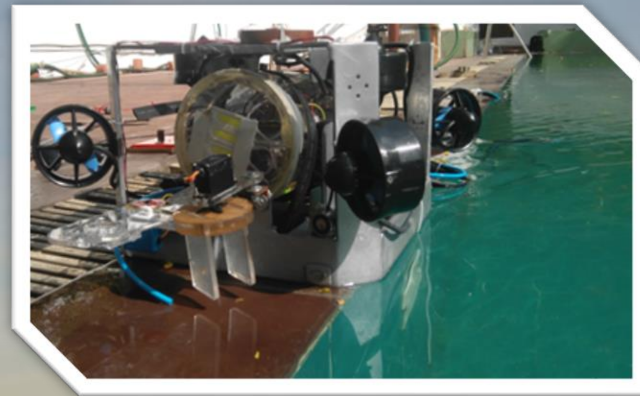
STRATODIVER



Dive Deep!

2018 Technical Documentation

Jet City- Aircrafts, Earthquakes & Energy

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MATE

SVKM'S NMIMS Deemed to be UNIVERSITY

TEAM SCREWDRIVERS

Abstract

Stratodiver is the latest creation by Team Screwdrivers in response to MATE's quest for 'Jet City: Aircraft, Earthquakes, and Energy.'. The versatile abilities of Stratodiver are due to its technologically advanced construction that includes six brushless thrusters for propulsion combined with its lightweight aluminum chassis and acrylic electronic chamber which allows easy maneuverability. Stratodiver is equipped with five HD cameras. It comes with three custom fabricated mechanical manipulators for ease of carrying out tasks and uses a custom designed tether that provides it power as well as communication lines. Stratodiver is controlled from topside using precise analog joysticks with trim. Our focus has been to learn and improve upon our past vehicle, Mansarovar, while focusing on constructing the most cost effective yet versatile and powerful ROV, and the result is Stratodiver. Stratodiver embodies the Indian spirit of using advanced technology at an affordable cost with the complete construction costing just under 1220 USD!

With a team of four hard-working students, Stratodiver 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, Spyder and Mansarovar 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.

The following technical document consists of the design rationale and our company processes required to produce our ROV Stratodiver

Team Screwdrivers 2018

Left to Right:

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Design Rationale

Our companies approach to create Stratodiver was not to make a copmplex and sophisticated design but to make a more simplistic and realistic design which can be put to real world use and not just the competition aspects. We believe the ROV has to perform the task assigned quickly, with minimum maintenance and operational costs. Hence, we choose components that are readily available should there be a breakdown in its operation. Also, a simple design helps a faster troubleshooting by its employees which reduces breakdown time in real world applications. We choose to continue with our octagonal design as it provides a lot of benefits such as n 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 maneuvering. Mounting the thrusters at 45 degrees allows a simple and complete 5 DOF (Degree of Freedom) motion.

Inspiration from Boeing and the Jet City

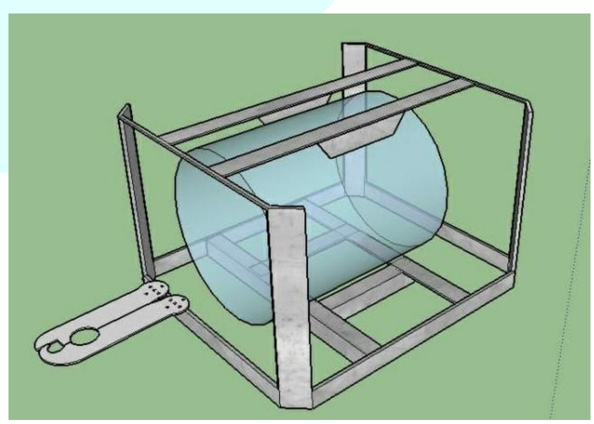
Stratodiver derives its name from the Boeing 377 Stratocruiser. The Boeing 377 Stratocruiser was a large long-range airliner with a range of 3650nmi (Nautical Miles) developed from the C-97 Stratofreighter military transport which was a derivative of the B-29 Superfortress. It incorporated innovative features such as two passenger decks and a pressurized cabin just as we innovated our ROV with a brand new to the industry electronic self-balancing fixture. Just as the venue of the competition, the original birth place of each Boeing Commercial Jet, the Stratocruiser was built at Renton which now produces the workhorse Boeing 737 at a massive rate of 47 jets a month planned to 52 a month.

Boeing 377 Stratocruiser

Mechanical Design Rationale

Structure

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 fiber and Iron. Aluminum was finally chosen, as it is durable, lightweight, recyclable, resists corrosion and cost effective. The strength of aluminum 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 aluminum 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 aluminum 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 Stratodiver, 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. Aluminum is extensively available in India and is used in large-scale mechanical projects. As a result, the company had easy access to aluminum and it could be welded as per the design requirements. This design is made keeping in mind the streamline flow of water

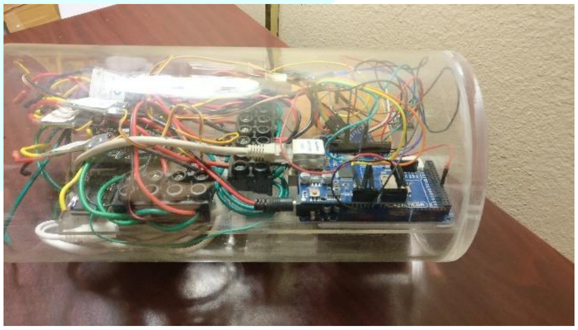
Initially we mounted the thrusters on the inside of the frame. However, we were not satisfied with the motion of the ROV as the force vectors were not balanced and hence we moved to a new configuration where we lowered the position of the thrusters and mounted them on the opposite ends.

Final config with shrouded IP20 thrusters

Electronic Chamber

The Electronic Chamber (EC) is made of a cylindrical mould of acrylic. All wires connecting the electronics within the EC with components outside like the thrusters and cameras are passed through plastic gland connectors and metal penetrators. 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. Multiple TVL 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 with a wide FOV (Field of View) of 120 Degrees. The EC closes with a O-ring flange and end Cap.

Making grooves for O-ring on Lathe Machine



Electronics Chamber

Buoyancy

Team Screwdrivers decided to build Stratodiver slightly positively buoyant so as to enable it to float back to the surface in case of any disruption in power supply. This was achieved by using the electronic chamber as the main source of positive buoyancy on the ROV. This saved us the effort of designing ballast tanks and dealing with pneumatics and air compressors, this also saved a considerable amount of money. The aluminum chassis and thrusters provide negative buoyancy. The placement was decided and altered to make a well-balanced ROV after taking in note the center of gravity (CG) and the center of buoyancy (CB). The important task was to ensure that the CB was above the CG otherwise the ROV would be imbalanced and would flip over in the water. This was ensured by the inhouse self-balancing fixture, thus providing good stability to the ROV. Compact pieces of the foam is also attached to the tether of Stratodiver to reduce the drag caused by the tether during ROV movement under water.

Waterproofing

Electronic chamber is the home of all the equipment that enables the ROV to function. Team Screwdrivers had to ensure that it is completely waterproof to function at a depth of 40ft. This was a complicated task as waterproofing an object that is to be permanently sealed is comparatively easier than waterproofing a re-openable container. We developed an inhouse flange with double O-rings Protection using CNC technology. These O-rings are basically a gasket which acts as a mechanical seal between irregular surfaces, and under compression it totally prevents the permeability of water or such fluid. Lot of wires had to be passed through the electronic chamber, to prevent seepage of water, we installed penetrators & glands on the end-cap of the chamber. Marine epoxy was used to seal test enclosures. Cameras were enclosed in a watertight enclosure made of acrylic with a gland at back for the wire. To prevent condensation from adversely affecting the electronics inside the chamber and the camera lens inside the external casing, we used industrial grade silica gel packed in cloth to absorb the moisture. LEDs were enclosed in another acrylic casing and also treated with epoxy to prevent any access of water to it. DC motors were first coated with epoxy, and the gearbox was filled with thick grease to prevent seepage of water. The connections were enclosed in a case. Servos that move the camera were filled with grease from inside to prevent water from entering, and with wires enclosed in a case. Waterproofing the tiny pressure sensor chip was another one of the waterproofing tasks; the pressure sensor requires a tiny portion of it to be exposed to the fluid whose pressure it needs to measure, but the remainder of the sensor needs to be waterproofed. To accomplish this we use epoxy. Temperature sensor was enclosed in a stick-like case keeping in mind the task.

Company members have waterproofed 360 Degree servo used in Stratodiver. 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. All epoxied electrical connections are sealed using liquid electrical tape to avoid any current leaks or a short circuit.

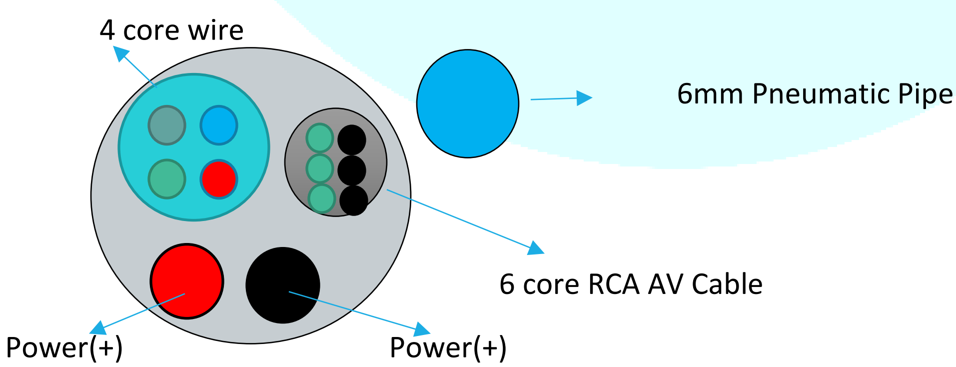
Tether

Our previous years ROV had a CAT6 cable for video signals and sensor values and 2 antenna wires enabling Wireless Communication. The video had a higher latency making it difficult to control the ROV. To improve reliability of the data signal and greatly reduce the latency, we switched to a Serial communication and Analog RCA cables. Using 2 RS485 converters the communication is faster than CAT6 Ethernet connection. There are multiple advantages of using RS485 over its previous versions. It enables Differential 32 channel communication of a distance of 1200metres from 10Mbps to 100kbps. This also adds simplicity to the communication protocol as it is a direct point to point communication. RS485 is connected to the 4 core cable in the tether.

Tether winder

Stratodiver's Tether also contains 2 10AWG Power lines. 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 Stratodiver. The tether length is 20 m long. 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 to make it neutrally buoyant as it adds additional drag to the ROV.

We have a rotary encoder attached to the tether housing. This provides an estimated tether left to the pilot operating the ROV directly. This reduces the oral communication required from the tether operator and the ROV. A 6mm pneumatic pipe also runs down the tether to provide flow of air for the liftbags.



Tether Cross-section

Payload Rationale

Introduction

Stratodiver has 3 payloads for various tasks to be performed. All payloads are electrically operated which reduces system complexity which increasing redundancy. The mechanical manipulator arm carried by Stratodiver is its main payload system and consists of one waterproof servo motors of torque 11kgf. The gripper of the arm 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 realized that the arm is of great importance for the smooth functioning of the ROV. The edge of the gripper consists of a hook-like curve, which will deal with the UBolts and hooks present in the props. Stratodiver's mechanical arms are 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.

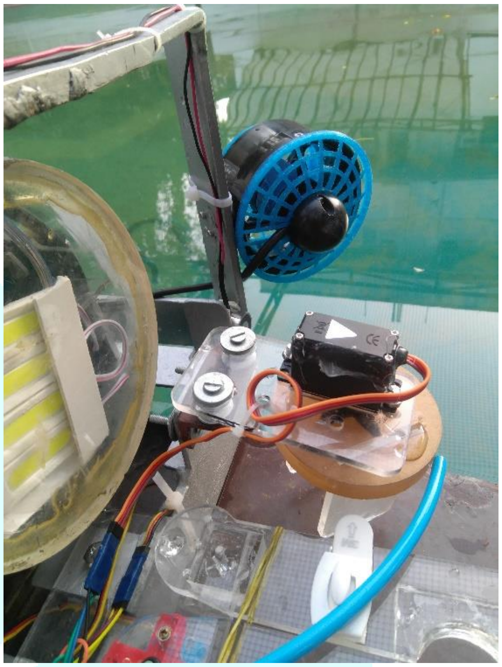
Laser cutting of various arm parts

Primary Gripper

The mechanical manipulator arm carried by Stratodiver is its main payload system and consists of one waterproof servo motors of torque 11kgf. The gripper of the arm 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 edge of the gripper consists of a hook-like curve, which will deal with the UBolts and hooks present in the props. Stratodiver's mechanical arms are capable of completing multiple tasks using the same design.

Primary Gripper

Rotating Arm



Specially for turning the Tees in Earthquakes task, we have constructed an inhouse arm using Acrylic and laser cutting. The primary design was not reliable and it was modified to increase redundancy. The circular acrylic piece has 2 cuts which fits additional acrylic pieces with round edges. This piece is attached to a 360 degree Servo. There are various advantages of using a 360 Servo over traditional DC Motors. DC Motors are more complex to waterproof and require both additional power source and a higher current driver. However Servos are directly controlled using PWM and a power source available on the ROV. This reduces system complexity. The 360 Servo is rated at 10kg-cm torque which can make it usable in real life conditions where higher torque might be required for jammed threads.

The rotating Arm

Measuring tool

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. There is a waterproof HD Camera attached on the tape. The HD camera can read the distance shown on the Tape once it has begun maneuvering to measure distance. Since the camera is fixed on the tape, when the orientation changes, the camera also tilts automatically. This allows a direct simple distance reading without use of complex image processing/expensive underwater equipment. This system is simple in design, cheap to build and very efficient. This system requires no mechanical control from the pilots on the station. The tool is mounted directly onto the chassis of Stratodiver along with the buoy marker. The tape self-retracts when released. This reduces the additional stress on the pilot allowing him/her to focus more on controls.

CAD of Measuring Tool

Electronics Rationale

Cameras

Stratodiver uses 5 HD TVL cameras which provide realtime video over just one cable with 3 views at a time. There are 3 waterproof Cameras which are outside the EC. We purchased waterproof Cameras as they are already IP67 rated which reduces the need of additional housing and waterproofing.

TVL 600 Cam

All the electronics in Stratodiver 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 Stratodiver 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. It is supplied power through a Delta DC/DC CONVERTER 12V 50A. A 12 to 6V Custom Converter powers the servos present in the ROV. A FRSky 40A Hall Current Sensor Module is used to read the current in the wires real time. It acts as protection to the 30A Littel Fuse housed in an Little 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.

GY-87

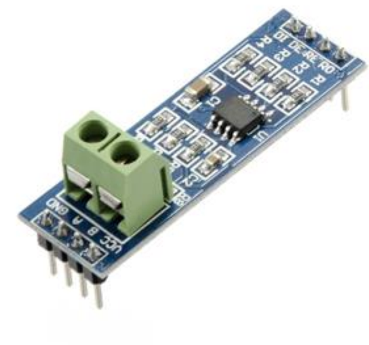
This is a new smart sensor incorporating 3 sensors i.e MPU6050, BMP180 & HMC5883L. This reduces IO Complexity and provides the values of all three sensors real-time through Arduino.

Arduino

An Arduino Mega 2560 module acts as the heart of the electronics present in Stratodiver and coordinates all activities of the ROV. The control box also features an Arduino for the Joysticks and point to point Serial Communication using RS485 Converter.

ESP8266 for Wifi Reception

Startodiver uses ESP8266 to receive WIFI data from the OBS. The module is in slave mode for reception while in master mode for releasing the liftbag.



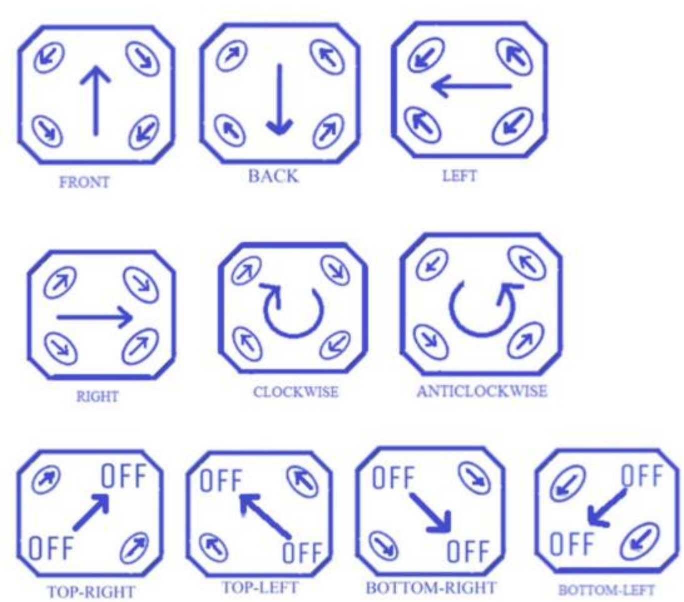
RS485 Module

Power Budget

unit	current(A)	voltage(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
RS485	0.5	12	6	1	6
Cameras	0.4	12	4.8	4	19.2
Servos	1	6	6	7	42
Lights	0.5	12	6	2	12
Sensors	0.3	5	1.5	3	4.5
Total		**12**			**932.7**
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 Efficiency, %(estimated)					85
Power Loss,W(Peak Power/Efficiency)					205.2
Power After Conversion at ROV					**1162.8**

Software Rationale

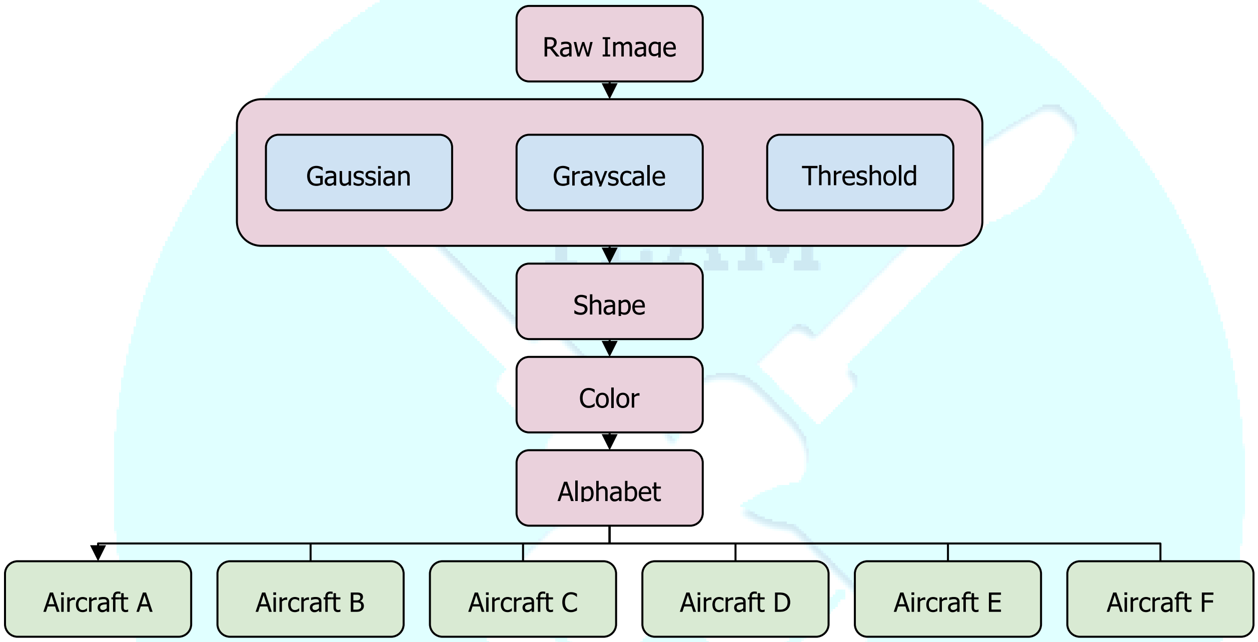
Programming



We have 2 modes of control i.e primary and backup. Our primary joysticks used for the thruster control consists of 2x 2-axis analog joysticks which has a one of its kind trimming feature. This allows extremely precise motion control which cannot be achieved by any other controllers(PS3/XBOX). Also 1 has a sustained non-returning stick which remains at its place unlike other joysticks. This helps in maintaining level altitude. Apart from this trimming feature, our ROV has altitude holding PID which uses the pressure/depth sensor to determine depth which is used as the reference as well as error for the PID. The robotic arm is controlled using a potentiometer connected to the Arduino Mega to provide a controlled motion unlike other controllers. The servo controlling the angle of the measuring tape has 2 positions for each of the orientations for measuring the distances. 2 positions of a switch at the control box guides the position of the servo. A GUI is developed by us for easy monitoring of the systems.

With programming we have achieved 5 DOF Motions with our thrusters.

Image Detection Algorithm



Algorithm description :

The algorithm for detection and recognition of the sign goes as follows:

Step 1 : Image acquisition

With the help of standard OpenCV method, *VideoCapture*, a stream of image frames is captured from the analog camera mounted on the ROV.

Step 2 : Preprocess

Pre-processing involves the following stages :

Resizing the image : This is done so that we can reduce the workload of the algorithm. This also helps with increasing accuracy for detection of contours.

Gaussian smoothing : Decreases noise and improves the contour approximation for shape recognition.

Grayscale and L*a*b : Conversion of the image to grayscale and L*a*b form.

Thresholding: We threshold the image before detecting the contours
Contour detection: The contours are detected from the image

Step 3: Detecting the shape

Once we have a pool of contours, we can simple check for the number of contours to detect a particular shape, for example, we can say that a particular image has a triangle if the number of contours is 3, while it is a rectangle if the number of contours is 4.

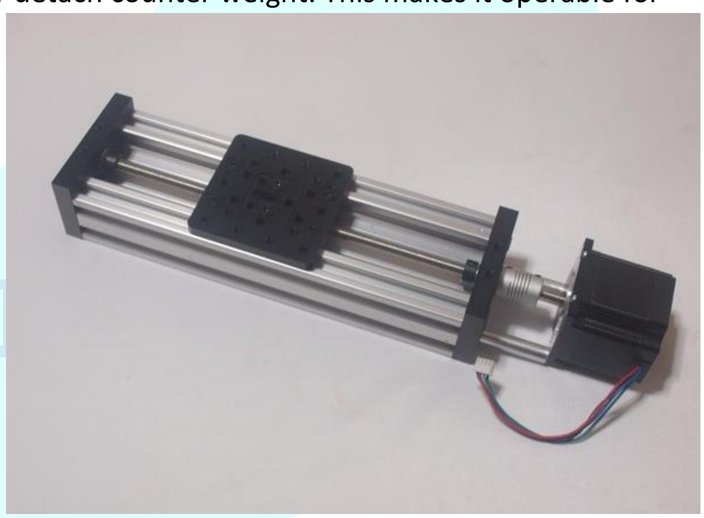
Step 4 : Detecting the color

A region of interest within the image after the detection of the shape. In order to label the color of the region of interest, we first define a set of values for particular colors. Later, we compute the Euclidean distance between the known dataset of colors and the averages of the particular region of interest. The known color that minimizes the Euclidean distance will be the detected color

Innovation (Out of the box)

First of its kind Electronic self-balancing fixture

Thinking out of the box we tried to cater to a real world problem of balancing the ROV. When the arm carries additional weight from the surface or to the surface. At the competition the weight is limited however in real-life ROVs carry upto a ton of equipment. This heavily disturbs the CG while piloting the ROV. TO counter this CG shift, operators attach or detach counter weight. This makes it operable for one way of the travel i.e either up or down ways. We have designed a state of the art electronic self-balancing weight at the bottom of the ROV. The weight moves in 1 axis depending on the tilt. It provides self-balancing real-time at all times of operation. 1 Stepper Motor guide the motion of the weight to adjust the position of the ROV to neutral. This greatly helps the pilot to have control of the ROV at all times. The fixture is completely design in-house.



The self-balancing fixture

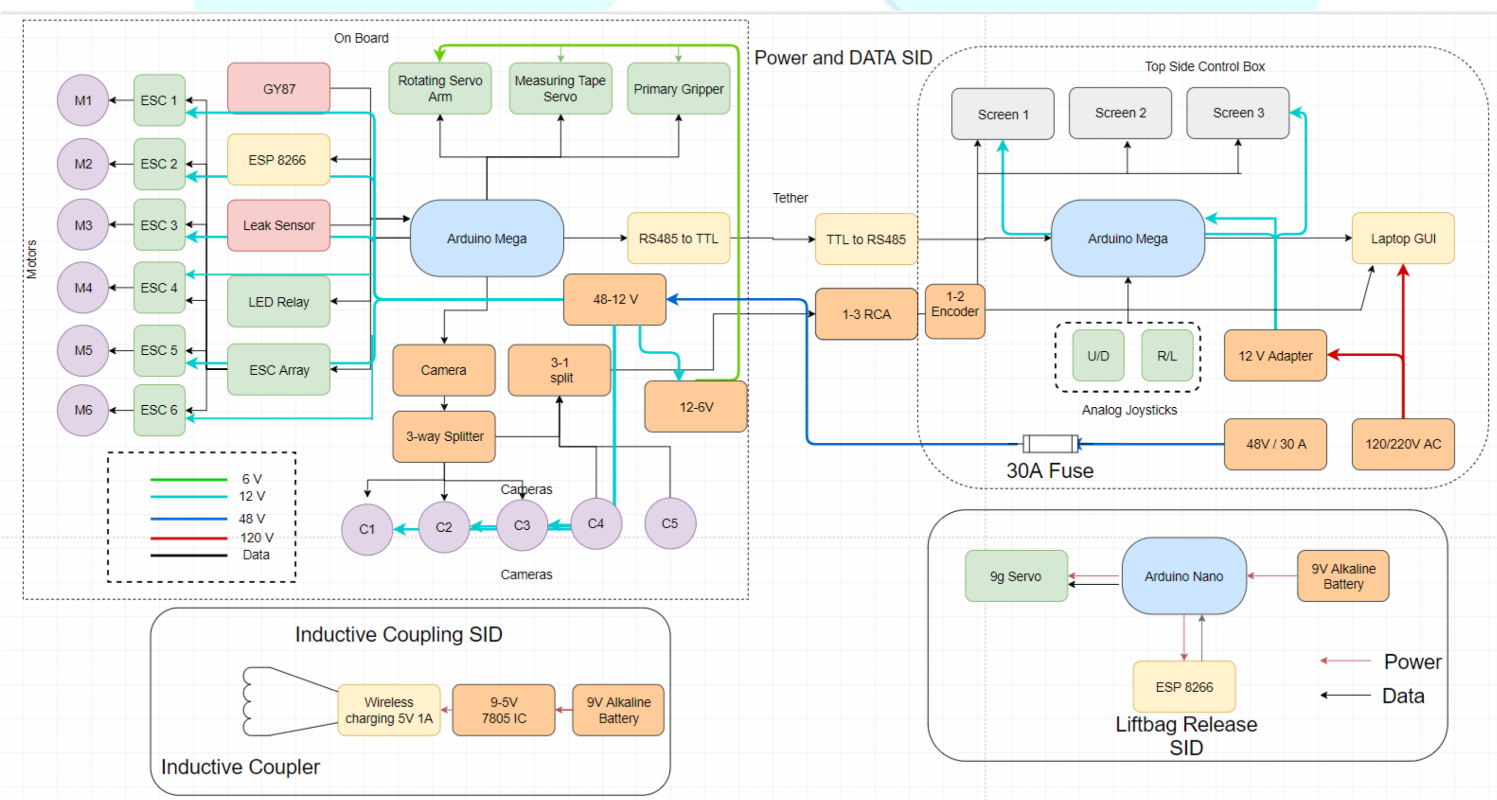
Build vs Buy

There were multiple instances where the employees had to take build vs buy decisions. This is very crucial as our prime motive was to develop a powerful and innovative ROV but on a tight budget. We choose to build most of the ROV components such as the Electronics chamber and its end cap/flange in a price which was almost 7 times cheaper than a similar option for purchase at Bluerobotics. Also we contrasted our own tether rather going for ready Fathom which saved us a lot of money. We also waterproofed the 360 servo rather than buying expensive waterproof motors. The team also found a cheaper alternative for Cameras. Usually Cameras cost a major factor in ROVs however we purchased cheaper FPV Cameras which are used in Drones. There multiple advantages of this. They have very low latency due to its application use and they are small in size with a wide view (120 degrees). We found a very reliable way of using them with AV Cables. Here we saved 8 times the money. We choose to 3D print thruster shrouds then buying them. This saved us 12 times money.

New vs Reused

The team had was able to save as much as 800$ by reusing T100 and T200 Thruster from our previous ROV. We didn't want to compromise waterproofing and safety of our ROV and hence we strictly purchased new components used in waterproofing, penetrators, cables. Fuse, etc. We choose to reuse the thrusters as they performed well in multiple tests. Microcontrollers like Arduino rarely tend to fail unless blown due to power surges or a short circuit. Hence we choose to reuse the Arduino Mega.

System Integration Diagrams(SIDs)



Safety

Team Screwdrivers employees follow the following protocols for Safety.

Seek safety

Aim safety

Follow Safety

Ensure safety

Teach safety

Yield safety

"The safety of people shall be the highest law"-Marcus Cicero

Team Screwdrivers holds safety of its members and Stratodiver 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 aluminum chassis or payload systems existing in Stratodiver. The components with sharp edges were meticulously redesigned to ensure this. The design of Stratodiver 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 Stratodiver:

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.

Required Training	Required Protective Equipment
1. Use of Soldering Iron 2. Use of Heavy/ Power tools 3. Using epoxy	1. Protective Gloves 2. Respirators 3. Earplugs or muffs

CEO/CTO wearing safety glasses while operating the Lathe Machine

Team member wearing gloves while soldering

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.

Detailed workshop and operational checklists are provided in the JSA Document.

Required Training	Required Protective Equipment
1. Transporting the ROV 2. Assembling the ROV 3. Setting up wiring and voltage 4. Launching the ROV 5. Retrieving the ROV	1. Non- Slip or Closed-toe shoes 2. Safety glasses 3. Protective Gloves 4. Life Jacket

Project Management

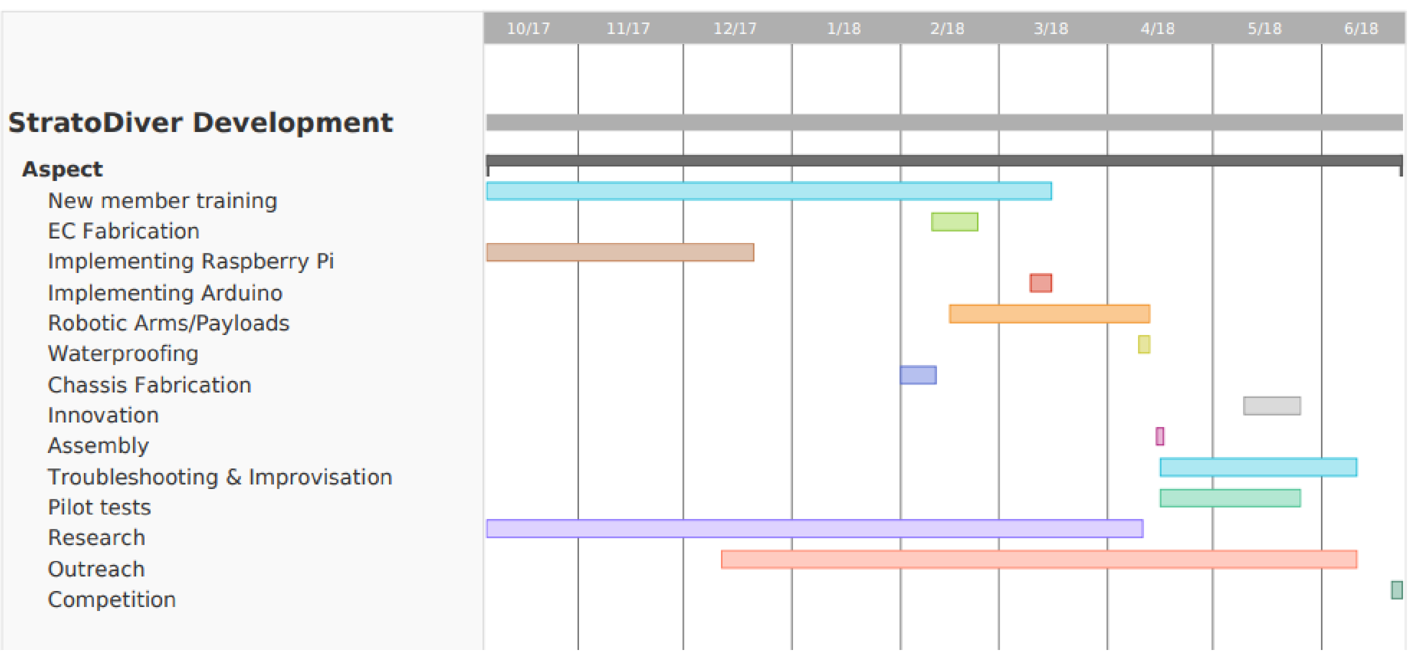
Schedule

The team started out planning a schedule for the year 2017-18. Other than the CEO/CTO all members were new and had to be briefed about the project and its aspects. The employees set a strong deadline for trying out various approaches and solutions for the new tasks. Even before the task list was declared, the team started working on issues faced to our last years ROV. Initially the team was working with Raspberry Pi for the control System. However after the tasks were declared, it was found that the system can be greatly be simplified using Arduino. This shifted the entire approach of the team. The team ensured that there are backups at every point making it very flexible to change if it was required.

Initially the team flagged off with 13 members but due to changes in academic calendar and examinations being at all the crucial times of the competition and the International competition dates itself, only 4 members continued to work on our ROV. With the team being smaller now, the responsibility on each member increased greatly. The team was running behind schedule at time but managed to complete the vehicle just in time.

Since all the members other than the CEO were new to this field itself, CEO took up the tasks of the CTO as well while leading all aspects of the company while training the employees. Since college had also to be attended while working on the ROV, the employees had to manage time. Even in between final examination employees were at the pool for trials and troubleshooting.

Here is a Gantt Chart of the development of Stratodiver.



Accounting

The budget was discussed in the start of the process to ensure as this is one of the most important aspects. Team members made sure that the components in good shape are reused instead of purchasing. However components which are crucial for safety such as fuse, etc. are brand new. We were able to achieve our target of making robust and innovative ROV despite keeping a lower budget. We kept a buffer at all places to ensure cost overheads were taken care of urgently if required. Since we were running on schedule at most of the times, we were able to save cost overheads.

S.no.	Type	Category	Expenses	Description	Sources/Notes	Amount (INR)	Runnning Balance (INR)
1	Reused	Electronics	Thrusters	Blue Robotics T 100	Used for vehicle propulsion	30150	37160
2	Reused	Electronics	Thrusters	Blue Robotics T 200	Used for vehicle propulsion	22000	59160
3	Purchased	Hardware	Aluminium	Aluminiuim Bars, L Bracket	Used for vehicle frame	700	59860
4	Purchased	Hardware	Nuts and Bolts	Stainless steel nuts and bolts	Used for securing different parts of the frame	400	60260
5	Purchased	Hardware	Washers	stainless steel washers	Used along with Nuts and Bolts	200	60460
6	Reused	Electronics	Arduino	Arduino Mega 2560 R3, Uno & Nano	Used for onboard vehicle control	2000	62460
7	Purchased	Electronics	USB Shield	Arduino Shield	Joystick to Arduino	200	62660
8	Purchased	Hardware	Acrylic	Electronic Chambers	Used as waterproofing Chamber for Electronic Housing	1600	64260
9	Purchased	Electronics	Camera	TVL Cameras	Used for providing video feed from ROV	3200	67460
10	Purchased	Electronics	Motor	Servo Motor	Used in manipulators	4000	71460
11	Purchased	Electronics	3way Spiltter	3 to one Splitter	Splitting and isolkating AV Signals	400	71860
12	Purchased	Electronics	DC Converters	DC to DC Converter	Used for converting 48V to 12 V	4000	75860
13	Purchased	Electronics	Sensor	Pressure Sensor	Used for measuring Pressure	350	76210
14	Purchased	Electronics	Sensor	Temperature sensors	Used for measuring temperature	300	76510
15	Purchased	Electronics	Fuses	LittelFUse and Holder	Used for overcurrent protection	3000	79510
16	Purchased	Electronics	Precise Joysticks	Controller with trimming feature	Used as controllers	500	80010
17	Purchased	Electronics	ESP8266	Wifi Module	Used in Lift bag and ROV	100	80110
18	Purchased	Electronics	Tether	AV Wire 20 meter	Used for carrying power to the ROV from topside	120	80230
19	Purchased	Electronics	Tether	4 Core Wire	Used for communication between ROV and topside	150	80380
20	Purchased	Hardware	Connector	Anderson Connector	Used for connection	190	80570
21	Purchased	Waterproofing	Cable Glands	PG Cable Glands	Used for waterproofing	130	80700
22	Purchased	Waterproofing	Marine Epoxy	Water repellent fluid	Used for waterproofing	800	81500
23	Purchased	Waterproofing	Silicone	Silica Gel	Used for waterproofing	200	81700
24	Purchased	Electronics	Wires	Different assortment of wires	Used for connection of different components	420	82120
25	Purchased	Electronics	PCB	Copper board and misc components for PCB	Used in fabrication of PCB	200	82320
26	Purchased	Electronics	Servo	Servo Motor	Used for Lift bag	150	82470
27	Cash donated	General		University Aid		200000	

Total Raised (INR)	200000

Total Cost	82470
Total Spent after reusing (INR)	28320
Final Balance (INR)	115360
Total Raised($)	2949.42
Total Cost($)	1216.192302
Total Spent($)	417.6375166
Final Balance($)	2531.79

Travel Cost							
28	Purchased	Logistics	Travel	Flight	Travel Expense for 5 Team members	430000	USD 6341
29	Purchased	Logistics	Accomodation	Stay during competition	2 rooms in Hotel Murano	109000	USD 1600
Outreach Cost							
30	Purchased	ROV Components for Outreach	Kits for Outreach	Gifts,kits, rov components for Outreach		150000	USD 2212

All Amounts mentioned are in INR (Indian Rupees), since majority of the purchases have been in the local currency. The exchange rates as of 25th May 2018, 1000 hrs, UTC is 1 USD=67.81 INR. The final balance amount was returned to the University. The Travel and transit cost of the team are not included in the above accounts.

Logistics

We received a lot of components from our previous years ROV and upon rigorous testing it was determined that most of the components are in good shape. This helped us in saving a lot of money in logistics and new purchases. However things which are crucial and can hamper safety are strictly new such as Fuse, etc. Most of the components were available locally.

Team Screwdrivers had established relations with FEDEX and DHL the previous year which helped us expediate the shipping process.

Locally the purchased items were handled by the Procurement and Logistics member.

Outreach & Inspiration

CEO/CTO at a workshop for ROVs

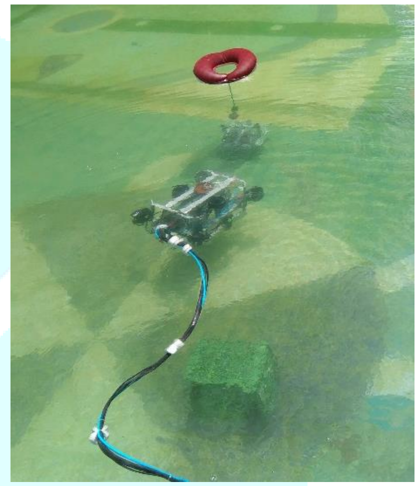
US Consulate, Mumbai

For the past 4 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 Mirza Samnani, our students have covered a wide arena of building ROVs, spreading awareness on how to make these machines using simple tools and logic. Reaching 70000+ citizens in India so far, the count is still on! The team bagged the "'Cause that's How We ROV" award last year. Its our motive 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 "Corporate Responsibility" document to be submitted on the 7th of June, 2018. Our Faculty mentor was our driving force for outreach which was well executed by our CEO due to his technical expertise. We successfully conducted workshops on ROVs, RC Planes, Arduino and sensors, drones, etc. Students were able to make a ROV by themselves in these workshops. Our outreach also consisted of lectures, seminars on recent advancements in technologies such as Hyperloop, Additive Manufacturing, Artificial Intelligence, Humanoids, etc.

Critical Analysis

Testing and Troubleshooting

Testing is the ultimate proof of a concept. What we think could work might not underwater. Hence the team made sure that rigorous testing is carried out at each step. The previous years team was completely new and faced waterproofing issues. The employees made sure they are double checking procedures at every step to make sure there are no errors whatsoever. This took a little more time but it saved a lot of troubleshooting time. The company calls it elimination at detection. Even despite carefully coding, even a small bracket used to cause an error. Non existence of brackets in a loop in the program caused a malfunction of the robotic arm. The employees then used reverse engineering to find out that the program was nowhere existent in the hardware but it the software. A multi-meter was kept handy at all times as it is the most vital tool in determining the errors rather than just guesswork. At one point our servos had just ceased to function. We quickly checked with a multimeter to find a whooping 2 volt drop. The source was at optimum voltage but one inspecting the wire we found that the wire which was sealed had a leak which caused rust and the resistance. We replaced the wire and sealed it with liquid electrical tape.



Stratodiver in action

Challenges

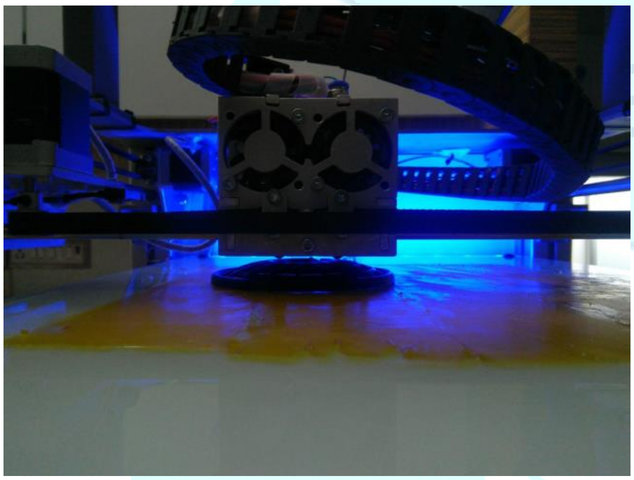
Technical

The team faced a myriad of technical challenges mainly due to new members in the team, but these challenges were successfully tackled by the team. The first major challenge was vehicle design, especially with additional points for weight and size. We focused on constructing the most multifunctional yet small sized ROV while being lightweight at the same time. A lot of research was done on unique materials like carbon and glass fibre but eventually settled on aluminum due to ease of work and affordability, an important lesson from this was that a simple design is often the solution to any task. Thus we decided to keep the ROV design minimalistic and elegant. Another challenge the team faced, mainly during trials, was achieving the required buoyancy. The team followed a trial and error method for this and it took quite a while to achieve the perfect balance that was desired. This included couple of redesigns and adjustments and using the proper tether and attachments. One recurrent problem throughout was the difference between practical knowledge and theoretical knowledge. Team Screwdrivers is blessed with talented members with great knowledge. This was very beneficial during the design stage, but the team faced some challenges during the construction phase as many of those designs were not implementable due to nontechnical constraints.

Also the signature feature of our ROV i.e self-balancing was to be designed from scratch with little to no help from resources. It took a little time to figure out how to get through it but the employees were successful in getting a breakthrough with his new technology.

Additive Manufacturing

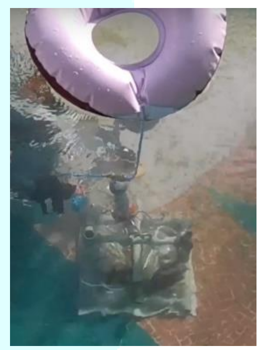
In order to 3D Print Shrouds for the thrusters the design had to be carefully redesigned for the bigger T200 thrusters. This technology was completely new for the rest of the team. Our CEO/CTO had Additive Manufacturing as a final year/Senior subject which helped us print the shrouds within 3 days using the stronger ABS Polymer. The company is trying to setup a local 3D printer that can print both PLA & ABS to support inhouse 3D printing and increase rapid prototyping which will be incremental In the development of future ROVS as well as an Outreach resource to teach to younger kids.



3D Printing of our thruster shrouds

Liftbags

The concept of liftbags was completely new to all the members as it is a new concept in the Competition. The employees spent considerable time on the drawing board designing a robust and appropriate liftbag. Team Screwdrivers is currently improvising the Liftbgs.



Liftbag

Non-Technical Challenge

Team Screwdrivers consists of very versatile members and one important lesson that we learned was the importance of task delegation and separation of duties. This became especially important during the construction phase as concurrent engineering allows us to prototype and test much faster than limited members working on construction. Team Screwdrivers started with 13 members however only 4 choose to continue due to changing academic calendar. It was really challenging for the new members to handle multiple tasks and work under pressure.

All team members came together irrespective of departments, and joined forces when times got tough and the deadlines were nearing.

Lessons Learnt

Technical

One major time-consuming troubleshooting was caused by jumper wires for the servo connections. Almost 2 days were spent in finding a solution. The problem was found in the high contact resistance wires which didn't provide adequate current to the servos. Replacing the power line and isolating through a separate power source quickly resolved the issue.

How a simple phenomenon of contact resistance can lead to serious problems was a crucial lesson for us. We simply switched to longer Servo Extension Cable with higher current capacity(18 AWG).

The development of Stratodiver enlightened us that a lot of knowledge we already have needs to be taken care of while designing any and every aspect of the ROV. Just assumptions and guesswork wont help for long.

Non Technical

The most important lesson was that our skills grow while working under pressure. Just as in the game of cricket, the team which is playing under a high pressure of winning steals the game. Learning is a life-long process and no one knows everything. The employees must also go for a get together and celebrate once a while. The increases the team bonding. Hierarchy is very important in an organization. It maintains the workflow and incorporates a sense of responsibility. At times things can go wrong and there can be personal issues but this should not affect the task and motive of the team.

Each project should have a schedule which can be achieved. But the team should try to complete the tasks before time to allow time for troubleshooting, issues, etc. This way the deadlines can be easily met without any delay.

Team Screwdrivers will try to implement incentives to achieve this. If the employee completes the task before the deadline can get an incentive.

The managers/leaders must be bold in their task allocations. Leniency from the upper management lead to delays from the employees resulting in mismanagement.

Team members stepped out of their comfortzones to achieve their targets. When the passion is there, there is a positive energy which drives you to work and even after sleepless night, the team didn't feel tired and still kept it going.

Senior Reflection

-Mirza Samnani CEO & CTO

I joined Team Screwdrivers last year in 2017 and this is my second year of participation at MATE. Being the only one to have continued from the previous team, it was my responsibility to look after all the aspects of the processes from day 1 while training the new members. Handling both the managerial an technical tasks kept me on my toes at all times. Each time Stratodiver was in the pool, all the sleepless nights, prolong troublueshootings and selfless efforts used to pay off. Having chosen subjects like Artificial Intelligence & Additive Manufacturing were a advantage in rapid prototyping and using supervised learning for image recognition. The courses Product Design Development and Industrial robotics helped me manage the project as per industry standards professionally. It was the realization of what I studied and its application in this wonderful company.Apart from the technical aspects, interacting with students not just as a part of Corporate Responsibility but for my passion to spread knowledge gave me a different satisfaction seeing the smiles on the faces of the students and seeing them enjoy all workshops, seminars, etc. Leading a a team of novice member was challenging but we all pulled it off together. As a member of Team Screwdrivers, I have not only gained technical knowledge but also invaluable interpersonal skills and gained a deep interest in the field of marine engineering. Due to graduate in summer 2018, this marks my last year as a part of Team Screwdrivers but I have made great friends during this journey and have gained unparalleled experience which will definitely be useful lifelong. I will continue to support the future teams. It was just a perfect theme & venue to end it, Jet City for my passion for Boeing, the aerospace industry and now the Marine industry!

Future Improvements

We are constantly analyzing our ROV to improve it in all ways possible. As a future development, we will add a 2 axis stabilizer to improve the stability of our ROV. Also we will fully switch to UDOO boards which are a mix of both Arduino & Raspberry Pi. We were successful in achieving one was communication. Team Screwdrivers looks forward to the use of hydraulics or pneumatics in making the payload systems. We are also updating our control box and making software improvements to our ROV. The team also plans to build inhouse thrusters. The company will continue to uphold its philosophy by working on a tight budget so that members learn to use the funds allocated efficiently.

Acknowledgments

Firstly, we extend our heartfelt gratitude to our mentor- Professor Sawankumar Naik, for introducing us to this competition and encouraging us to push our limits and aim for the sky.

We would also like to thank-

- MATE for organizing this challenging competition
- Weyerhaeuser King County Aquatic Center for hosting the Competition
- MPSTME, SVKM’s NMIMS for financially aiding us and giving us this precious opportunity
- SVKM’s CNM School for providing access to the swimming pool for testing of ROV
- All electronics shops in Lamington Road, Mumbai, for catering to our requirements.
- All workshops in Marol for allowing us to work on their machines for various fabrications and Laser Cutting
- US Consulate Mumbai, Nehru Science Centre (NSC) Mumbai, various Municipal Schools 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.

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