward thrust, and 0 represents reverse thrust.

6. ELECTRICAL:

A. Power supply:

BASE STATION:

The whole ROV is going to be controlled from the base station with the help of an XBox controller. The controller is connected to a laptop via USB. The commands are then processed and the sent down to the ROV via the Ethernet CAT 5 Cable.
We have 2 plates in our electronic chamber. One plate has all the power devices; another plate has all the working boards.

- There is a main 48 V supply provided by MATE itself.
- That supply is taken to the ROV using 2.5 mm multistrand cable of 20 m length.

The Data that is sent from the station to the ROV is sent through CAT 5 Ethernet

Electronic Board Stage 1:

- As soon as it enters in the ROV, there is a positive bus and negative bus.
- We have 4 DC – DC converters in our ROV.

1. 48 -12 V (20 amps max) – To handle 2 motors at a time.
2. 48 -12 V (20 amps max) – To handle 2 motors at a time.
3. 48 -12 V (20 amps max) – To handle all other 12 V devices
4. 48 -5 V (10 amps max) – To handle all 5 V devices.

- For each of the converter, we have a blade fuse of respective amps.
- Each converter output is connected to 2 bus bars (one positive, one negative)
- Then there are fuses based on the applications we have.

1. 0.5 Amp Glass Tube Fuse – For HUB
2. 0.5 Amp Glass Tube Fuse – For Arduino UNO
3. 0.5 Amp Glass Tube Fuse – For Arduino DUE
4. 0.6 Amp Glass Tube Fuse – For Camera 1
5. 0.6 Amp Glass Tube Fuse – For Camera 2
6. 0.5 Amp Glass Tube Fuse – For Servo 1
7. 0.5 Amp Glass Tube Fuse – For Servo 2
8. 20 Amps Blade Fuse – For Motor Driver 1 and 2
9. 20 Amps Blade Fuse – For Motor Driver 3 and 4

Electronic Board Stage 2:

- The Output of each of fuse in the 1st plate goes to the 2nd plate to respective devices.
- The Ethernet Cable coming from the station is fed to the HUB.

- The 2 Arduino boards are connected to the HUB via Ethernet CAT 5 Cable.
- The Arduino board gives signals to everything and is the heart of the whole electronics.
- Arduino boards are used to control the motor drivers, which will control the motors.

B. Connectors

The connectors are primarily used to make a connection between the motor and the motor drivers. The biggest hurdle was to waterproof these connectors. Commercial waterproof connectors were available but expensive and hence we decided to make it ourselves. It consists of an orange pipe with a diameter large enough to fit the electronics chamber opening. The chamber end is clamped shut using an O-clamp, while the other end is fitted tight with a rubber cork. This cork has connecting wires punched through it. Any gap in the cork is sealed using and adhesive (Araldite). The cost of the connector amounts to less than a dollar!
The second type of connector used is a 39 pin Amphenol connector. It connects the above mentioned connector to the motor driver. This is done so that the wires are detachable from the electronics board. This allows us to remove the board as and when the need arises without having to disconnect the entire connector. All we need to do is unplug the connector to break the connection between the motor and the motor driver. The Amphenol connector is not waterproof and is mounted on the electronics board itself.

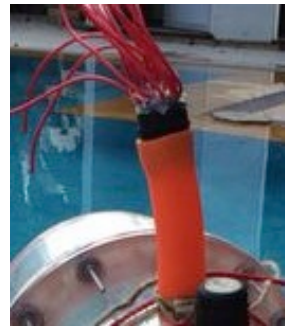


Fig 6.1 Manufactured Connectors

7. AGAR-AGAR GEL

We have used 12 V, 6 Amps bilge pump to ensure the proper functionality of agar agar gel suction mechanism. Two wires are connected to the switch box out of which one goes to the 12 V power supply and other wire is connected to the micro-controller. When the pin is high on the controller, the electronic switch turns on the pump and intakes the gel and stores in the bag connected to the other opening. It was ensured that the switch is not pressed for a longer duration as that may lead to the risk of bag bursting, so to avoid it a push button was used on the controller.
Housing of the whole system is made in such a way so that it is easily detachable from the chassis if required.

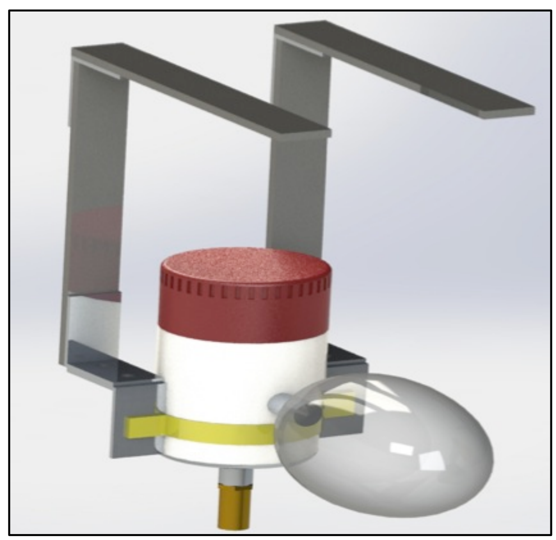


Fig 7.1 CAD Design of Agar Agar gel

8. TROUBLESHOOTING TECHNIQUES

We checked for the leaks to necessitate dropping of the ROV into the pool and checking for waterproofing once it was pulled back up. Now an innovative and efficient leak check technique has been developed by technical members at Team Screwdrivers. If leaks are discovered, they are quickly fixed by Team screwdrivers Technical department members.
Since we manufactured the Thrusters on our own, we did have quite a difficult time initially pertaining to its functioning. Here we have used 40 mm propellers and usually for a better thrust we can make use of 50 mm propellers. This was overcome by use of eight thrusters in our ROV which are strategically placed to give maximum thrust while efficiently consuming power from the source. These thrusters are not only economical but efficient in terms of performance as well and facilitate the smooth movement of the ROV.

9. RISK ANALYSIS & MITIGATION

- **Preliminary Hazard List:**

Part	*Hazards*	*Accidental Event (what, where, when)*	*Probable Cause*	*Consequences*	*Probability*	*Severity*	*Overall Hazard /Risk Rating*
1. Chassis & Waterproofing	Insufficient Tensile Strength	While picking heavy weight in water	Insufficient Design Analysis	Bending of Frame/ damage	2	3	Medium
	Water leak in Electronics Chamber & Connectors	Electronics chamber submerged in water	Spacing between gaskets & Connector	Water seeping into Electronics Chamber	4	4	High
2. Electronics	Flow of excess current	Working under load conditions	Fluctuating current	Damage electric equipment's	2	4	Medium
	Exposed Wiring	When ROV is in motion	Organization of Electronics	Short Circuit & Failure	1	3	Low
3. Propulsion	Stable Propeller housing	Maneuvering the ROV	Detachment of Propeller with housing	Loss of maneuverability / Damage other parts	4	4	High
4. GUI & Controller	Losing communication with ROV	During demonstrating task	Software Bug or loss of packets	Losing control over ROV	4	2	Medium
5. Cameras & Lighting	Insufficient Light on Camera	Any point of time	Low lighting condition	Low Quality Deed	2	2	Low
	Delay or Lag	During demonstration	Extended Data line	Signal attenuation	1	3	Low
6. Sensors, Agar-Agar Gel Collections, Robotic Arm	Wrong Conductivity Reading	While taking samples	Inefficient calibration & Corrosion of Probe wire	Reading differs with actual	2	2	Low
	Agar-Agar Gel collection bag overfull	While collecting samples	Running pump for more than required time	Leak or damage in the collection bag.	3	4	High

	Robotic Arm-Damage of servo waterproofing	During demonstration	Prolong use of servos resulting in damage of O-ring	Water damages the servos	2	3	Medium
	Robotic Arm - Reduce torque at greater depth	Deep water demonstration	Increase in water pressure at depth	Less Torque for holding things in water	1	3	Low

Rating Criteria's:

- *Overall Rating:*

Severity \ Probability	1.Very unlikely	2. Remote	3.Occasional	4. Probable	5. Frequent
4. Catastrophic					
3. Critical					
2. Major					
1. Minor					

Low - Acceptable
Medium - Further Investigation
High - Not Acceptable

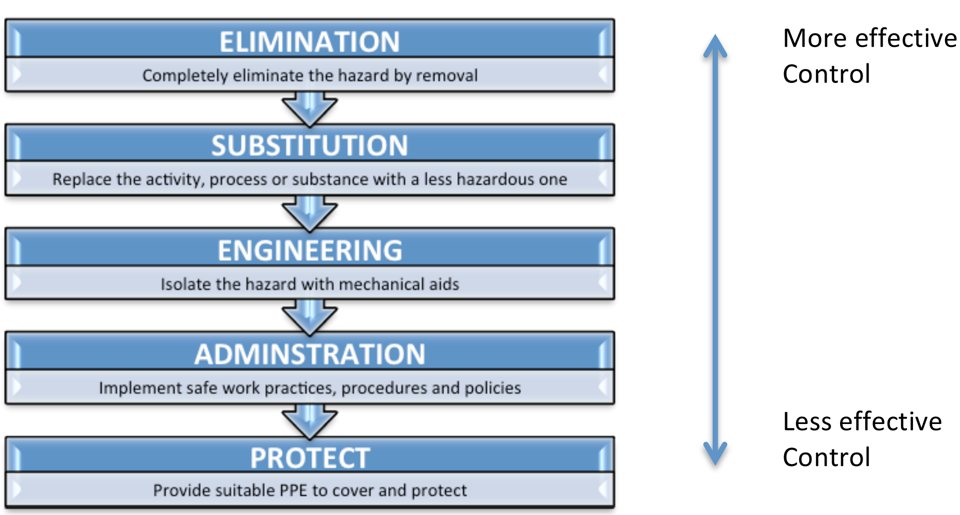
- *Severity classes*

Rank	***Severity class***	***Description***
4	Catastrophic	Failure results in major damage to the ROV
3	Critical	Failure results in minor damage to the ROV
2	Major	Failure results in a low level of exposure damage to the ROV
1	Minor	Failure results in minor system damage but does not cause damage to the ROV

- *Frequency Class*

1	Very unlikely
2	Remote
3	Occasional
4	Probable
5	Frequent

Risk Control Process:



Risk Control & Review Table

Implemented Risk Control

Hazards		*Control Method*	*Risk Control Steps*	*Implementation Remark*	*Review*
1. Chassis & Waterproofing	1.1 Insufficient Tensile	Elimination	Changing the PVC Pipe Chassis to Aluminum Chassis	Feasible & Implemented *	After replacing the chassis from PVC Pipes to Aluminum, the ROV was more robust and strong to handle situations while performing the task. There were no air pockets present in the PVC Pipe chassis resulting in elimination of non-required buoyancy.
		Substitution	Add thicker PVC Pipe for Chassis	Still might affect the stability	
		Engineering	Multiple Joints and Support	Feasible to implement.	
	1.2 Water leak in Electronics Chamber & Connectors	Elimination	Change type of gasket	Feasible & Implemented *	Multiple screws were bolted on the Flange of the Chamber with a custom rubber made gasket, which resulted in much more tight and reliable waterproofing of the chamber. The chamber later was able to stop water from entering and depth greater than 5 meters.
		Engineering	Increase number of Bolts on Flange	Feasible & Implemented *	
2. Electronics	2.1 Flow of excess current	Elimination	Adding fuses at every input and output connections	Feasible & Implemented *	Adding fuses regulated the flow of current on the circuit. Incase of excess flow, the fuses blows which can be easily reliable as compared to the circuit. While testing the ROV, no such condition raised of fuse blowing up, resulting in better reliability and flow control.
		Substitution	Adding over current protection circuit	Feasible but adding on more space & restrictions	
	2.2 Exposed Wiring	Elimination	Adding Heat shrink tubes and Insulation on board	Feasible & Implemented *	Heat shrink tubes and hot glue were added on all power bus connections, which prevented any short circuit risk on the board.
		Substitution	Making customized PCB	Expensive Resource & Complex	
3. Propulsion	3.1 Stable Propeller housing	Elimination	Adding hooks on the earlier made housing	Difficult to mount on chassis	The new housing was made efficiently looking at the placement positions. Plus the streamlining of the propeller was done with the housing.
		Substitution	Making a stable and easy to mount housing	Feasible & Implemented *	

4. GUI & Controller	4.1 Losing communication with ROV	Elimination	Change the protocol from UDP to TCP	Complex & Slow Communication	Making changes and upgrades in the code resulting in the micro-controller checking the packets send and received over the network, avoiding loss of packets.
		Engineering	Error correction techniques in the code	Feasible & Implemented *	
5. Cameras & Lighting	5.1 Insufficient Lighting on camera	Elimination	Add Flash lights to the Camera	Feasible & Implemented *	Adding Flash lights near the camera resulted in better and clear view of the objects within the water. The camera was able to more precisely recognize the color of the shipwreck.
		Substitution	Add Night vision in the camera	Expensive & not reliable	
	5.2 Delay or Lag	Elimination	Use single high quality USB cable for every camera and directly connect it to the computer	Feasible but more number of cables in tether	Using a high quality USB cable and hub taking the feeds directly to the computer resulted in no lag or delay
		Substitution	Using a USB Hub and directly connecting it to Control Computer	Feasible & Implemented *	
6. Sensors, Agar-Agar Gel Collections, Robotic Arm	6.1 Wrong Conductivity Reading	Elimination	Regular calibration the home made sensor	Feasible & Implemented *	To have a precise reading, we made a homemade conductivity sensor and order a factory made sensor, took both the reading and observed the difference. The accuracy was -+10%, with this accuracy we got a flexibility of using any of these sensors.
		Substitution	Purchasing factory made probe for accurate reading and reliability	Feasible & Implemented *	
	6.2 Agar-Agar Gel collection bag overfull	Engineering	Replace the On/off Pump Switch with Push Button	Feasible and easily implemented.	The push button limits the working of the motor resulting in limited collection of agar-agar gel. The collection bag used is made up of heavy quality polyurethane giving a stronger collection area
		Substitution	Collect the sample in a small chamber on the chassis instead of a bag	Consuming space on chassis	
	6.3 Robotic Arm- Damage of servo waterproofing	Elimination	Timely checking the O-ring seal	Feasible & Implemented *	Keeping a track on wear and tear of the O-ring is only way to keep the waterproof intact. Plus applying grease reduces the wear and tear.
		Engineering	Proper greasing of the servomotor for long reliability.	Feasible and can be implemented	
	6.4 Robotic Arm - Reduce torque at greater depth	Engineering	Optimized mechanism for the robotic arm	Feasible & Implemented *	The gear ratio when mechanically changed on the robotic arm increased the torque of the gripper by 30%.

10. TESTING

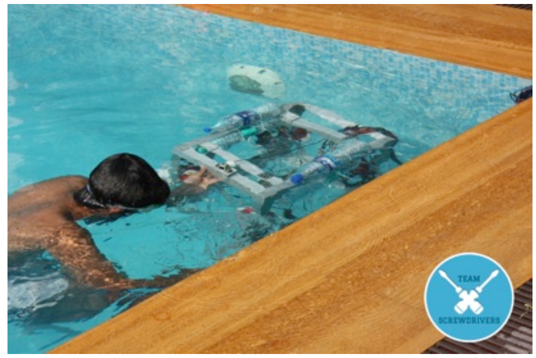


Fig. 10 – Testing at nearby pool

The test was conducted at Swimming pool of Country Club, Kandivali, Mumbai. This test was declared partially successful. The waterproofing of the electronics chamber was also tested by sealing it with grease.

Team Screwdrivers conducted second test immediately on 29th of March 2014, this test mainly focused on Waterproof connectors. The Waterproof connectors are used to detach the tether cable from the electronic chamber. It plays a vital role to keep the electronics chamber dry and functional. The test results came out to be successful and desired outcome was obtained. This test was carried out in MPSTME laboratories only.

A third major test was conducted to check on the thrusters, the new chassis i.e. the aluminium one and the buoyancy. This test was conducted on 15th of April 2014. These thrusters were self-manufactured by Team Screwdrivers and hence it was absolutely necessary to test them as soon as possible. These thrusters passed the test successfully as they were able to manoeuvre the Remote operated Vehicle clockwise as well as anticlockwise, forward motion and backward motion of the ROV was also successfully carried out. This test was conducted at swimming pool facilities of Country Club, Kandivali, Mumbai.

After all these series of testing's Team Screwdrivers conducted one more test on 24th of April 2014, to check on controls and tether. This test was conducted at Hydraulic engineering laboratories of MPSTME.

Shortly after this the final demonstration video for submission was carried out. Before the making of the demonstration video the ROV was checked and tested thoroughly for all the components and declared successful.

11. FUTURE IMPROVEMENTS

There are quite a few areas which need scope for future improvements. Power connecters to the electronic chamber need ample waterproofing. Providing better thrust of the Thrusters. Upgrading to better propulsions. Usage of 50 mm propellers in place of 40 mm. In future the execution of the ROV manufacturing needs to be done much earlier so that maximum time is given for testing of the equipment, which will help to make the necessary changes in time. Also learning from our mistakes from the ROV we built this year, we will emphasize more on design of the ROV and minor specifications which were neglected. If we discuss it in depth, better design of chassis needs to be taken care of next time. This year self-manufactured, economic buoyancy tanks were used in the ROV, hence in future buoyancy tanks to be used for better results. Also involving industry experts and taking timely consultations while manufacturing the ROV to yield maximum efficiency and output.

12. SAFETY:

Mechanical safety:

All the propellers are guarded by motor shell and a special fan covering which prevents direct contact with the propeller and each motor is covered by a bright red guard. Further a special housing using stainless steel rods is mounted from people putting their fingers inside.

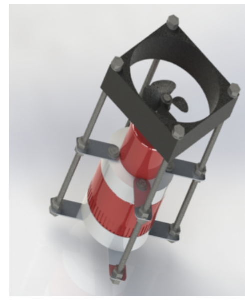


Fig: 12.1 CAD design of Thrusters housing

Electronics safety:

This is most critical part of safety as most of the equipment requires high current. All our electronic boards are served with fuses to prevent current overloading. Emergency power cut off is implemented in case of any emergency.

Waterproofing safety:

A thorough check of the safety list is done before testing the ROV in water. Deck crew during testing uses life jackets and gloves without fail.

13. CHALLENGES

Technical challenges

- **Waterproofing:** We did have quite an issue with the waterproofing in the beginning. At first, the tube that houses all of the on-board electronics had a severe leakage problem. After sealing the exposed cable, additional tape was put onto the threads of the cap which seals the tube. After these modifications were made, we experienced much less water leakage. All wires that entered the main housing were removed from their sealing, and resealed.
- **Thrusters:** Since we manufactured the Thrusters on our own, we did have quite a difficult time initially pertaining to its functioning. Here we have used 40 mm propellers and usually for a better thrust we can make use of 50 mm propellers. This was overcome by use of eight thrusters in our ROV which are strategically placed to give maximum thrust while efficiently consuming power from the source. These thrusters are not only economical but efficient in terms of performance as well and facilitates the smooth movement of the ROV.

Non-technical challenges

The major challenge that we faced was to procure the materials from different parts of the world all the way from NY, boulder, China, Australia to name a few. For this we set up a two tier system: Tier 1 which had all the procurement done at national level. Tier 2 involved all the procurement at the international level. The Tier 1 team handed the list of non available items to

Tier 2 team. Meanwhile the tier 1 team has started procuring the materials tier 2 started with their online. The major things that were not easily available are DC-DC convertor, the conductivity mechanism, servo motors, EC shield. Our college followed a centralized system of payment in which funds from all sources were to be submitted into college & it was then released as per demand. The process included the verification of bills by the CEO, cross checked by the faculty in charge then again checked by the higher officials like Deputy registrar followed by the signature of Dean sir. This entire process would take around 2-3 days & further 2-3 for processing in the accounts department. This all task was very well handled by the CFO & his team.

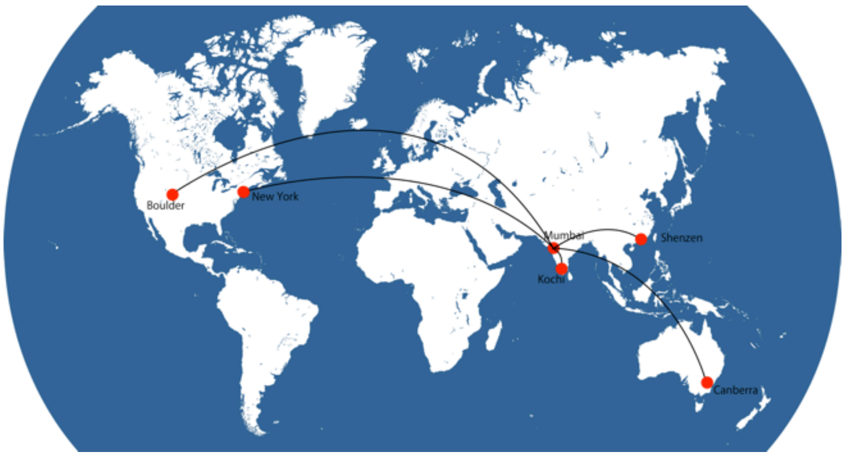


Fig 13.1 Geographical Procurement Map

14. REFLECTIONS

Vivek Maurya:

"I am a fourth year B.Tech student from NMIMS, MPSTME Mumbai and also the Chief Executive Officer of Team Screwdrivers, I administer all the departments by keeping a check on the overall progress. The main mission statement of Team Screwdrivers according to me is to provide opportunity to all as it will help as a platform for budding geniuses"

Jaidev Kulkarni:

"From the first meet onwards I have conducted wide research on thrusters, waterproofing and cables. The concept of building an underwater ROV is in itself a very challenging experience which opens the doors to a lot of research and understanding of the underwater terrain. The various tasks assigned to me to be completed in the give time frame makes it even more amazing for me and I am constantly compelled to think out of the box. MATE ROV is indeed one of the best platforms for me portray my technical talent. I think of Team Screwdrivers as a family which has come together to achieve this task"

15. OUTREACH

The zeal towards underwater robotics and marine engineering was transferred through focussed outreach activities to school students and were mentored by the Team Screwdrivers to take the initiative further.

Fig 15. Students during outreach session.

The first event itself gave an insight to the team on varied perspectives of students towards the study & their innovative ideas.

Growing up with the level of understanding, it was intended to go in-depth about the study of underwater robotics for school students. In the first few events, presentations on basics of robotics inclusive of the components, thrusters, robotic arms, cameras, actuators, sensors, mechanism and its application were delivered.

Nehru Science Centre came forward to help Team Screwdrivers in their novel initiative. They encouraged the team with different resources and also invited the team to conduct an Outreach activity for the school students. Team Screwdrivers had a rewarding experience for themselves when they conducted Outreach for the students coming from all over the country.

Team Screwdrivers was not only able to device Technological Solutions for Daily Life for different sections of the society, but also generate interest to work towards them.

16. ACKNOWLEDGEMENT

MATE Centre: Organising 13th Annual MATE International Competition, and providing an excellent platform to showcase technical knowledge.

Thunderbay National Marine Sanctuary: Venue of the competition

NMIMS, MPSTME Mumbai: Providing funds for letting us use their labs and manufacturing workshop.

Nehru Science Center Mumbai: For letting Team Screwdrivers conduct outreach activities.

Prof Sawankumar Naik: Our Faculty Mentor, for guiding and supporting us, He motivated the team to broaden horizons and push them to their limits

Country Club, Kandivali for letting us use the swimming pool for testing purposes.

Advanced Valves: Providing funds to manufacture the ROV

Solid Works: Provides the Solid Works Student Edition CAD Software.

17. REFERENCES

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2. "Underwater Robotics: Science, Design & Fabrication" Dr. Steven W. Moore. 2010, ISBN 978-0984173709.
3. "Mission and Specs" ROV Education and Resources. MATE Center.
4. Sharp, Arnold G. *Design Curves for Oceanographic Pressure-resistant Housings*.
5. The ROV Manual: A User Guide for Observation Class Remotely Operated Vehicles/ Robert D. Christ, Robert L. Wernli Sr. 2007, ISBN 978-0750681483.

18. LESSONS LEARNT

As far as the design of chassis is concerned we learnt to make a decisive design for the ROV before manufacturing with exact calculations and weight bearing requirements, with right kind of material to be used to avoid any future problem. We need to be aware how the designed device will be build. This will help to avoid development of structures that would be impossible to build. Furthermore we learned effective time management, working on the ROV, working towards deadlines, while managing our studies at the same time. We learned valuable soft skills through the process. We learned how to collaborate with team members from different disciplines, working together on integrating ideas and concepts to develop the complete ROV system.

All the team members regularly had meeting and everything was planned systematically keeping all the aspects in mind. Planning and execution have gone hand in hand and have been beneficial for the entire process of ROV manufacturing.

19. BUDGETING

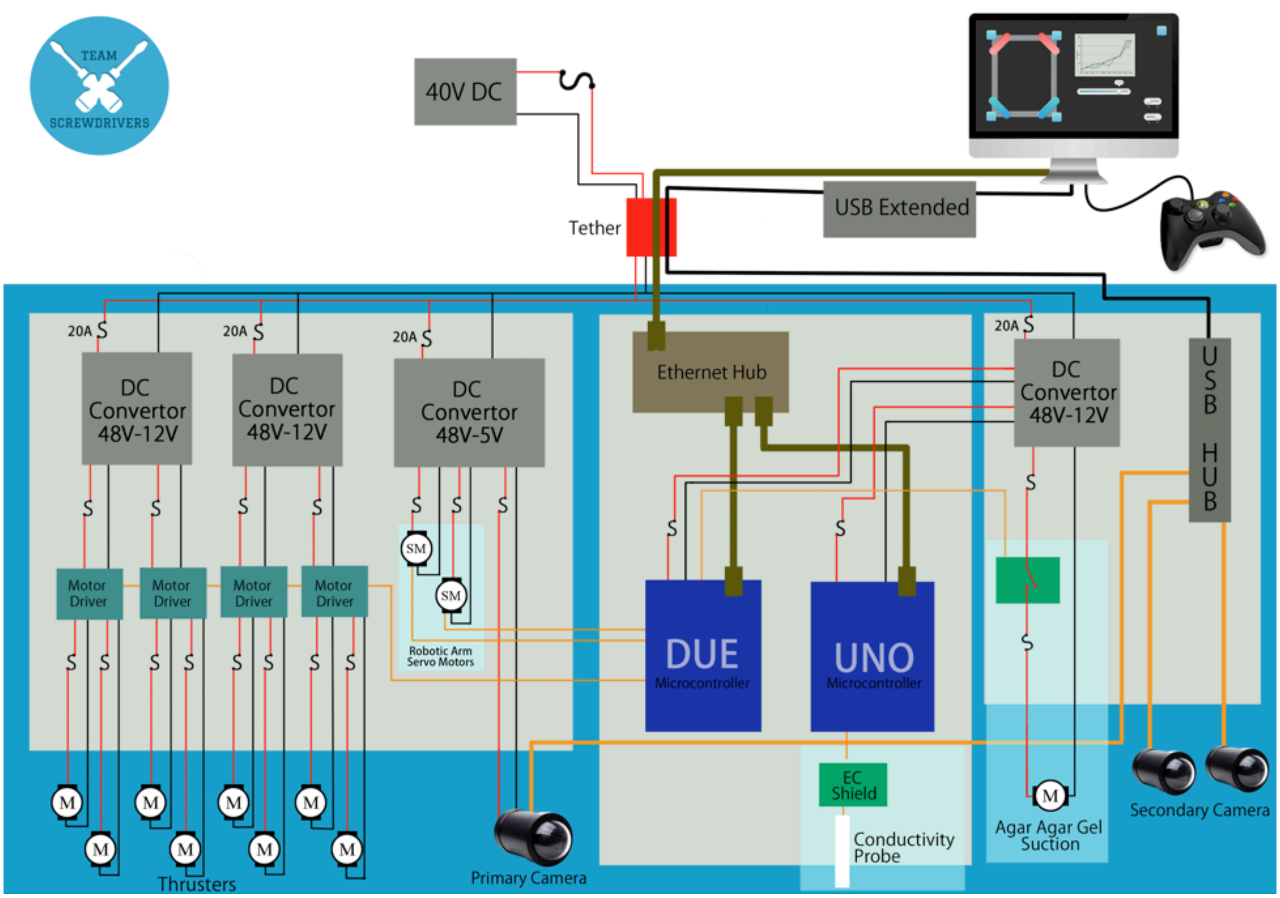
DEPARTMENT	DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST (INR)
Chassis	Aluminum sheets	Required		975
Propulsion	Bilge pump	8	1500	12000
	Propellers	10	190	1900
	Housing	8	210	1680
Conductivity Sensor	Atlas Scientific Probe	1	10050	10050
Agar-Agar Suction mechanism	Pump	1	1200	1600
	Nozzle/Other materials		400	400
GUI/Video system	X box controller	1	2300	2300
	Water Proof camera	1	12500	12500
	Webcam Camera	2	1100	2200
Electronics	Motor driver	6	300	1800

	Arduino DUE	1	4400	4400
	Arudino UNO	1	1875	1875
	Wi-Fi Shield	2	2387	4775
	DC motor Driver 20V	3	776	2328
	DC-DC Convertor (48-12V)	3	3143	9429
	DC-DC Convertor (48-12V)	1	3143	3143
	SMPS (12V)	2	900	1800
	SMPS (48V)	1	2100	2100
	Ethernet Hub	2	600	1200
	Acrylic sheet for mounting	Required	600	600
	Fuse, PCB etc	Required	1900	1900
	Electric wires	Required	1400	1400
	EC Shield	1	1800	1800
Robotic Arm	Mechanical Gripper	1	1800	1800
	Waterproof Servo motor	2	3900	7800
	Accessories	Required	800	800
Tether	Housing	20 mtrs	900	900
	Tether Cable	20 mtrs	750	750
Water proofing	Water proof chamber	1	5200	5200
	Gasket	1	700	700
	Pipe	Required	300	300
	Round clips	15	100	1500
	Silicon gel	2	150	300
Tools & Accessories	Tool Kit & Accessories			3600
Miscellaneous				3200
	TOTAL ROV MANUFACTURING COST (A) INR ($)			**₹ 1,11,005 ($ 1922)**
Website & MATE registrations	Hosting & Domain Name			2100
	Registrations			6500
	OTHER EXPENSES (B) INR ($)			**₹ 8,600 ($146)**
Travel	Airline Tickets	9	82000	738000
	Visa	7	12000	84000
	Accommodation & meals	9	7300	65700
	Bus Tickets	9	8400	75600
	TOTAL TRAVEL COST INR (USD) (C)			**₹ 9,63,300 (US$ 16327)**
	TOTAL PROJECT COST (A+B+C) INR (USD)			**INR 10,85,305 (US$18,395)**

APPENDIX A: SAFETY CHECK LIST

Items	Things to be checked	Checklist
1.	Plan and arrange the system and work area for safe and comfortable working.	
2.	Connect the tether to the ROV	
3.	Check the waterproofing of all connectors whether they are tightened properly.	
4.	Check for cables whether they are tightened properly.	
5.	Check for waterproofing of electronics box.	
6.	Using digital multimeter, check whether the 48 V input and ground is connected or no.	
7	Connect power supply with the tether.	
8	Check all warning lights in the main sealed housing	
9	Turn on the power and see whether ROV is functioned properly.	
10	Put the Rov in water.	
11	Recheck for electronic chamber waterproofing.	
12.	The ROV is ready for the mission.	

APPENDIX B: SYSTEM INTERFACING DIAGRAM



APPENDIX C: SOFTWARE FLOW CHART

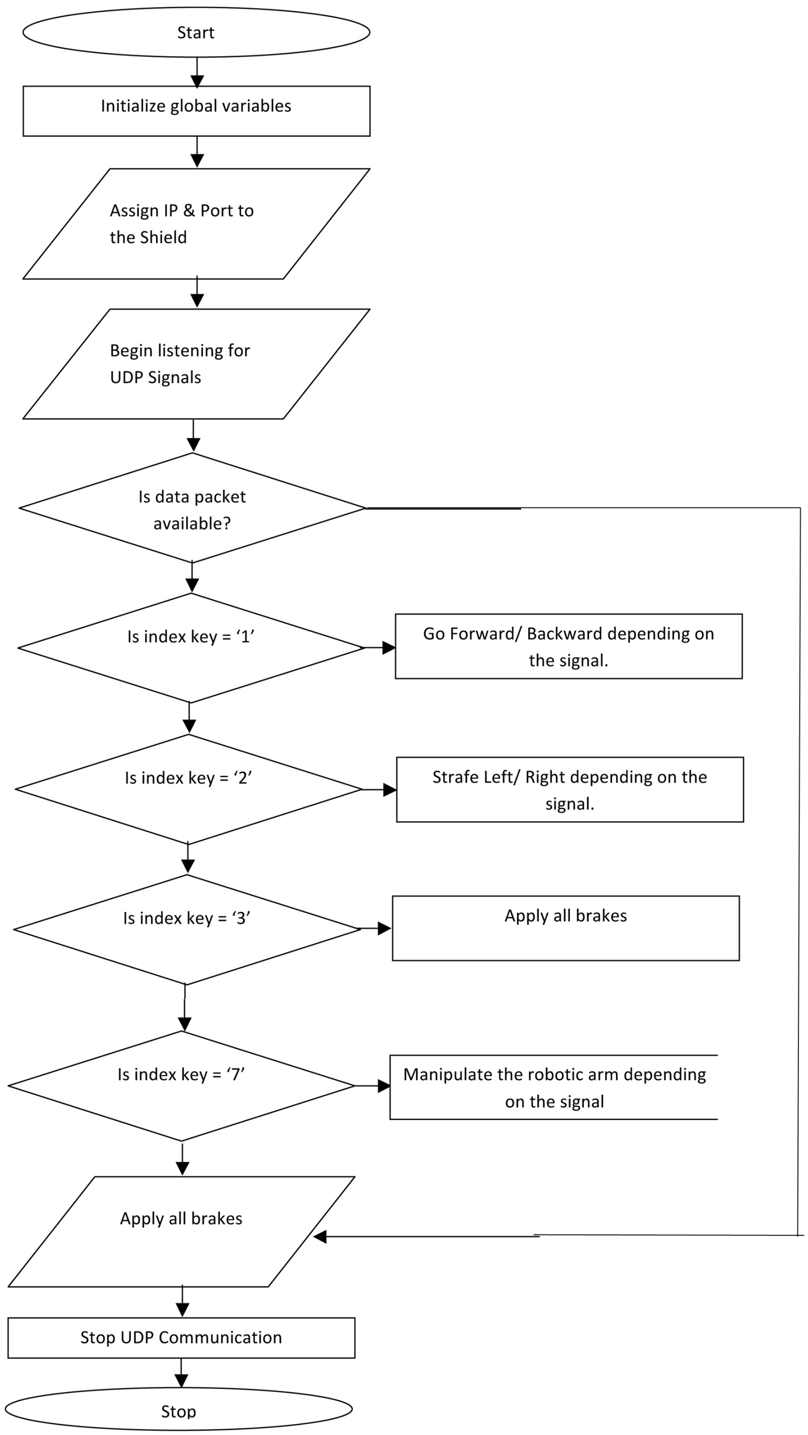
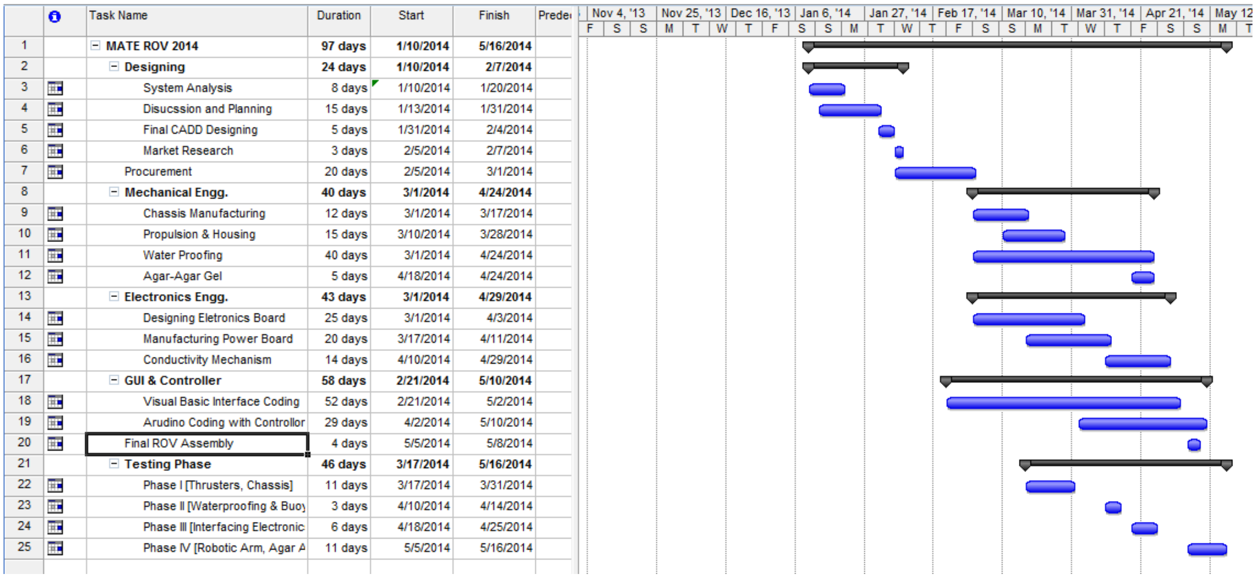


Fig. Software Flow Chart

APPENDIX D: GANTT CHART



	Task Name	Duration	Start	Finish	Prede
1	MATE ROV 2014	97 days	1/10/2014	5/16/2014	
2	Designing	24 days	1/10/2014	2/7/2014	
3	System Analysis	8 days	1/10/2014	1/20/2014	
4	Disucssion and Planning	15 days	1/13/2014	1/31/2014	
5	Final CADD Designing	5 days	1/31/2014	2/4/2014	
6	Market Research	3 days	2/5/2014	2/7/2014	
7	Procurement	20 days	2/5/2014	3/1/2014	
8	Mechanical Engg.	40 days	3/1/2014	4/24/2014	
9	Chassis Manufacturing	12 days	3/1/2014	3/17/2014	
10	Propulsion & Housing	15 days	3/10/2014	3/28/2014	
11	Water Proofing	40 days	3/1/2014	4/24/2014	
12	Agar-Agar Gel	5 days	4/18/2014	4/24/2014	
13	Electronics Engg.	43 days	3/1/2014	4/29/2014	
14	Designing Eletronics Board	25 days	3/1/2014	4/3/2014	
15	Manufacturing Power Board	20 days	3/17/2014	4/11/2014	
16	Conductivity Mechanism	14 days	4/10/2014	4/29/2014	
17	GUI & Controller	58 days	2/21/2014	5/10/2014	
18	Visual Basic Interface Coding	52 days	2/21/2014	5/2/2014	
19	Arudino Coding with Controllor	29 days	4/2/2014	5/10/2014	
20	Final ROV Assembly	4 days	5/5/2014	5/8/2014	
21	Testing Phase	46 days	3/17/2014	5/16/2014	
22	Phase I [Thrusters, Chassis]	11 days	3/17/2014	3/31/2014	
23	Phase II [Waterproofing & Buoy	3 days	4/10/2014	4/14/2014	
24	Phase III [Interfacing Electronic	6 days	4/18/2014	4/25/2014	
25	Phase IV [Robotic Arm, Agar A	11 days	5/5/2014	5/16/2014	

Fig. Gantt Chart

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