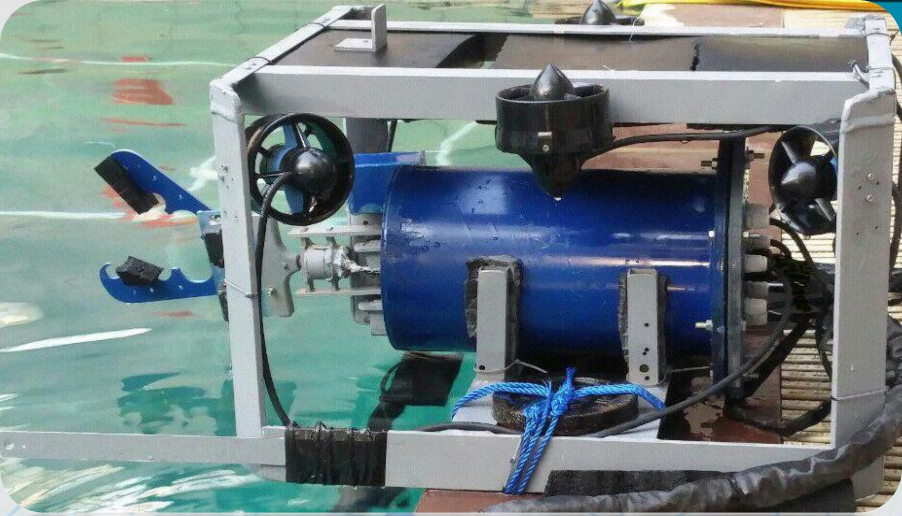

STAFF MEMBERS- TECHNICAL

Mansi Singh – Chief Executive Officer

Mirza Samnani – Chief Technology Officer

Chandni Raghuraman- Chief Financial Officer

Sahajdeep Chhabra – Software Specialist / Electronics Expert

Jatin Swami – Payload Specialist / Logistics Manager

STAFF MEMBERS- NON TECHNICAL

Simanti Bose – Outreach President

Komal Sharma- Marketing Head

Avi Dhruv- Marketing Executive

Mentor – Prof. Sawankumar Naik

MANSAROVER

MATE

SVKM'S NMIMS Deemed to be UNIVERSITY

TEAM SCREWDRIVERS

ABSTRACT

Team Screwdriver's ROV "Mansarover" is India's response to MATE's quest for 'Port Cities of the Future: Commerce, Entertainment, Health, and Safety.' The needs of the Port of Long Beach, California, are some of many across the world and Mansarover is manufactured with the aim to aid the management of such ambitious ports.

With a team of eight hard-working students, Mansarover is the result of passion for marine technology and the motivation gained from the myriad of opportunities this project presents to the company. The lessons learnt from Team Screwdriver's previous ROVs like Vikrant and Spyder has propelled the team to take innovative turns in design to create the best budget ROV of the competition, embodying both smooth movement and efficient workmanship.

Mansarover's features include six brushless thrusters for propulsion combined with its lightweight aluminium chassis and acrylic electronic chamber, which allows easy manoeuvrability. Arduino Mega is used to coordinate the activities of Mansarover seamlessly, with connections systematically soldered into Printed Circuit Boards, aligned in stacks. Mansarover is equipped with a surveillance HD camera and one IP Board Camera, which have full pan and tilt capability for pilot comfort and survey. Long hours of deliberation and experimentation by members of the company have led to the use of two RC controllers for manoeuvring Mansarover, due to the controller's unique features and guarantee of stable piloting. Topside coding of Mansarover is done using Java programming, which is fed via a single Ethernet Cable from the station to the Electronic Chamber.

TEAM SCREWDRIVERS 2017

Left to right: Komal Sharma, Sahajdeep Chhabra, Chandni Raghuraman, Mirza Samnani, Mansi Singh, Jatin Swami and Simanti Bose

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DESIGN RATIONALE

1. Design Evolution and Structure

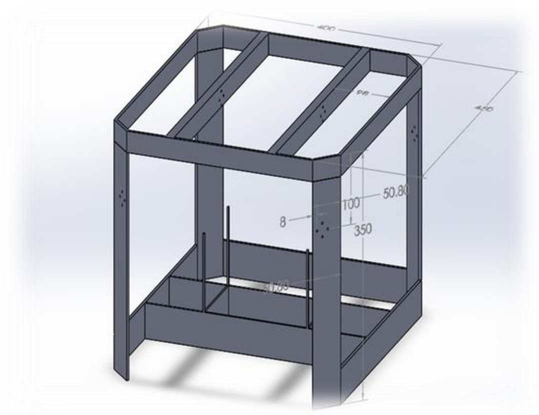
The design of Mansarover was chosen to ensure that it produces a variety of movement options for piloting and the weight of payload is equally distributed along the chassis. Keeping in mind the different tools to be housed by Mansarover, the company staff set their eyes on an octagonal structure. The diagonal edges of Mansarover help in making the movement of the ROV swift as it cuts through the water and regulates excessive water currents coming from the thrusters. It also acts a firm platform to mount the thrusters controlling horizontal plane movement. The diagonal edges are inclined at 45 degrees, thus providing equal support to both front-back and right-left manoeuvring.

In the initial planning stages, members of Team Screwdrivers deliberated on the usage of a variety of materials to construct the chassis, like ABS, carbon fibre and Iron. Aluminium was finally chosen, as it is durable, lightweight, recyclable, resists corrosion and cost effective. The strength of aluminium ensured that the thrusters and payload equipment could be attached directly to the structure without the need for an intermediate mounting “bracket.” The chassis is made up of rectangular aluminium pillars welded with L-shaped joints to support rods that give additional support to the shrouded thrusters. The bottom of the chassis contains four cuboidal aluminium rods places in a square of 11cm X 11cm so that the Electronic Chamber (EC) can be attached within the square. The sides of the EC compartment include a wedge to mount the main robotic arm of Mansarover, a mount for the secondary arm and tools. The bottom plane of the ROV below the EC compartment has a net attached so that the robotic arm can retrieve/ insert items to be collected/placed in the seabed. The chassis also consists of mounts for the two HD cameras carried by the ROV. Mansarover derives its name from the sacred Mansarovar Lake in Tibet. Hence, company members have chosen the blue-grey colour scheme to reflect its namesake.

Aluminium is extensively available in India and is used in large-scale mechanical projects. As a result, the company had easy access to aluminium and it could be welded as per the design requirements. This design is made keeping in mind the streamline flow of water.

Figure 1: Aluminium Chassis painted grey

Figure 2: CAD representation of aluminium chassis



2. Electronic Chamber

The Electronic Chamber (EC) is made of a cylindrical mould of acrylic and painted with blue spray paint. All wires connecting the electronics within the EC with components outside like the thrusters and cameras are passed through plastic gland connectors. The sizes of gland connectors used are as follows:

Sr No.	PG Thread	Hole size (approx. diameter)
1	PG 7	13mm
2	PG 9	15.7mm
3	PG 11	19mm
4	PG 19	24mm

The gland connectors are waterproofed with epoxy fluids, Teflon tape and O-rings so that no water passes through the wires. The end cap consists for holes for attaching the gland connector and it is screwed to the hull. A CCTV full HD camera is mounted in the EC. The camera surveys the external environment of the EC and has a direct view of the manipulator arm.

Figure 3: Acrylic Electronic Chamber painted blue.

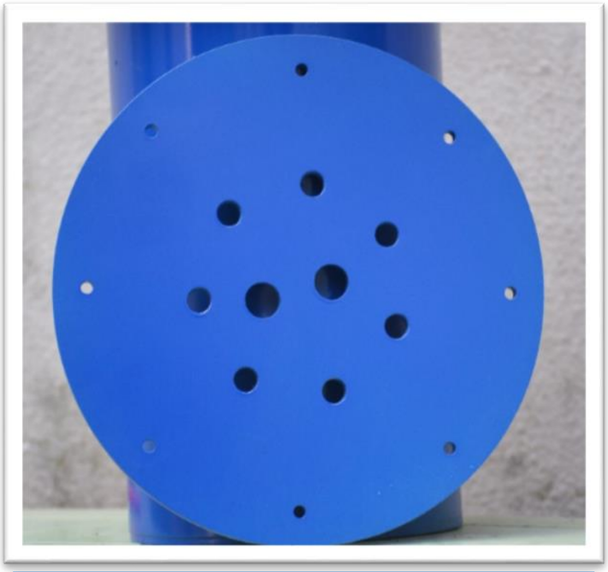


Figure 4: Acrylic Electronic Chamber End Cap before attachment of screws and gland connectors

Figure 5: Acrylic cylinder before it is painted

3. Buoyancy

The octagonal structure preserves the Centre of Gravity of the ROV at the centre of the Electronic chamber hull. Hence, Mansarover has a topside covering of 3 cm thick Ethylene-vinyl acetate (EVA) foam. The foam is waterproof and hence does not absorb water; it is lightweight, smooth and highly durable in harsh conditions. Due to EVA foam being extremely positively buoyant, the float has been mounted in 3 pieces instead of one, ensuring that there are gaps for water to flow through and reduce the excessive effects of the foam. Compact pieces of the foam is also attached to the tether of Mansarover to reduce the drag caused by the tether during ROV movement under water.

Figure 6: EVA foam mounted on Mansarover for buoyancy

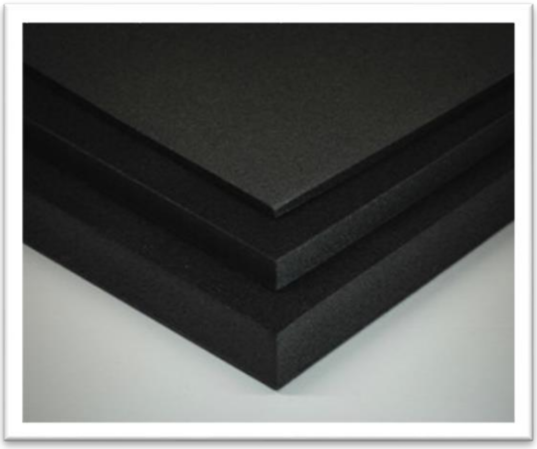


Figure 7: EVA foam texture and colour

4. Waterproofing

Waterproofing of the Electronic Chamber (EC) and on-board cameras is paramount for the proper functioning of any ROV. Learning from past hassles faced by Team Screwdrivers in mastering the art of waterproofing, the company has spent a lot of time in the drawing board to find durable solutions. Connector glands are first taped with Teflon tape, which acts as a sealant to repel water. It is then attached to an O-ring, which stops the flow of water from one end to another. O-rings are a gasket, which act as a mechanical seal between irregular surfaces, and under compression, prevent the permeability of water or any streamline fluid. O- rings are also deployed between the hull and the end-cap of the EC, sealing it from the fast flowing water. The sensors are placed in a singly moulded acrylic chamber within the EC to provide further protection. Epoxy fluids of silicon base are used to conceal the casing that hold LED lights and other delicate equipment used in the ROV.

Figure 8: Teflon tape

Figure 9: Silicon Gel

Figure 10: PG 19 connector with O-ring

Company members have waterproofed all servo and DC motors used in Mansarover. First, the motor is coated with epoxy, and the gearbox was filled with thick grease to prevent seepage of water. Each sensor is placed in a specifically designed casing that is made to aid the sensor's functionalities and ensure that it is not in contact with water. Cameras are enclosed in a watertight moulds made of acrylic with a gland connector at back for the wire. To prevent condensation from adversely affecting the electronics inside the chamber and the camera lens inside the external casing, industrial grade silica gel is packed in a cloth to absorb the moisture. This method has been tried and tested in previous ROVs made by Team Screwdrivers and has produced reliable results.

5. Programming

Mansarover is controlled from a laptop via two RC controllers. An Arduino Mega module is used to coordinate all activities within the ROV. The coding for thruster movement and sensor reading is done using JAVA programming language on the Arduino coding environment. The Graphical User Interface (GUI) set-up on the laptop is created using features provided by MATLAB.

RC controllers provide a range of signals, unlike a two-state signal produced in a generic joystick controller. As a result, the coding is done such that, a signal is decided over a range of pulses, with each pulse giving the same output, but with varying degree of power. For example, let us consider the Blue Robotics T100 thruster. Forward motion must be set when the value is between, say, 0-50. However, at 0 the thruster power is minimum and at 50 it is maximum, although both signals produce the desired forward movement only. Thus, JAVA programming is incorporated in communicating between the RC controller's receiver and the Arduino Mega module.

The GUI presents the status of all the sensors present in the ROV at real-time. The live video stream from both cameras present in Mansarover can be seen via the GUI. The GUI showcases the current sensor's and pressure sensor's reading at all times and alerts the team members at the station when there is a change in its values. The temperature sensor indicates the temperature of the EC constantly. The monitoring of the real-time values of the sensors give pilots the ability to monitor the present condition inside the EC. Coordination between the company members monitoring the GUI and pilot is paramount, to avoid overloading of components.

Figure 11: Arduino Mega USB cable

Figure 12: Arduino Mega 2560

The tasks have been separated using their basic functions, like manoeuvring, robotic arm control, camera servo, LED control, receiving sensor data from Arduino, etc. All these tasks are designed to run in parallel. This increases the throughput of the system and makes the system extremely coherent. Compartmentalization of information in the GUI is a staple feature of ROVs built by Team Screwdrivers, as this approach has always been successful for our engineers. The Arduino program accepts the command sent by the Java controller, validates it and executes the command affecting the ROV components. Along with this, the Arduino system also sends the temperature and pressure sensor data to the Java controller intermittently. If the ROV does not receive any communication from the controller for more than 5 secs, it shuts off all systems and waits for communication to resume. This feature ensures that the ROV and its components are safe even during malfunctions.

The advantage of using an Arduino Mega is that accepts commands from the controller in a specific format. When a command is received, it first validates the command by its format. Commands sent to the ROV are used to directly run the ROV components. No processing is done on the Arduino which reduces its workload thus keeping the microcontroller ready for the next command. The increased number of ports also ensures that no secondary device having extra ports is introduced to take a share of the power supply or increase the burden of the ROV inside the EC. Thus, using a minimalistic approach, members of Team Screwdrivers are always kept informed of Mansarover's status, even at a depth of 4m.

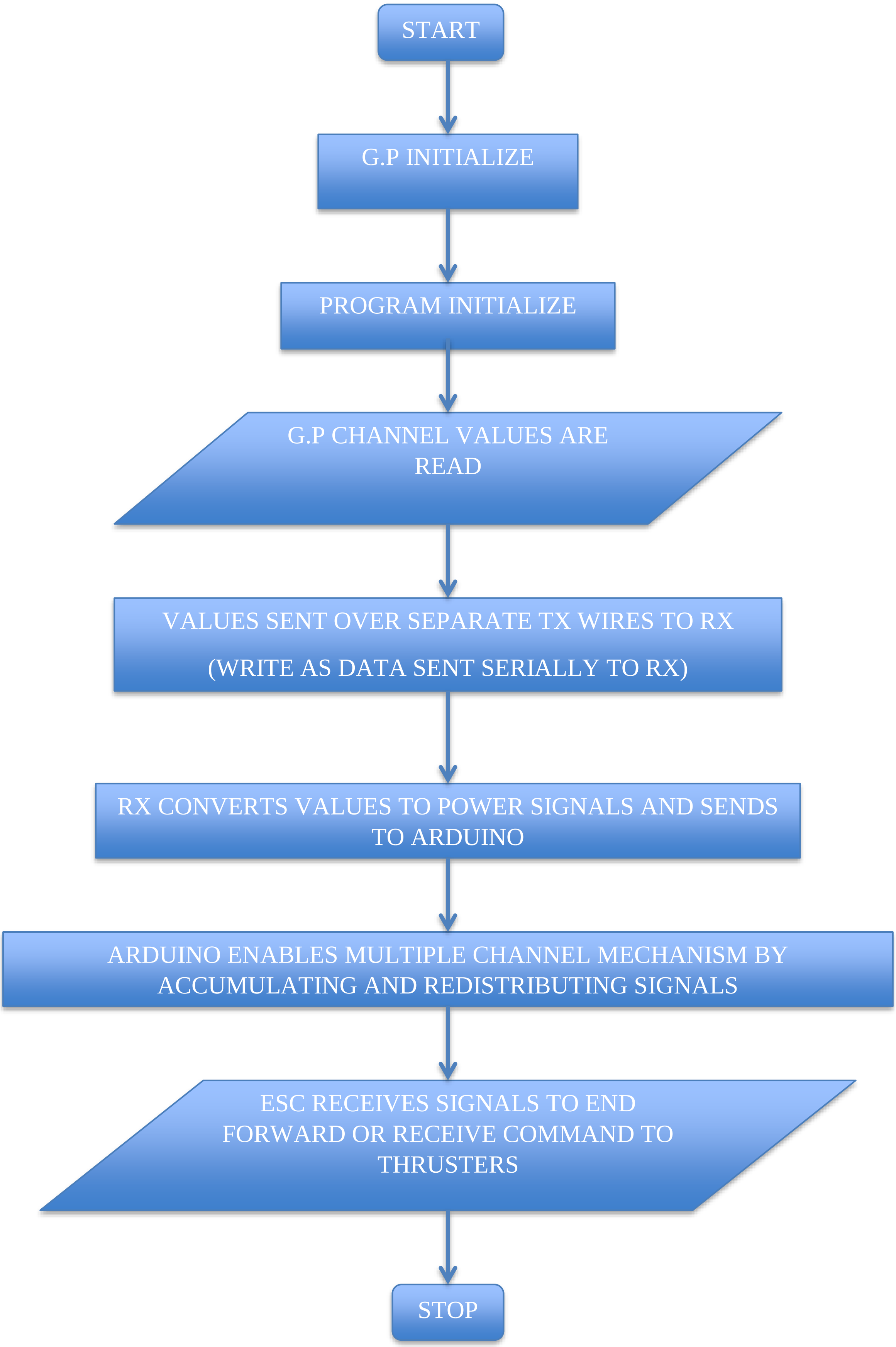
Software flowcharts are shown in page 9 and page 10.

6. Tether

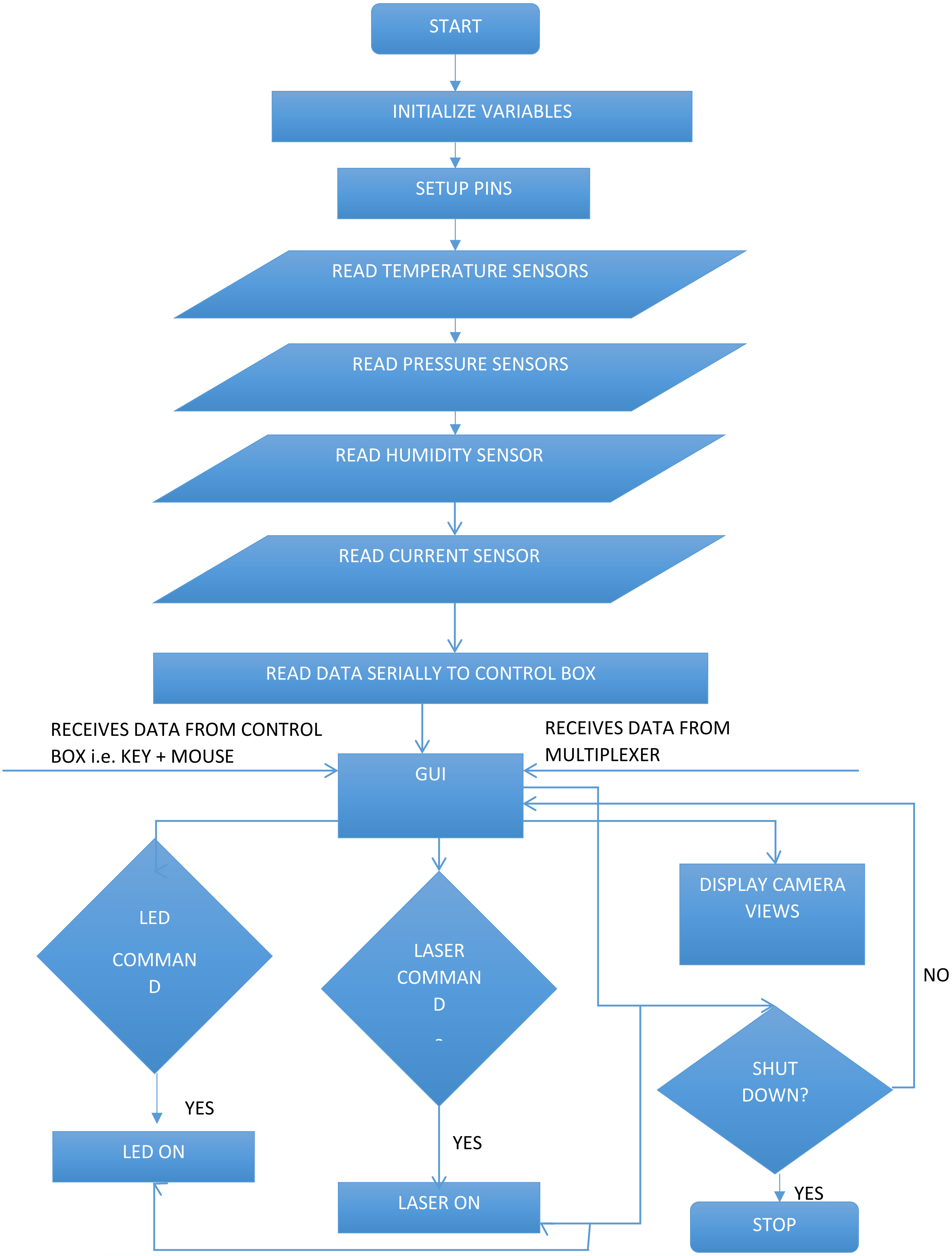
Mansarover's tether consists of one Ethernet CAT 6 cable, two 12 AWG wires for power supply and two high power cabled to connect the RC controller's receivers. The Power supply cables can carry up to 60A of current and the cables were selected due to its durability, minimum resistance and flexibility. The power lines are rated for a resistance of 0.08 Ohms and with estimated peak draw of 30A, we suffer a voltage drop of only 30*0.08 = 2.4V. This provides us a minimum operating voltage of 45.6V, well above the 36V rated cut off voltage of our DC to DC converters on-board Mansarover. CAT 6 cable is used to retrieve the video feed from the two cameras on board the ROV. CAT 6 cables are proven more lightweight and safe compared to CAT 5. In addition, we wanted to make use of double the bandwidth that CAT 6 theoretically provides over CAT 5. Hence, Team screwdrivers unanimously chose to use this cable in Mansarover.

The tether length is 17 m long and the wires are taped with Teflon tape. We incorporated this step in tether making as we observed the usage of Teflon tape in a variety of electric cables. The taped wires are then passed through a heat shrink tube, a tube that compresses on heating. Once the heat-shrink tube is heated, we pass it though a plastic spiral tether shield, which protects all the wires. After deploying these methods, the tether produced by team screwdrivers is firm and negatively buoyant. As a result, small pieces of foam are attached to the tether every 50cm.

Software Flowchart for ROV movement



Software Flowchart for GUI working



7. Thrusters

Mansarover makes use of six thrusters for primary propulsion. Team Screwdrivers recycled the Blue Robotics T100 thrusters used in its previous ROVs like Spyder and Vikrant. This saved the team considerable amount of time, money and logistics. The ROV makes use of four T100 thrusters for lateral and longitudinal movement. The thrusters are rated for a maximum forward thrust of 2.36 kgf and a maximum reverse thrust of 1.82 kgf. The company members felt the need to use a thruster of more torque for the up-down movement of the ROV and hence we have made use of two Blue Robotics T200 thrusters, rated with maximum forward thrust of 3.55 kgf and maximum reverse thrust of 3.0 kgf. Both T100 and T200 are brushless electric motor based thrusters. The thrusters' housing is made of high-strength, UV resistant polycarbonate injection moulded plastic. These thrusters are operated using Afro Electronic Speed Controllers (ESCs) which are operated on 12V DC.

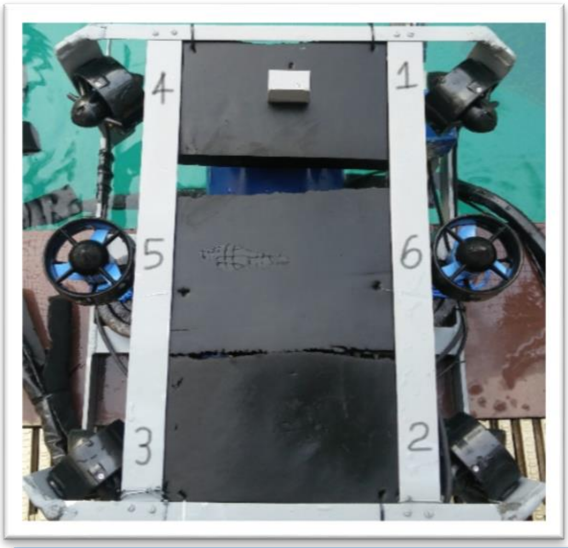


Figure 13: Thruster placement and numbering abode Mansarover

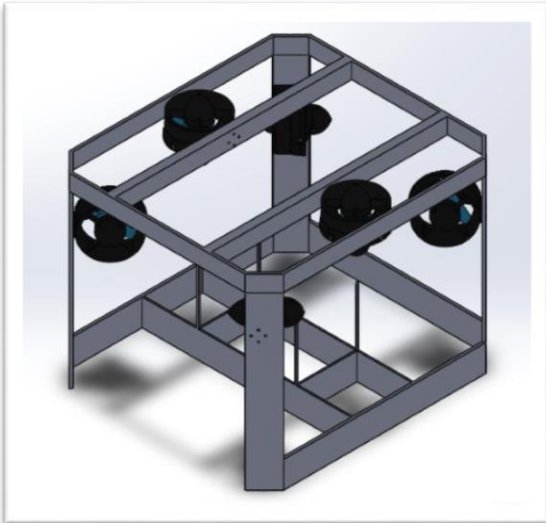


Figure 14: CAD representation of thruster placement

Thrusters 1, 2, 3, 4 form the lateral group of thrusters and are mounted in the 45-degree diagonal pillars of the chassis. They propel the ROV in ten different directions in the horizontal plane.

Thrusters 5 and 6 form the vertical group of thrusters that are responsible for the diving and rising of the ROV. They are T200 thrusters and are placed symmetrical to the two side plates of Mansarover's chassis. All the six thrusters are managed efficiently so as no thruster interferes with the thrust of any other thruster during operation and do not create any drag. The thruster cables are 1 m long and are fitted into groves made in the chassis so that no dangling wires are present to hinder Mansarover's movements or streamline water flow.

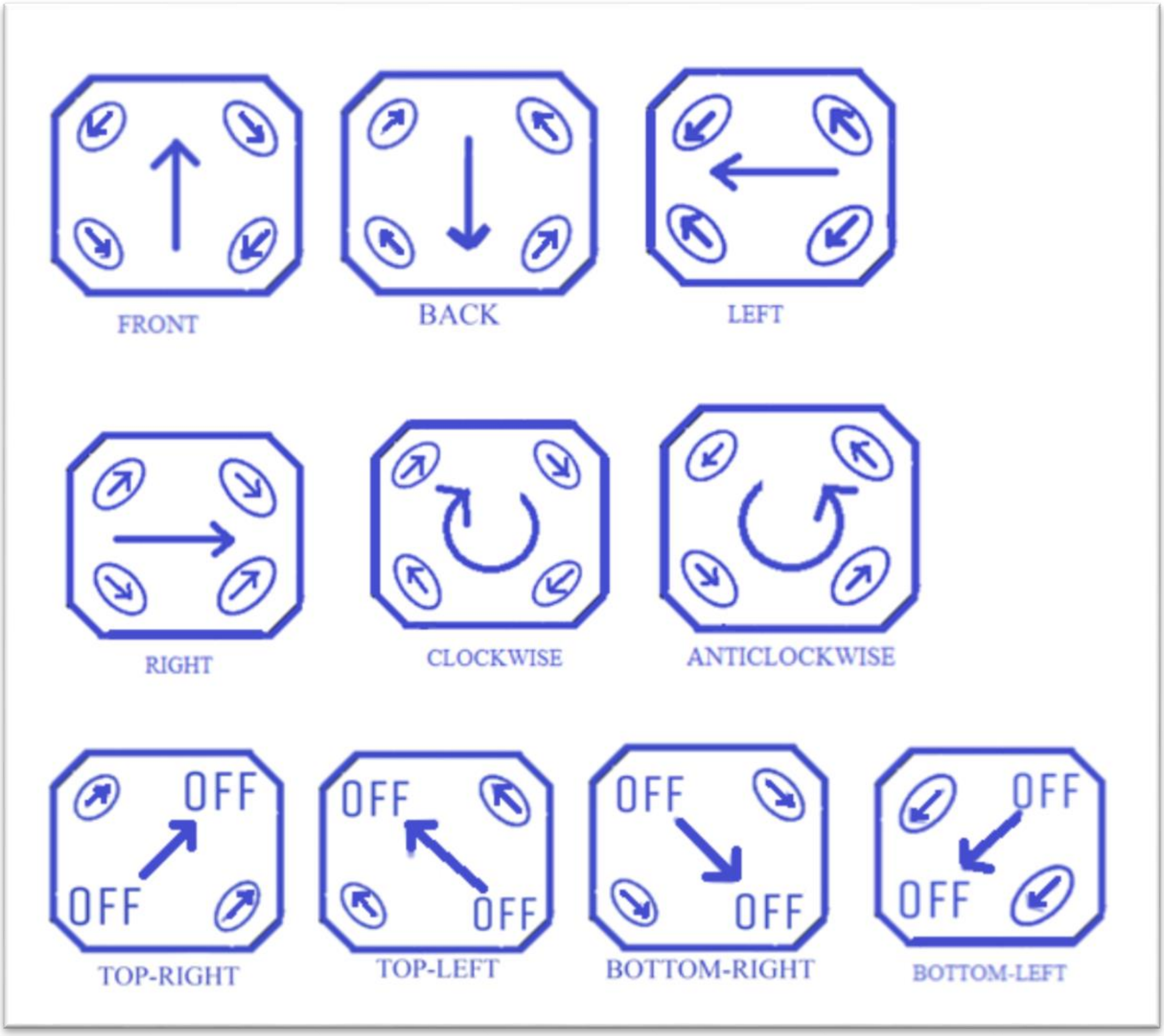


Figure 15: Directions possible by Mansarover in horizontal plane with the help of T100 thrusters 1,2,3,4

8. Electronics

All the electronics in Mansarover are placed within the acrylic Electronic Chamber (EC). The EC houses the PCB and associated wiring for the thrusters and motors.

The size and complexity of the circuit has been reduced significantly due to the use of PCBs and the RC controller. The electric board of Mansarover has been designed for maximum isolation between high power and low power signals, so as to reduce the likelihood of electromagnetic interference between the wires in the EC.

An Arduino Mega 2560 module acts as the heart of the electronics present in Mansarover and coordinates all activities of the ROV. It is supplied power through a Mortata Power Solutions DC/DC CONVERTER 12V 35A. A Delta Electronics DC/DC CONVERTER 15W 5V 3A is also used in parallel to power the RC controller Receivers and Servos present in the ROV. A Generic ACS712 30A Hall Current Sensor Module is used to read the current in the wires real time. It acts as protection to the 30A Bullz Audio Platinum Fuse housed in an acrylic Fuse holder.

MPU 6050 is a three-axis Gyroscope Accelerometer Sensor Module compatible with Arduino Mega. It provides real-time values of thruster acceleration and orientation of the ROV. The BME280 is an integrated environmental sensor specifically designed for placement in low size and power conditions. It tracks temperature, pressure and humidity of the EC and alerts pilots of any waterproofing failure or damage. The thrusters are controlled by electronic speed controllers, which are mounted on the board itself and segregated in a stack structure. L298N motor drivers drive the DC motors, which are used in the custom fabricated mechanical manipulators.

Mansarover uses two HD cameras for surveillance. The main camera is DH-IPC-HFW1320SP -0360B Full HD surveillance camera manufactured by Dahua Technologies. It is mounted in the electronic chamber and holds a direct view to the main manipulator arm of Mansarover. The second camera is a full HD board camera filled with a SONY 3MP lens for precision and clarity. This camera is mounted at the top of the EC and is attached to a pan-and-tilt mechanism. Both cameras are powered by the 12 V rail and communicate over Ethernet. The cameras along with Arduino are plugged into an Ethernet switch on-board Mansarover, which has been used by previous ROVs built by Team Screwdrivers. A DC 5mW, 650nm Red Copper Head Tube Laser Dot Diode Module is the laser used by Mansarover to illuminate sediment samples within the seabed. It has passed all safety requirements put forth by MATE and boasts of 2000 hours of life with continuous output, coupled with its sleek design and lightweight. Mansarover is also equipped with High Power LED SMD bead Chips that illuminate the path taken by the ROV and improves video feed quality from the cameras.

Figure 16: IP Board camera with SONY lens

Figure 17: Dahua CCTV HD camera

Figure 18: DC/DC 12 V converter

Figure 19: DC/DC 5 V converter

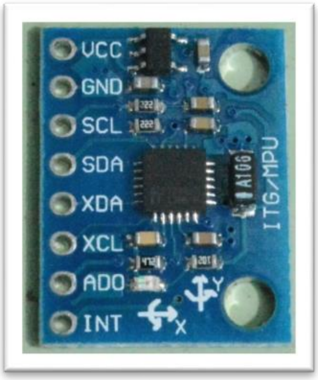


Figure 20: MPU 6050 sensor

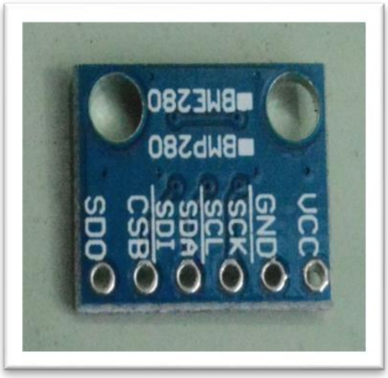


Figure 21: BME 280 sensor

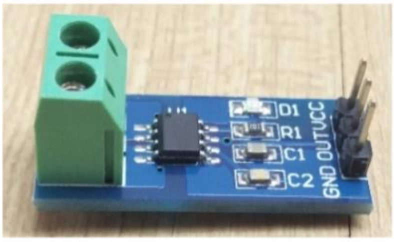


Figure 22: Current sensor

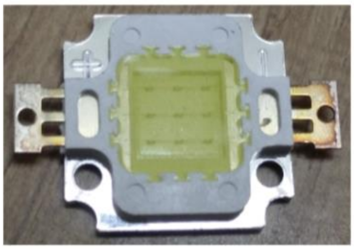


Figure 23: LED button light


Figure 24: 30 A Fuse

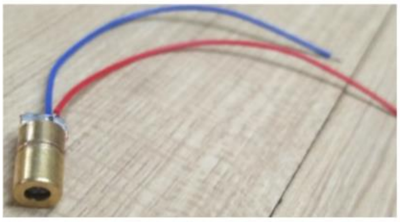


Figure 25: Red Laser diode


Figure 26: 30 A fuse in acrylic fuse holder

9. Power Budget

Unit	Current (in A)	Voltage (in V)	Power, W	Quantity	Total
Arduino Mega	0.75	12	9	1	9
BlueRobotics T200	17.5	12	210	2	420
BlueRobotics T100	8.75	12	105	4	420
Ethernet Hub	1	12	12	1	12
Cameras	0.4	12	4.8	2	9.6
Servos	0.5	5	2.5	7	17.5
Lights	0.5	12	6	2	12
DC Motor	0.3	12	3.6	1	3.6
Total		**12**			**903.7**
Peak Power Available at Top of Tether W(30A*48V)					1440
Power Loss Due to Tether Resistance (30A^2 * 0.08Ohm)					72
Peak Power Available to ROV end of Tether					1368
Regulator Efficieny, % (Estimated)					85
Power Loss, W (Peak Power/Efficiency)					205.2
Power After Conversion at ROV					**1162.8**

10. Mechanical Arm and RC controller

The mechanical manipulator arm carried by Mansarover is its main payload system and consists of four waterproofed servo motors of torque 11kgf, one waterproofed DC motor manufactured in India, 3-D printed shafts to connect the DC motor to the gripper of the arm, which is made of acrylic. Base of the arm mounted on to the aluminium shaft of the ROV chassis is also carved out of acrylic. Intense discussions were held while designing the manipulator arm as company members realised that the arm is of great importance for the smooth functioning of the ROV. The grooves present in the arm are 1.5 inch, 1 inch and 0.5 inch in diameter, as they are the diameters of most of the PVC pipes used as props in the competition. The edge of the gripper consists of a hook-like curve, which will deal with the U-Bolts and hooks present in the props. The arm is painted blue to aesthetically match the colour scheme of Mansarover. Two servo motors move the arm up to 180 degrees in the horizontal plane at the base and two servo motors are attached to the two ends that manipulate the gripper of the arm. The DC motor is used to rotate the gripper in order to accomplish certain tasks.

Mansarover's mechanical arm is capable of completing multiple tasks using the same design. This saves time and ensures that the ROV does not need to return to the base station for replacement of any payload system tool.

Two RC controllers are used to control the movement of Mansarover. It consists of two receivers that are placed in the EC. One receiver controls thruster movement and the other controls Arm and Payload tool movements. One of the main reasons for choosing the RC controller over a joystick or Xbox controller is its trimming feature and separate receiver chip. The trimming feature of the controller is that the pulsating values it is sending continuously on demand by the operator can be set at a particular value for all the channels. For example: If the pilot feels that the ROV should be stable at a point inside the water for a particular task, then the values can be set to a particular value in its range and then from that channel only those values or higher values will be sent. Although the RC receiver is meant to communicate wirelessly with the controller, Team Screwdrivers has successfully wired the receiver to the controller as it increases transmission rate, reduces interference and noise without inhibiting the receiver's natural capability of accurately stabilising and decoding analog signals. The transmitter-receiver combination deployed by RC controllers ensures that there is no direct power connectivity between the controller and the EC. This inhibits signal manipulation in the Arduino and keeps the system secure.

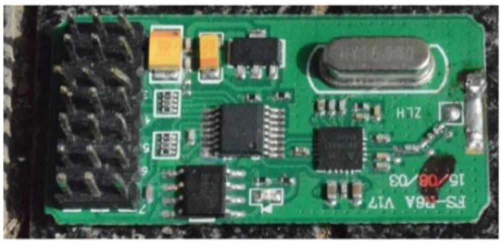


Figure 27: RC controller receiver

Figure 28: RC controller

Figure 29: Mechanical Arm gripper

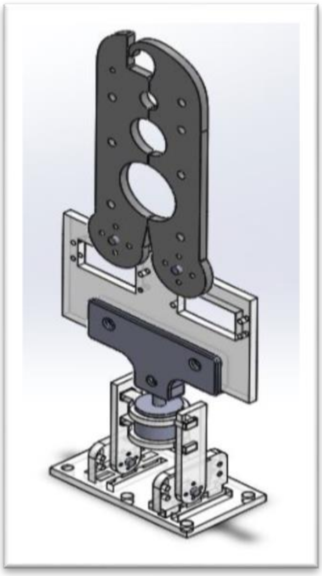


Figure 30: Mechanical Arm gripper (CAD)

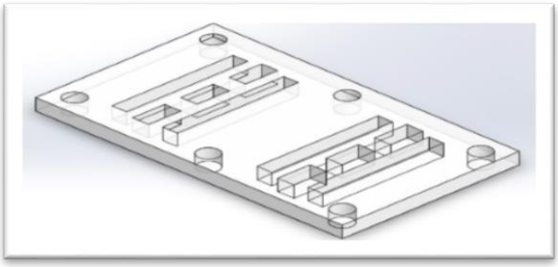


Figure 31: Mechanical Arm base CAD, Acrylic

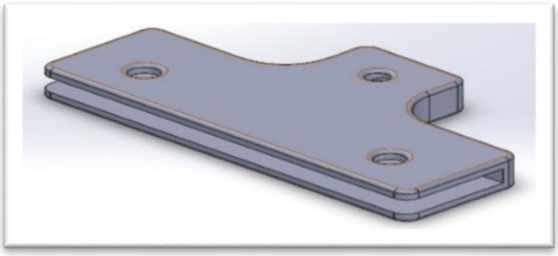


Figure 32: DC motor connector CAD, 3D Printed

11. Secondary Payload Systems

Mansarover makes use of two additional payload systems to aid the manipulator arm in completing the tasks specified by MATE.

The 'Syringe system' is used to collect sediment samples from the base. It consists of a large 150ml syringe and a DC motor with high torque attached to the plunger of the syringe. The controller switches on the DC motor that will enable the syringe to suck the sediment sample. Once the syringe is full, the DC motor is switched off and company members on the surface retrieve the sediment. This entire system is attached to the Mansarover's chassis and the HD cameras on board can easily read the syringe calibration. This payload system is easy to implement, light weight and cost effective.

The 'Measuring tool' is used to measure distances of objects from the ROV in the seabed. It consists of a steel pocket take with its end attached to a hook. The hook is used to latch on to U-Bolts of objects whose distance need to be measured from the ROV. The HD cameras can read the distance shown on the Tape once it has begun manoeuvring to measure distance. This system is simple in design, cheap to build and very efficient. It helps company members to create maps of the seabed along with the compass housed in sensor MPU 6050. This system requires no mechanical control from the pilots on the station. The tool is mounted directly onto the chassis of Mansarover along with the buoy marker, which has to be left off by the ROV on the seabed.

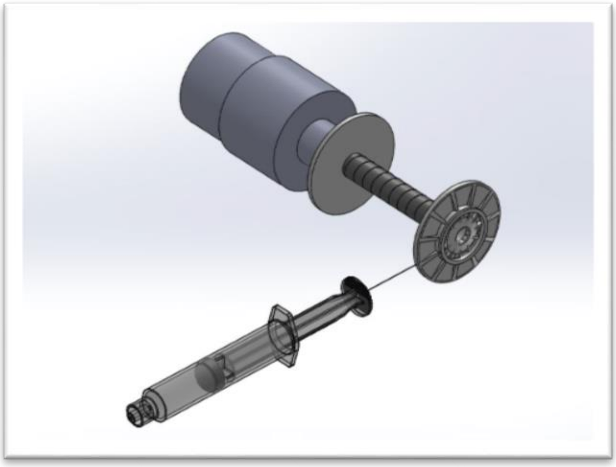


Figure 33: CAD representation of the 'Syringe System'

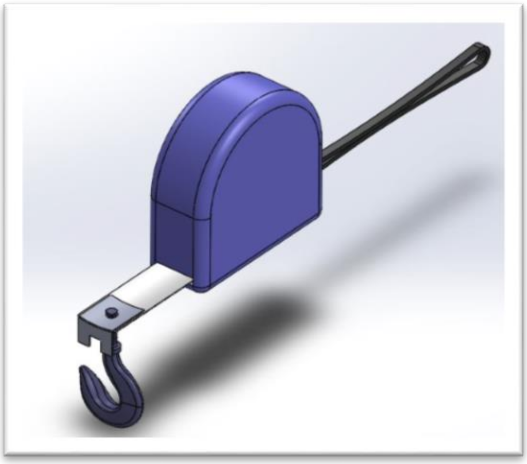


Figure 34: CAD representation of the 'Measuring Tool'

12. Troubleshooting Techniques

Making Mansarover has had its share of challenges, but the methodological approach taken by members of team Screwdrivers has made trouble shooting less cumbersome and strenuous. During test runs, mechanical components failed very often. Initially, team members spent precious time checking every component for malfunctions and this inhibited progress extensively. To ensure that critical time is not wasted, all connections were soldered firmly and enclosed in heat shrink tubes and silicone gel. This ensured that water-based malfunctions are eliminated. A lot of time was devoted to waterproofing the circuits and making their connections firm.

Team members did not shy away from talking to industrial grade manufacturers and electronics shop owners in order to find solutions to their problems. The internet was helpful to some extent, but a lot of mixing and matching of techniques, experimentation and endurance led the team to find solutions to its problems. During on-site test runs, if the ROV failed to function properly, all team members ensured that the equipment on the station were fist checked before bringing the ROV to the surface as it helps in narrowing down the area affected, saving time and energy. Some major concerns faced by the team included waterproofing of the EC and motors and wiring of the RC controller to its receiver. By implementing simple techniques and running SWAT analysis over critical decisions, troubleshooting becomes easy.

Team Screwdrivers holds safety of its members and Mansarover's components in high stead. As a result, the team always carries out precautionary drives and maintains a safety checklist before embarking on the day's activities. Team members have ensured that no sharp edges are present in the aluminium chassis or payload systems existing in Mansarover. The design of Mansarover ensures that it can be easily handled without damaging or risking life and property. All members of Team Screwdrivers followed the following guidelines meticulously during the building of Mansarover:

Workshop Safety:

- Team members had to wear appropriate clothing before entering the workshop
- Safety shoes must we worn at all times in the workshop
- Rubber gloves must be worn while dealing with electrical equipment and adhesives
- The workstation must be kept clean and ventilated at all times
- All team members must have access to the fire extinguisher and first aid kit
- Avoiding flammable materials at work station
- Work on electronics must be done with power supply switched off
- No loose ornaments must be worn and hair must be tied up while working with the ROV.

Operational Safety:

- Only members who know swimming must enter the pool during test run
- A member must be present near the power supply switch and at the station at all times.
- All requirements of the Safety Checklist are met before beginning test-run
- Wires must be properly insulated and no loose strands must be present so that short circuits are avoided
- No harmful equipment must be present near the pool during test-runs
- All swimmers must use safety goggles during their time inside the pool for clear visibility.

Figure 35: Team members wearing proper clothing and gloves while working on the EC components of the ROV

Challenges faced and lessons learnt

Technical

Some of the big challenges faced by Team Screwdrivers in building Mansarover was the challenge in using RC controllers, waterproofing of the Electronic chamber and the proper usage of waterproofing materials like Teflon tape, epoxy fluids and silicone gel. While some of these challenges were prevalent from previous years, the present teams desire to use try using sophisticated designs added to the burden. Team members learnt the importance of a simple design and immediately adapted to the new strategy, just enabling them to complete Mansarover on time for the competition.

Team members have realised that simplicity is the key to make an efficiently functioning ROV. Minimalistic designs were used to make the final incarnation of Mansarover, which is explained in this documentation. Analysis and experimentation has proven to be equally important. Team members have learnt to be thorough with the technical manual so that every detail is catered to, so that Team Screwdrivers can build the best possible ROV that exemplifies efficiency and uncomplicatedness.

Non-Technical

For the academic year of 2016-2017, Team Screwdrivers consists of students who are working on a marine vehicle for the first time. As a result, a lot of time was spent in the drawing board with research and analysis. The lack of practical experience and minimal work force slowed down the progress but the team members endured and pulled through in the end with marvellous results from Mansarover. Timetables, charts, conference calls, research materials, long hours of discussion with the team’s respected mentor Prof. Sawankumar Naik really motivated company members to be up for the challenges faced during the manufacturing process of Mansarover. The unavailability of desired products in India also delayed production time as most materials had to be imported from countries like USA, Australia, China, Hong Kong and Germany.

The team constantly prepared a journal of all the logistical glitches it faced along with remedies for the same. Members will actively take part in the recruitment process for the next academic year so that people with practical experience are always present to anchor Team Screwdrivers. Excel sheets of procurement sites both in and out of India have been prepared to aid the next team. Strong ties will be maintained with shipping companies like FedEx and DHL so that shipment delays of imported products due to customs are not encountered.

Future Improvements

Team Screwdrivers looks forward to the use of hydraulics or pneumatics in making the payload systems. The company will continue to uphold its philosophy by working on a tight budget so that members learn to use the funds allocated efficiently. The team also hopes to make in-house thrusters using bile-pumps and increase the number of components manufactured next year. The use of RC controllers will be encouraged and more tests will be conducted on how to maximize its capabilities for next year. The team also hopes to use other efficient water proofing methods to make the ROV sustainable.

Outreach and Inspiration

For the last 3 years, Team Screwdrivers has worked meticulously to empower people from different factions of the society to imbibe in themselves a scientific temperament and grow hand in hand with advancing technology. The workshops conducted by our team members have reached out everywhere: to primary schools, secondary schools, specially abled people and many others. Our work has inspired them in profound ways to learn more about the way machines function under water, the challenges an Engineer faces to keep all components secure and in working condition as well as the experience cherished through accomplishment of a scientific marvel.

Under the leadership of Outreach President Ms. Simanti Bose, our students have covered a wide arena of building ROVs, spreading awareness on how to make these machines using simple tools and logic. Reaching 12000+ citizens in India this year, the count is still on! The team has participated in the "'Cause that's How I ROV" competition to spread awareness on the importance of social growth and how it can run parallel to scientific growth. The mission and vision of Team Screwdrivers outreach will be elaborated on the "Outreach and Inspiration" document to be submitted by 9th June, 2017.

Figure 36: CEO mounting the thrusters

Figure 37: CTO drilling grooves for O-rings

Figure 38: CFO updating the finances sheet

Senior Reflections

Mansi Singh - CEO

It has been one of the best opportunities in my life to be the CEO of Team Screwdrivers, representing India at the MATE ROV Competition. As a first timer, being trusted with this responsibility of handling a team full of beginners was a huge impetus toward pushing the limits of my capabilities. Being a part of this organization has helped me gain knowledge and experience beyond my engineering curriculum. It has enabled a practical exploration of a completely new world driven by innovative technology, and aimed at providing solutions that would echo into the future. Dedicating ourselves to this higher goal has also enabled us to master the important art of optimizing the use of resources at our disposal. Starting off as novice enthusiasts, this unforgettable journey, full of unique challenges and thrills has been one of phenomenal learning and growth for my team and me.

Sahajdeep Chhabra – Software Specialist, Electronics Expert

As a final year student, I wanted to finish my college year on a high by trying something innovative and challenging. Team Screwdrivers was the answer I was looking for. I put my software knowledge and on-field electrical experience to use and helped build this beautiful ROV for the prestigious MATE competition. The journey had its share of difficulties, as it is not always fun to tread through uncharted territories, but I have learnt lessons that I will treasure for a lifetime. Watching the ROV glide in the pool got me overwhelmed, I could not believe that I was capable of building a sub-sea machine. It would not have been possible without the endurance and zeal shown by the Team, I feel blessed to be a part of this experience.

ACKNOWLEDGEMENTS

Firstly, we extend our heartfelt gratitude to **our mentor- Professor Sawankumar Naik,** for recruiting is, encouraging us during tough times and preparing us to represent India in this prestigious MATE ROV competition.

We would also like to thank-

- MATE for organizing this challenging competition
- Long Beach City College for hosting us this June
- MPSTME, SVKM's NMIMS for financially aiding us and giving us this precious opportunity
- CNM School, for lending us their swimming pool where we have relentlessly carried out all our test runs
- Blue Robotics, for providing us with thrusters and ESCs
- All electronics shops in Jogeshwari and Lamington Road, Mumbai, for catering to our requirements.
- Nehru Science Centre (NSC) Mumbai, for letting Team Screwdrivers conduct outreach activities

We would also like to thank our family members, friends, team volunteers and well-wishers for extending their warm wishes and support during this journey.

REFERENCES

- MATE Centre – “Explorer Manual FINAL 3_29”
- Bluerobotics.com – T100 thruster documentation / T200 thruster documentation
- Detlaww.com – 12V DC/DC converter and 5V DC/DC converter documentation
- HomebuiltROV.com – For guidance on troubleshooting and waterproofing.
- Arduino.cc – For Arduino Mega 2560 documentation
- Alldatasheets.com – For information on sensors and diodes

APPENDIX: A

Technical Budget

Sr No.	Date	Type	Category	Expenses	Description	Sources/Notes	Amount (INR)	Running Balance (INR)
1	05-10-2014	Reused	Electronics	Thrusters	Blue Robotics T 100	Used for vehicle propulsion	37160	37160
2	10-01-2017	Purchased	Electronics	Thrusters	Blue Robotics T 200	Used for vehicle propulsion	25000	62160
3	11-01-2017	Puchased	Hardware	Aluminium	Aluminium Bars,L Bracket	Used for Vehicle frame	700	62860
4	11-01-2017	Puchased	Hardware	Nuts & Bolts	Stainless Steel Nuts & Bolts	Used for securing different parts of the frame	400	63260
5	11-01-2017	Puchased	Hardware	Washers	Stainless steel washers	Used along with Nuts and Bolts	200	63460
6	13-01-2017	Reused	Electronics	Arduino	Arduino Mega 2560 R3	Used for onboard vehicle control	600	64060
7	13-01-2017	Reused	Electronics	Ethernet Shield	ENC28160 Module	Used for Ethernet to Arduino communication	200	64260
8	25-01-2017	Puchased	Hardware	Acrylic	Electronic Chambers	Used as waterproofing chamber for electronic Housing	1600	65860
9	02-02-2017	Puchased	Electronics	Camera	IP Board Camera Module	Used for providing video feed from ROV	870	66730
10	13-01-2017	Puchased	Electronics	Motors	DC and servo motors	Used in manipulators	1500	68230
11	20-02-2017	Reused	Electronics	Ethernet Switch	Delink 10/100 Network Switch	Used for networking Arduino Camera and tether	400	68630
12	13-01-2017	Puchased	Electronics	DC Converters	DC to DC Converter	Used for converting 48V to 12V	7500	76130
13	20-02-2017	Puchased	Electronics	Sensor	Pressure Sensor	Used for measuring pressure	350	76480
14	20-02-2017	Puchased	Electronics	Sensor	Temperature Sensors	Used for measuring temperature	300	76780
15	20-02-2017	Puchased	Electronics	Fuses	Polyswitch Fuses	Used for overcurrent protection	320	77100
16	13-01-2017	Reused	Electronics	RC Controller	Controller with trimming feature	Used as Controllers	4000	81100
17	13-01-2017	Puchased	Electronics	Motor Drivers	L298N Module	Used for controlling DC motors	800	81900
18	10-01-2017	Puchased	Electronics	Tether	Wire 22 metre	Used for carrying power to the ROV from topside	600	82500
19	10-01-2017	Puchased	Electronics	Tether	Cat6 wire 25 metre	Used for communication between ROV and topside	300	82800
20	15-05-2017	Puchased	Hardware	Connector	Anderson Connector	Used for connection	190	82990
21	25-01-2017	Puchased	Waterproofing	Cable Glands	PG Cable Glands	Used for waterproofing	130	83120
22	25-01-2017	Puchased	Waterproofing	Marine epoxy	Water repellent fluid	Used for waterproofing	1000	84120
23	25-01-2017	Puchased	Waterproofing	Silicone	Silicon Gel	Used for waterproofing	200	84320
24	10-01-2017	Puchased	Electronics	Wires	Different Assortment of Wires	Used for connection of different components	150	84470
25	02-02-2017	Puchased	Electronics	PCB	Copper Board & Misc Components for PCB	Used in fabrication of PCB	600	85070
26	13-01-2017	Puchased	Electronics	Servo	Servo Motor	Used for camera Pan and tilt	450	85520
27	09-01-2017	CashDonated	General	.	University Aid	.	200000	116990

Total Raised (INR)	200000
Total Spent (INR)	85520
Final Balance (INR)	114480
Total Raised ($)	3099.34
Total Spent ($)	1325.28
Final Balance ($)	1774.06

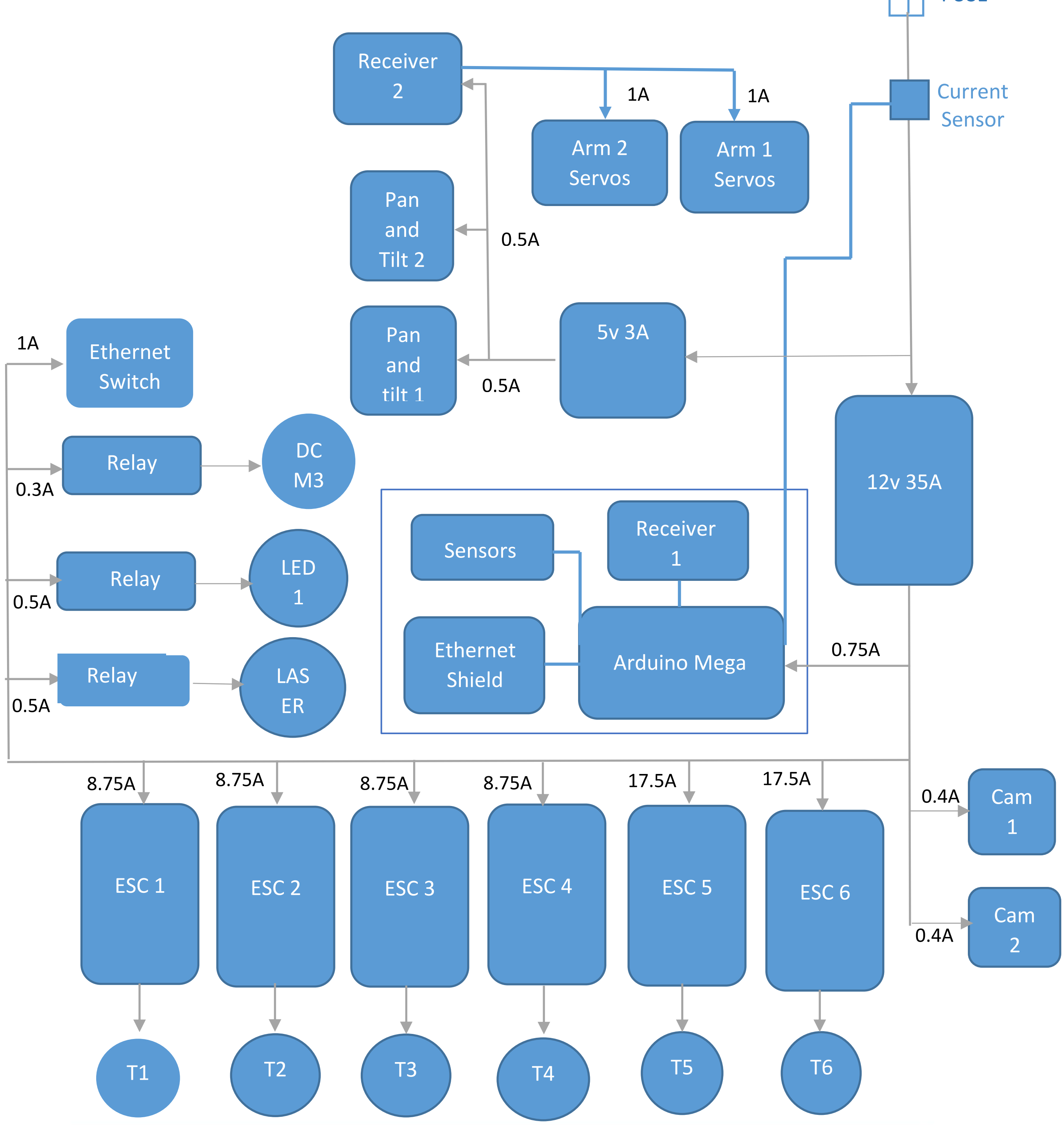
All Amounts mentioned are in INR (Indian Rupees), since majority of the purchases have been in the local currency. The exchange rates as of 26th May 2017, 1600 hrs, UTC is 1 USD=64.53 INR. The final balance amount was returned to the University. The Travel and transit costs of the Team are not included in the above accounts.

Travel cost:								
28	25-04-2017	Purchased	Logistics	Travel	Flight	Travel expense for 7 team members	420000	USD-6506.58
29	20-05-2017	Purchased	Logistics	Accomodation	Stay during competition	3 rooms in Long Beach Hotel	200000	USD-3098.37

System Interconnection Diagram (SID): Power

FUSE CALCULATIONS

Total Power consumed = 903.7 Watts
Total voltage reaching the ROV = 48Volts - (30Amp * 0.08Ohm)
= 45.6 Volts
ROV Full Load Current = 19.82 Ampere
ROV Overcurrent Protection = ROV Full Load Current * 150%
= 19.82 A * 150%
= 29.73 Ampere (30Amp Fuse can be used)



APPENDIX: C

System Interconnection Diagram (SID): Data