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Department of Electrical and Electronics Engineering

Major Project Presentation

DESIGN AND DEVELOPMENT OF SUBMERSIBLE DRONE FOR UNDERWATER IMAGING

Under the guidance :
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Submitted by:

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- Motivation
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Introduction:

Most of the marine life is dying today, or is dead. The pollution is increasing day by day. A large portion of our waterbody is full of wastes. Most of the small fishes **use corals as their habitats**. To tackle this predicament **active monitoring of aquatic life is imperative**. Corals are dying around the world due to Coral Mining, Climate change and other abusive actions by human.

Small remotely controlled underwater vehicles can be utilised to **carry equipment like cameras and sensors** to the habitat of the fishes, corals and other marine life **to monitor and generate reports on the status of the lifeforms** and track the deterioration if needed.

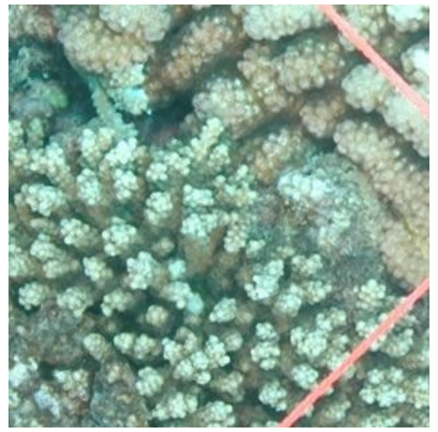
Types of Corals

Brain Coral

Branch Corals

Paly Coral

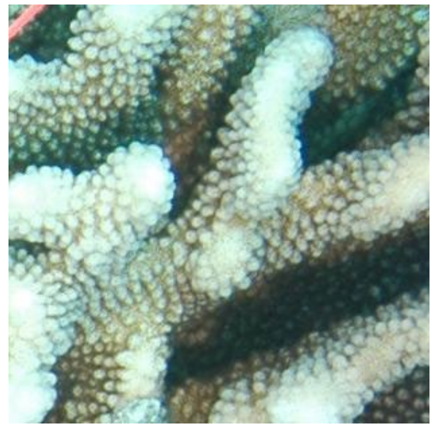
Acropora coral



Favid Coral

Pavona coral

Pocillopora coral



Porites coral

Literature survey:

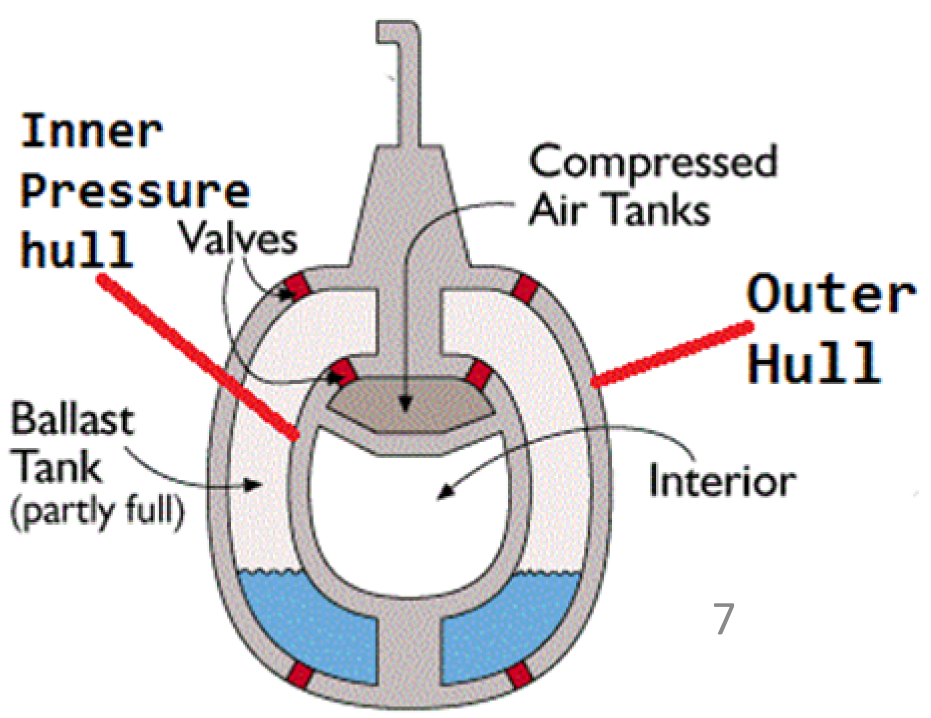
S.no.	Title	Journal / Conference	Major Observations
1	Autonomous under water vehicles : Recent development and future prospect	International journal for research in applied science and engineering technology	Summarise the development of AUV in India and tends to focus on future developments
2	Design and fabrication of a prototype submarine using Archimedes principle	3rd international conference of informatics , electronics and vision 2014	Design of propulsion ,diving system and efficient power system
3	Development of advanced lithium ion battery for underwater vehicle	2011 IEEE symposium on underwater technology	Lithium ion rechargeable battery for deep underwater use
4	Imaging system for advanced underwater vehicles.	Journal of maritime research ,8(1):65-86	Underwater Image processing
5	Development of remotely operated submarine vehicle	2008 IEEE Europe ocean conference	Control system of depth to simplify the operators work and collect accurate data

Motivation:

- Most ROV(remotely operated vehicle) available in the market are of vertical propeller type which **uses second propeller for the sole purpose of maintaining depth**. These ROV **are ballast free** and the lack of ballasts **hugely limit the air tight payload capacity** as buoyancy in these systems are a function of continuous power.
- However, the use of ballast tanks can change and hold the buoyancy passively without using anymore power after the required buoyancy is achieved. Thus **allowing for a larger payload** to be carried without losing any power for underwater hovering for long duration.

ROV WITH VERTICAL AXIS PROPELLER

SUBMARINE WITH BALLAST TANK



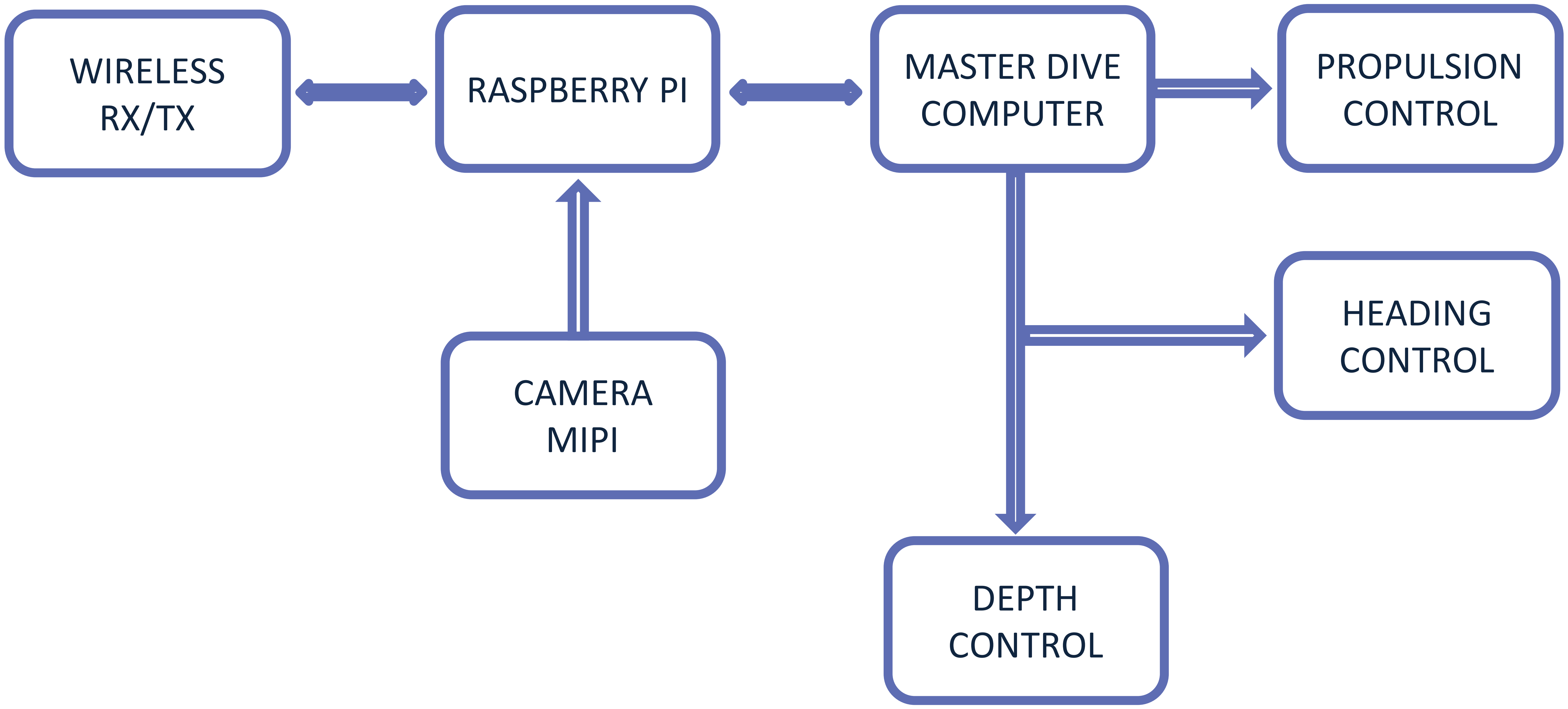
Problem Statement:

- To design , fabricate and test a wirelessly controlled submersible vehicle for real time underwater imaging of aquatic life .

Objectives:

1. Development of submersible drone.
2. Design and implementation of controller for propulsion.
3. Design and implementation of heading and depth controller.
4. Development and implementation of image processing system.
5. Design and integration of drive system for motor.

Methodology:



WIRELESS RX/TX

- FPV (First Person View) unit is used for wireless controlling of the submarine.

- The video feed is broadcasted across on **2.4GHz** bands of Raspberry pi's wifi while control operations will be broadcasted over 2.4 GHz NRF Module.

RASPBERRY PI

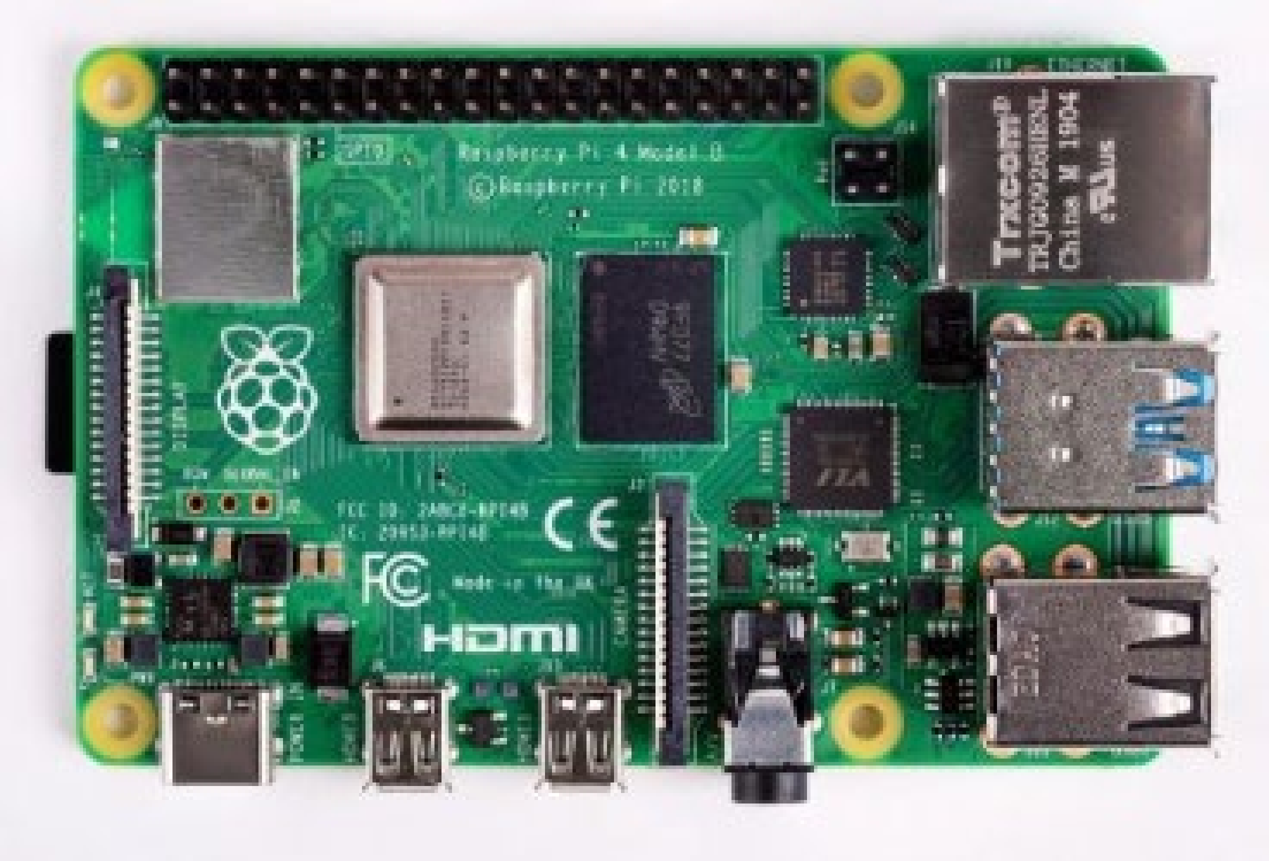
- This is used as an interface for communication of the **Camera Module** and the **Master Dive Computer.**

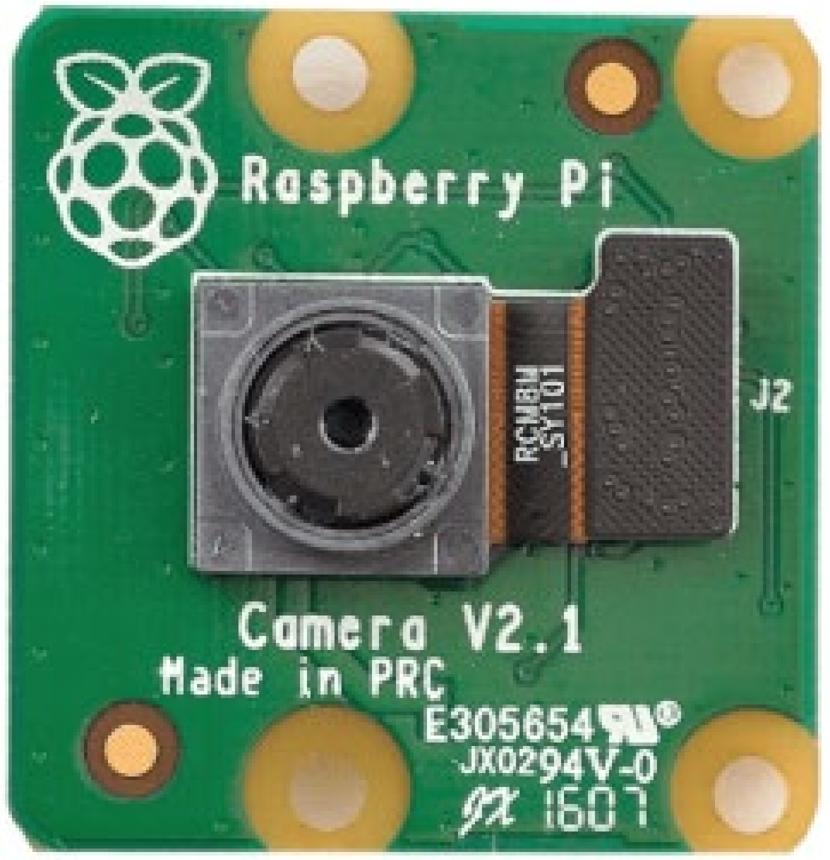
- **A Raspberry Pi** is a **Single Board Computer(SBC)** capable of running an operating system.

- **The SBC** is also capable of interfacing over the USB and other various networking protocols

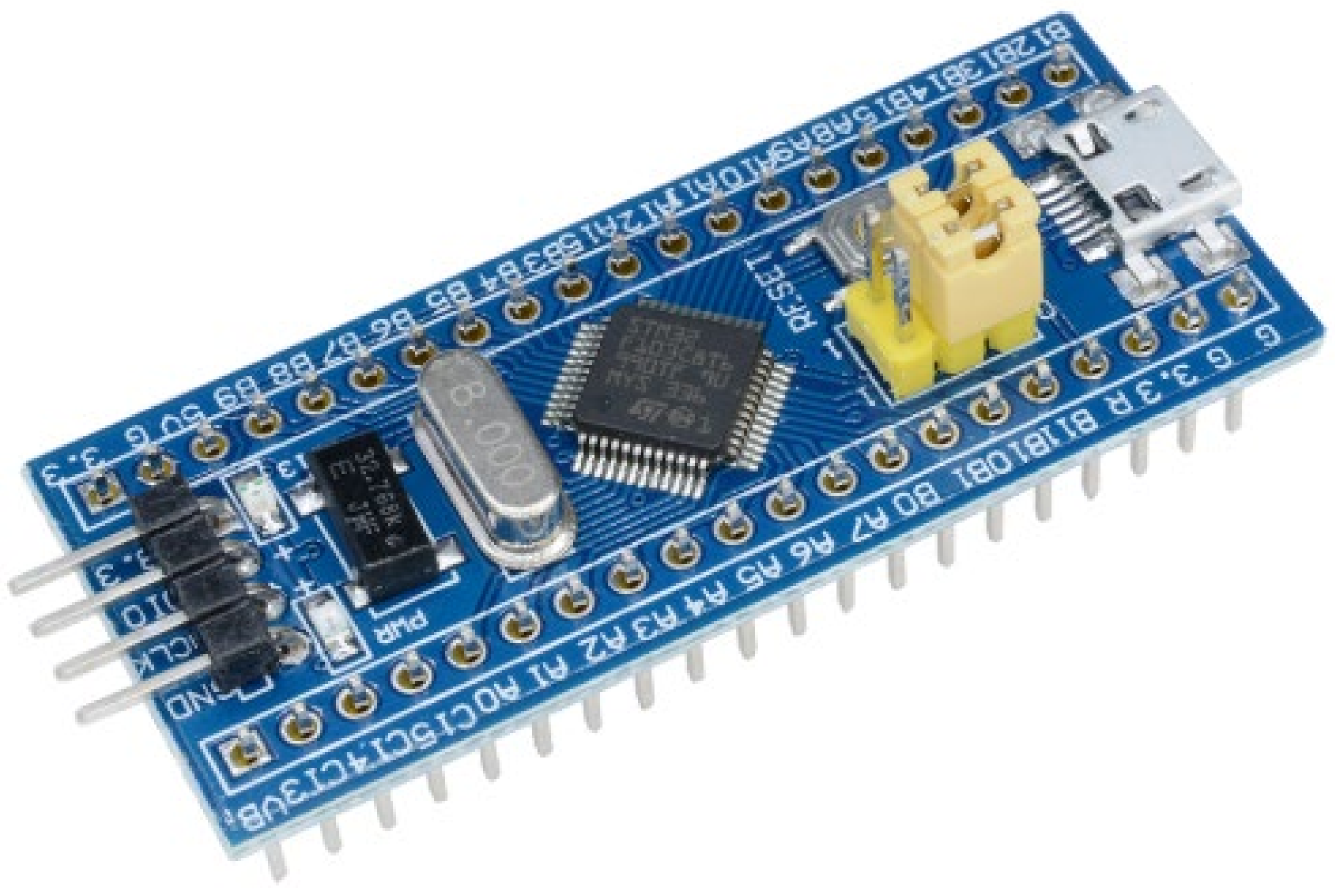
- The device boast a **4 core processor** and **4 Gigabyte** of Random Access Memory.

- The camera is connected over the **MIPI(mobile industry processor interface).** The camera is at least FullHD Capable and will carry flashlight with it.





Master Dive Controller

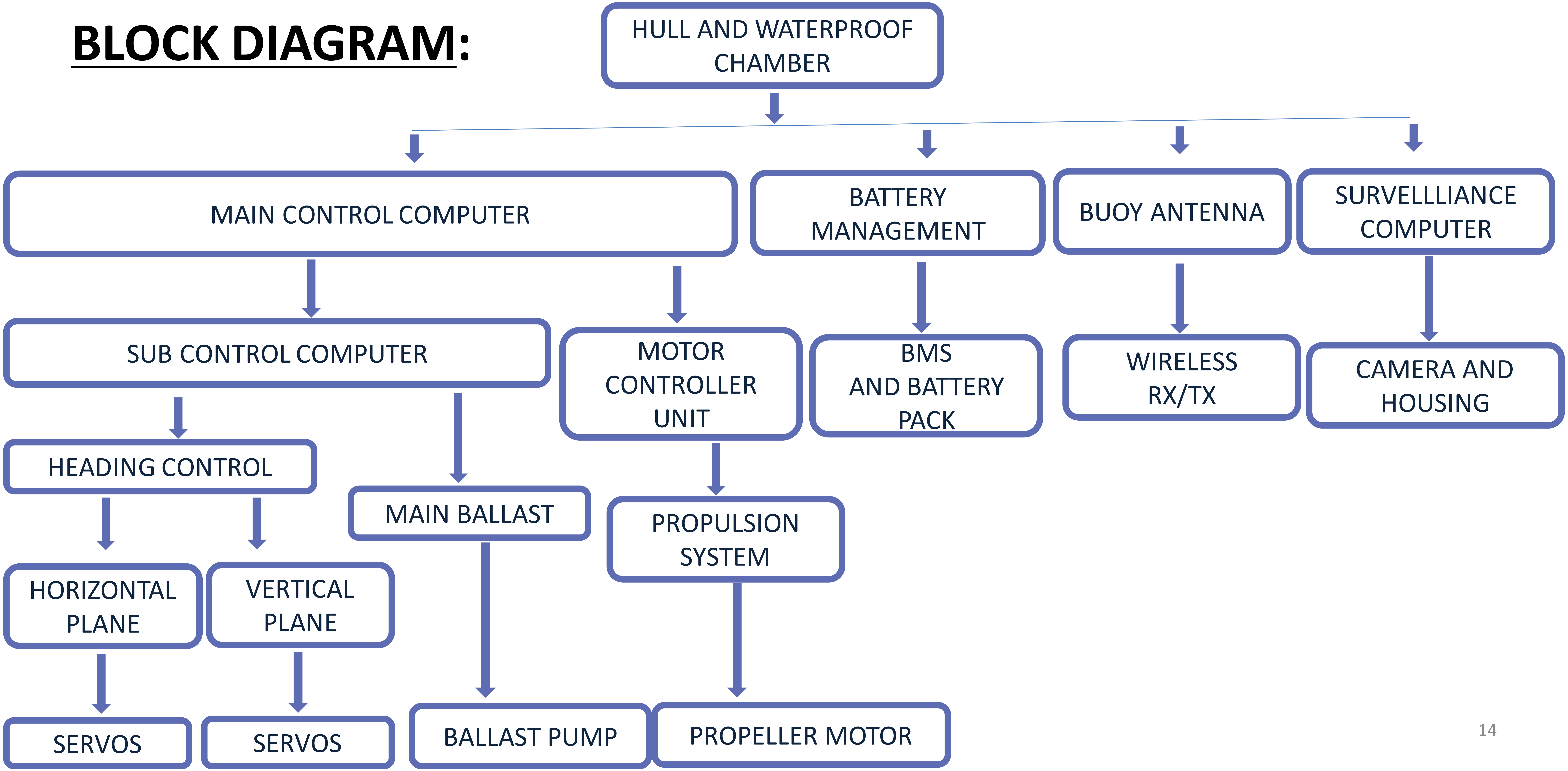


- Master dive controller sends and receives signals from propulsion, depth and heading controllers.
- ATmega 328p chip is used as a master dive controller.
- 32KB flash memory, 2KB ram
- It runs on 16Mhz base clock.
- SPI enabled.
- Incorporates 10 bit ADC

Propulsion , heading and Depth controller.

- ATmega 328p chip serves as the propulsion controller.
- ATmega 328p is used for Heading and depth.
- These two controller receives signals from Master dive controller.

BLOCK DIAGRAM:

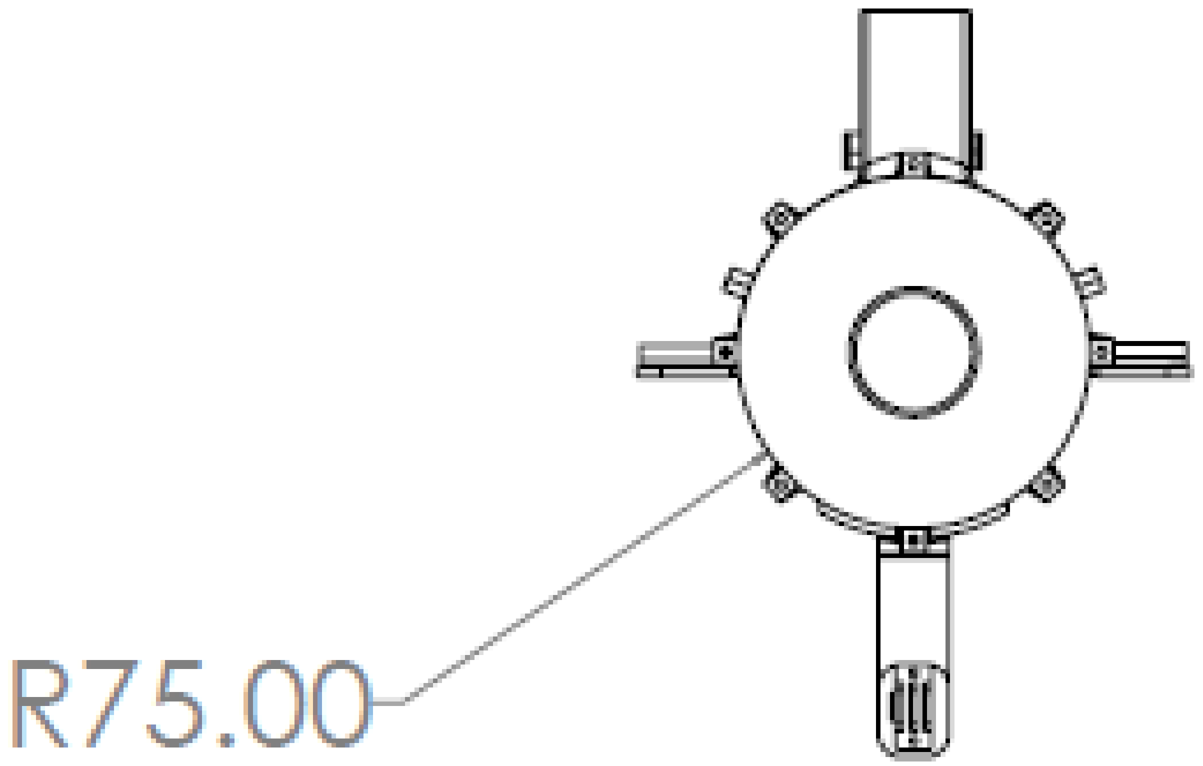


Development of submersible drone

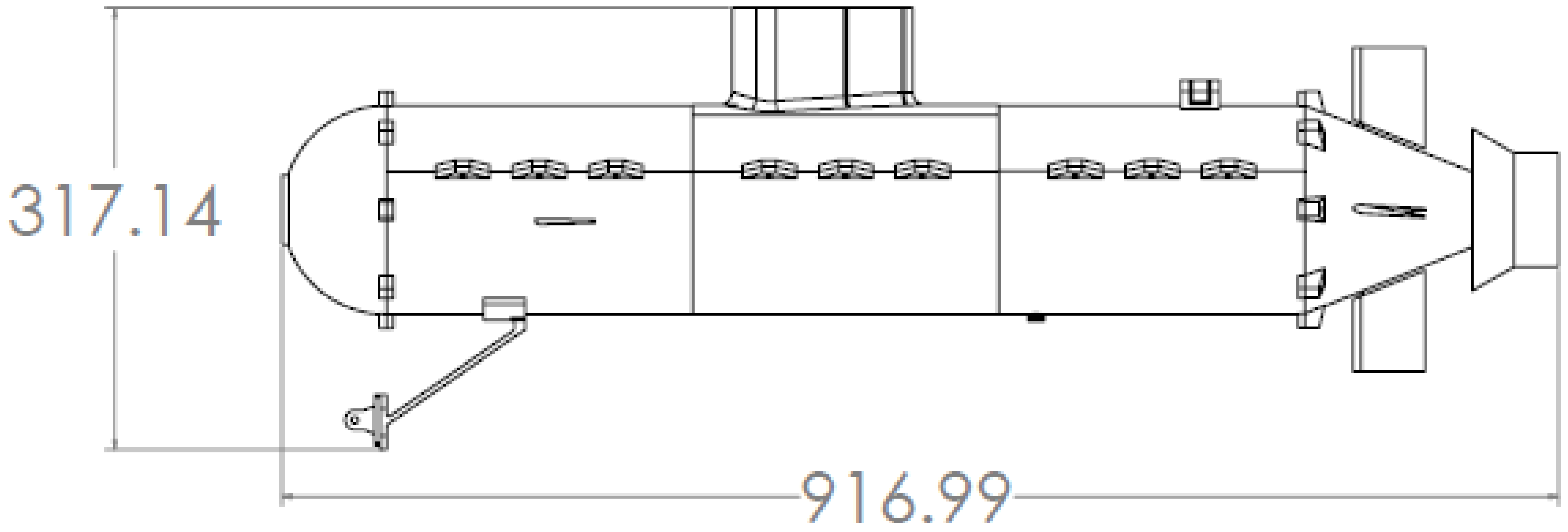
1. All 3D Parts of this projects were designed using SolidWorks.

2. 3D Parts were sliced and printed in two printers – Ender 3 & Pramaan.

2D drawings of Submersible Drone with dimensions:

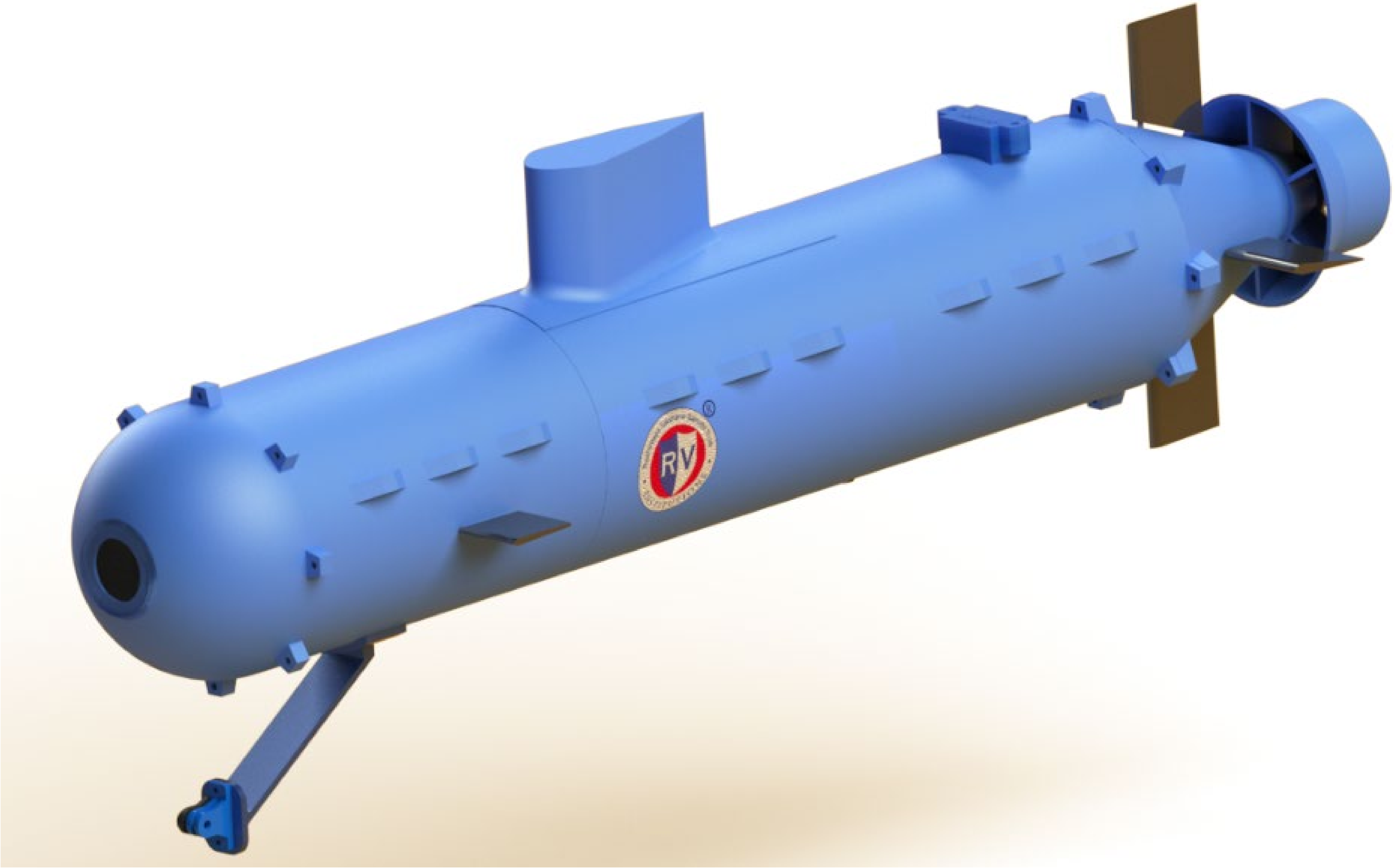


Front view



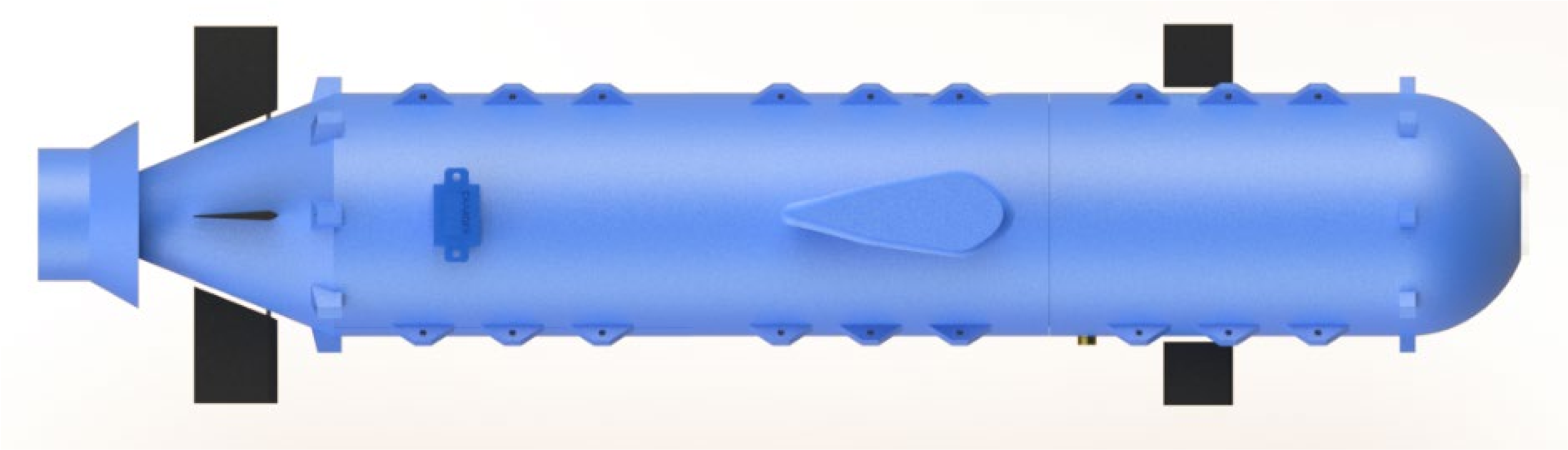
Side view

Design of Submersible drone

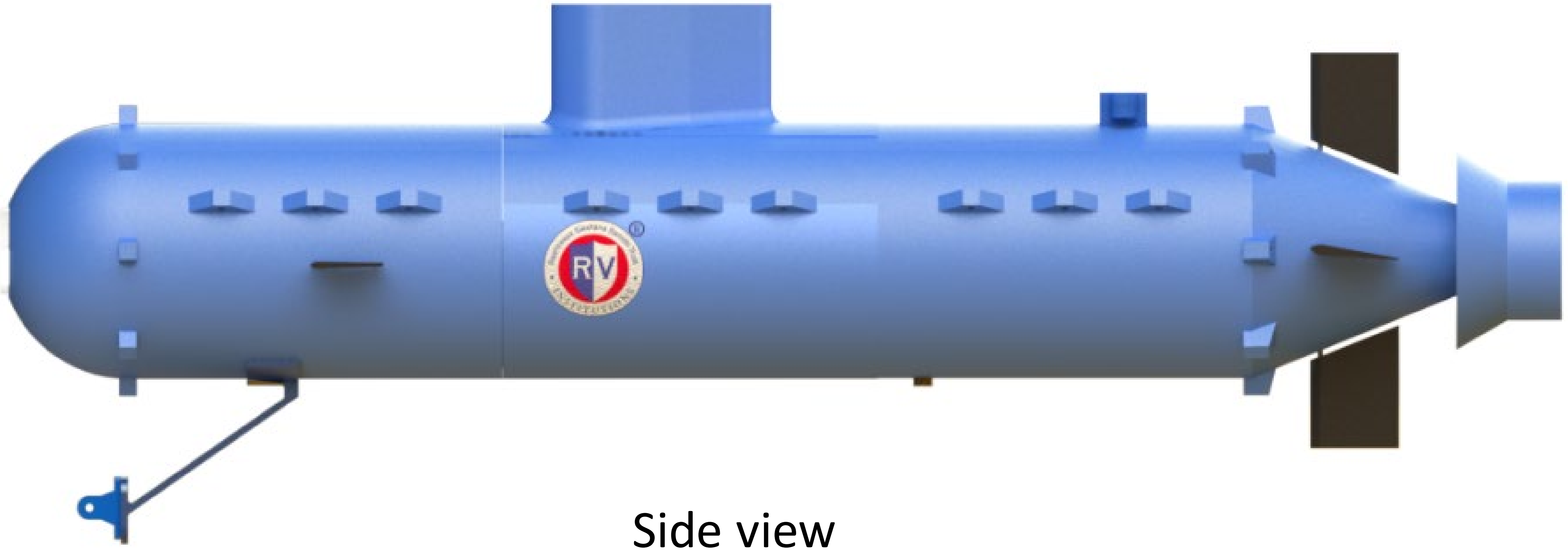


Isometric view

Design of Submersible drone

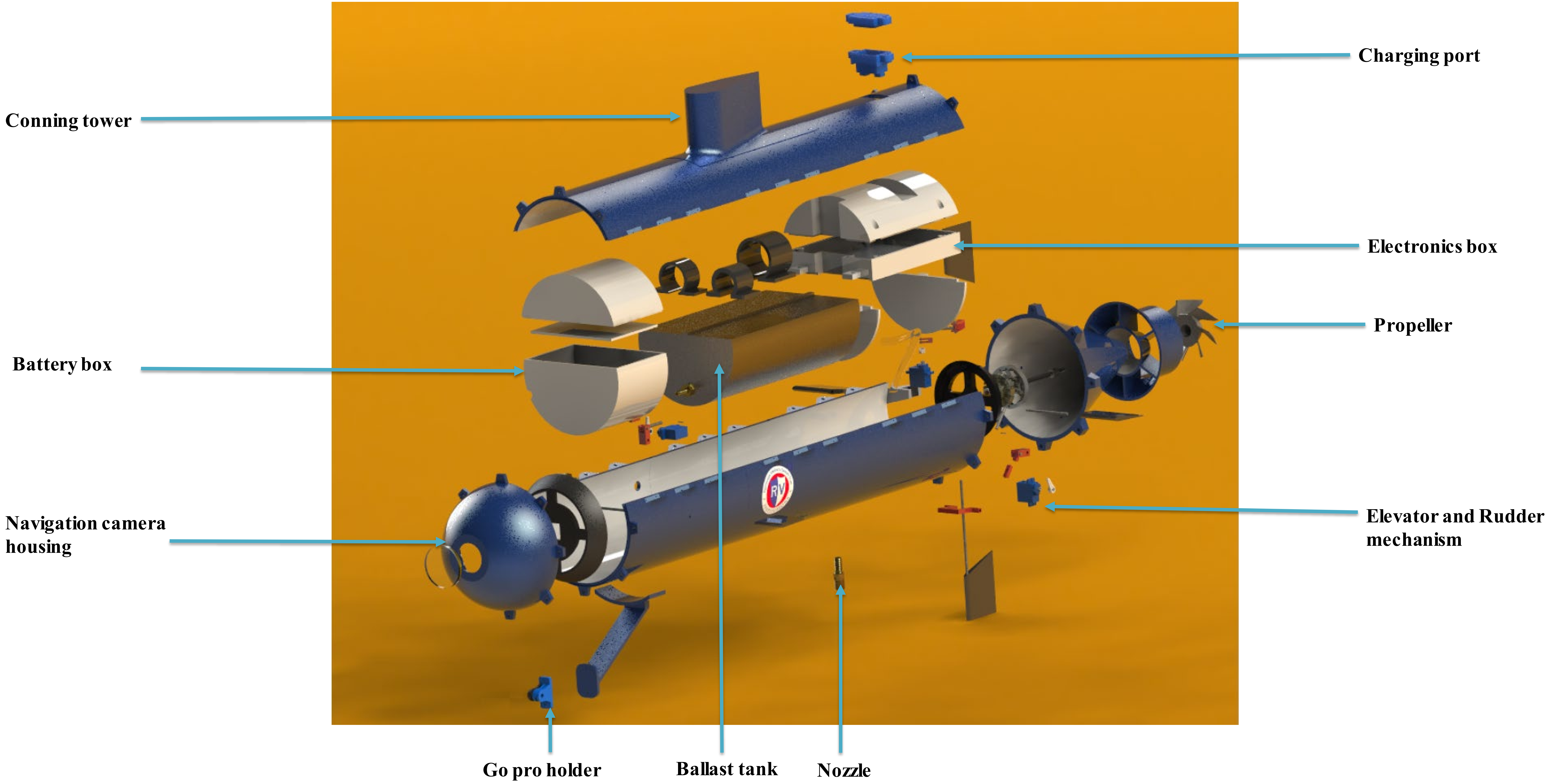


Top view

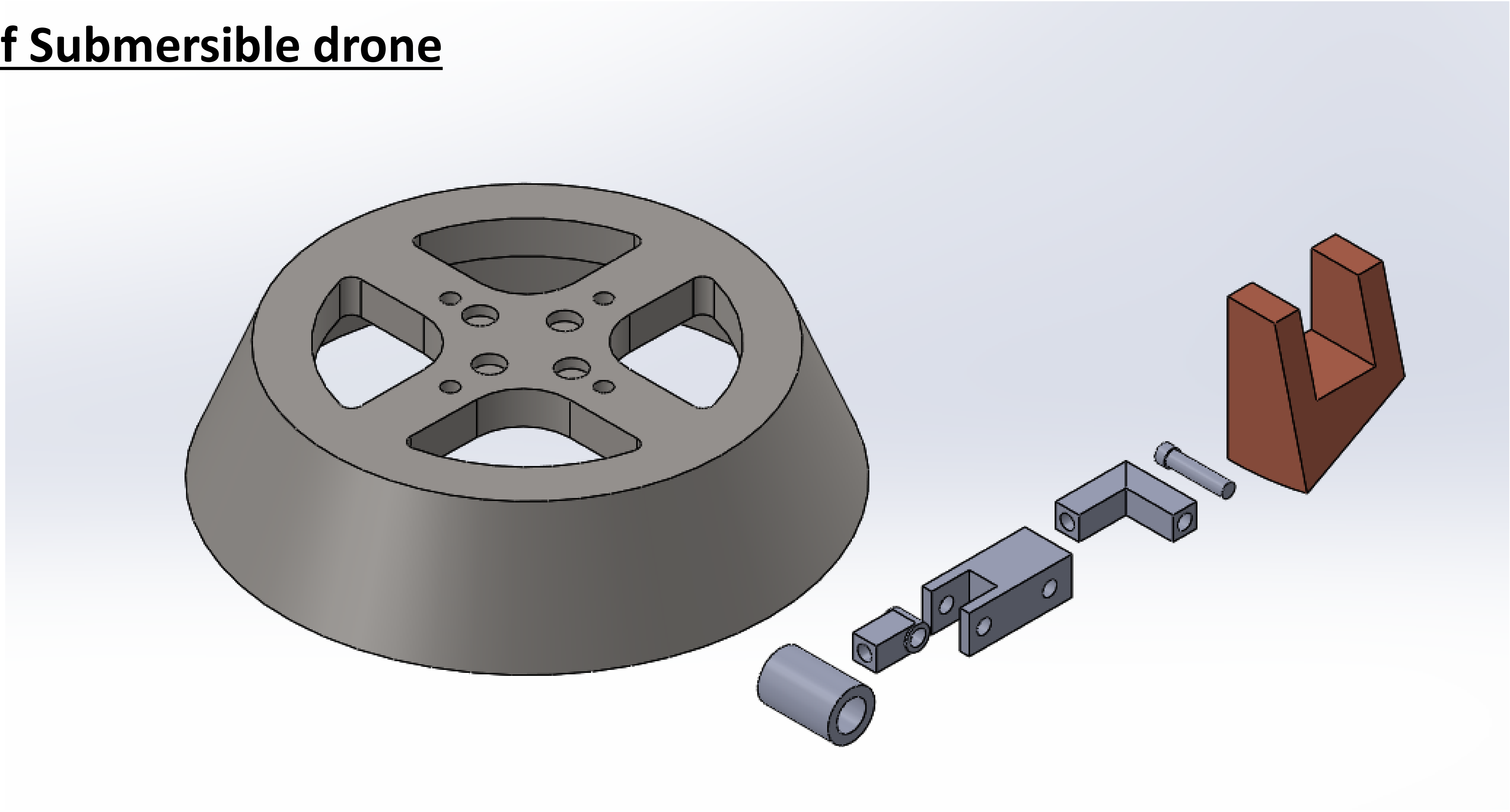


Side view

Development of submersible drone: Exploded view

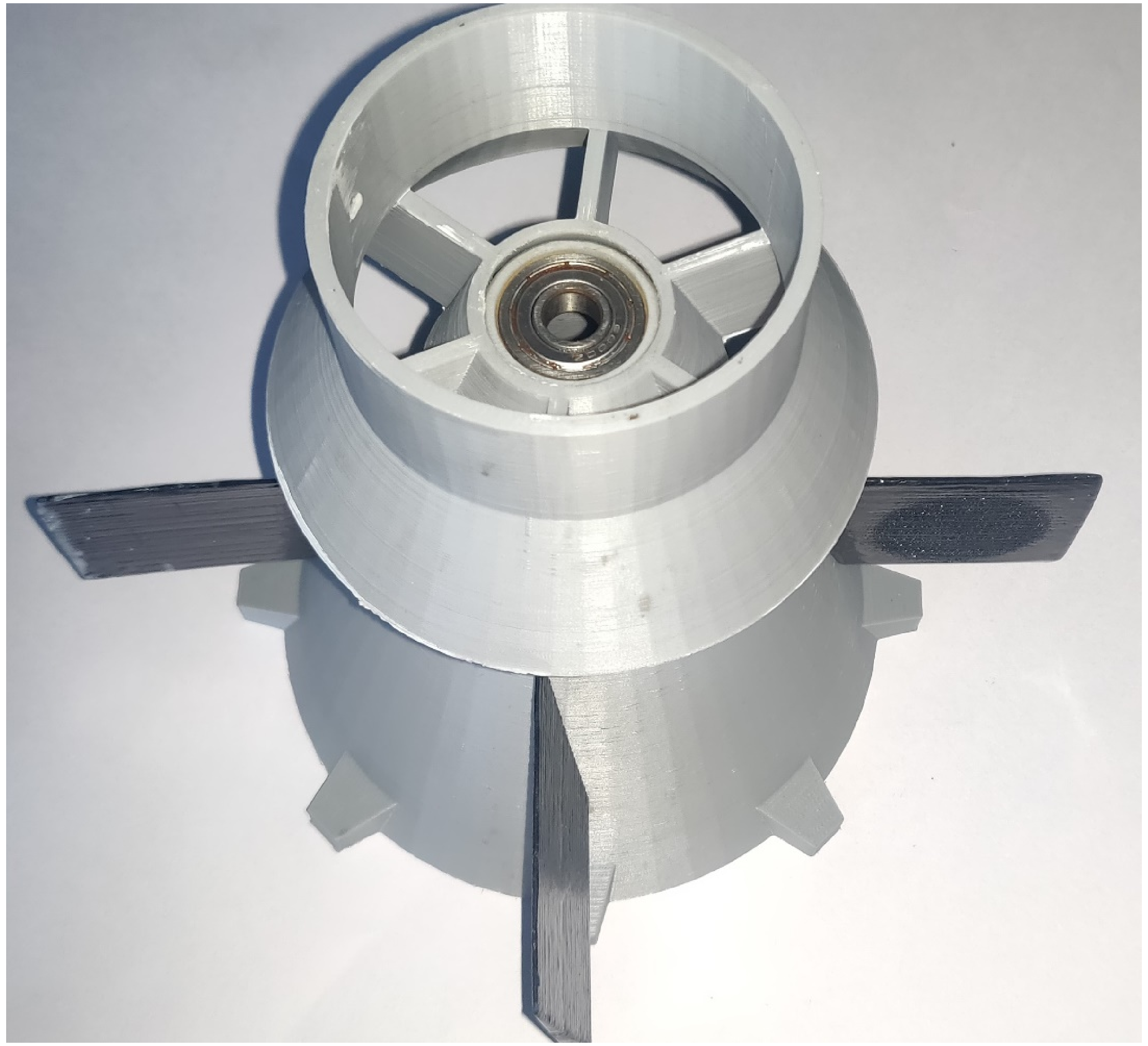


Design of Submersible drone

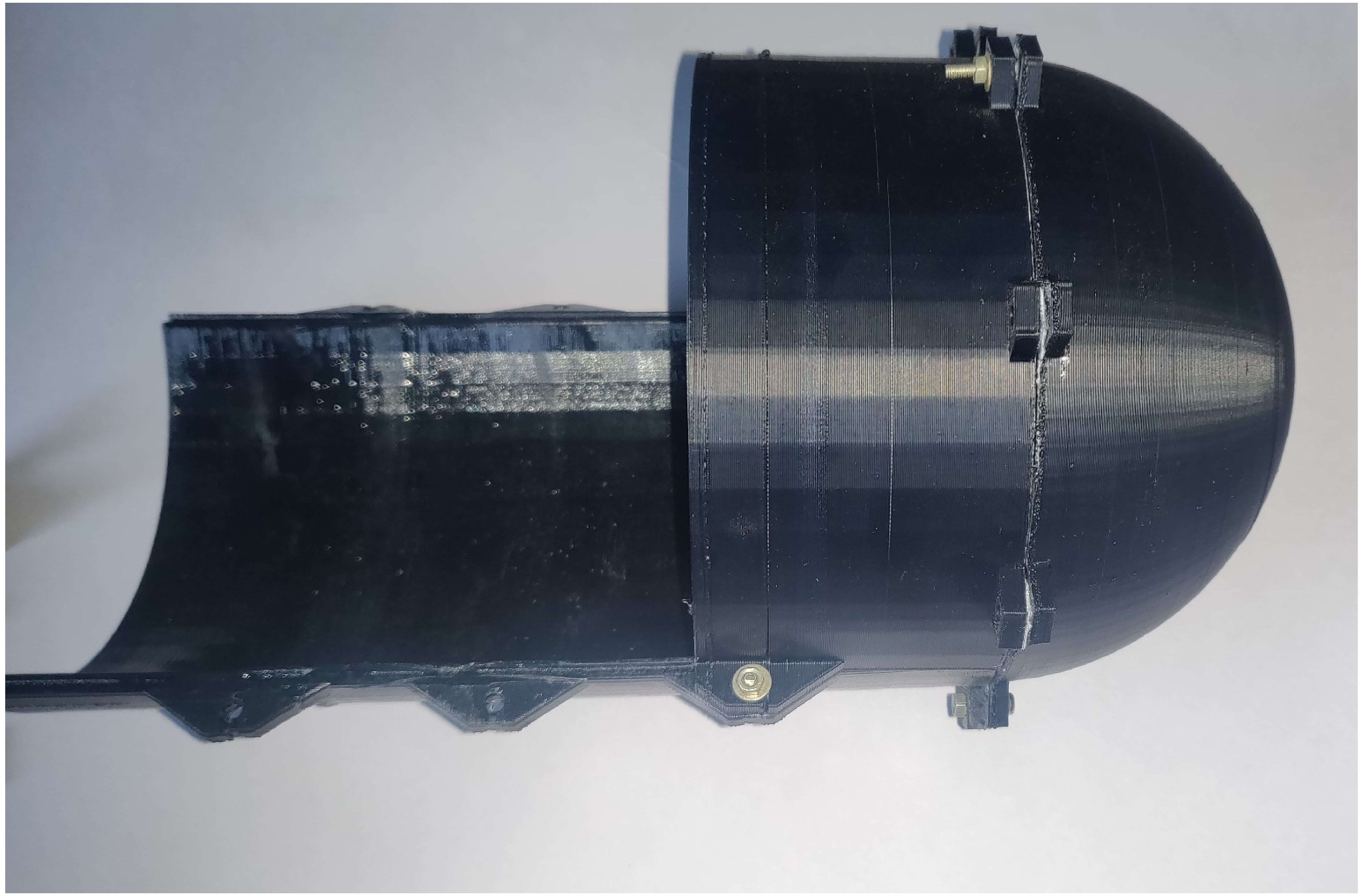


BLDC motor holder and Servo mechanism components

3D printed parts

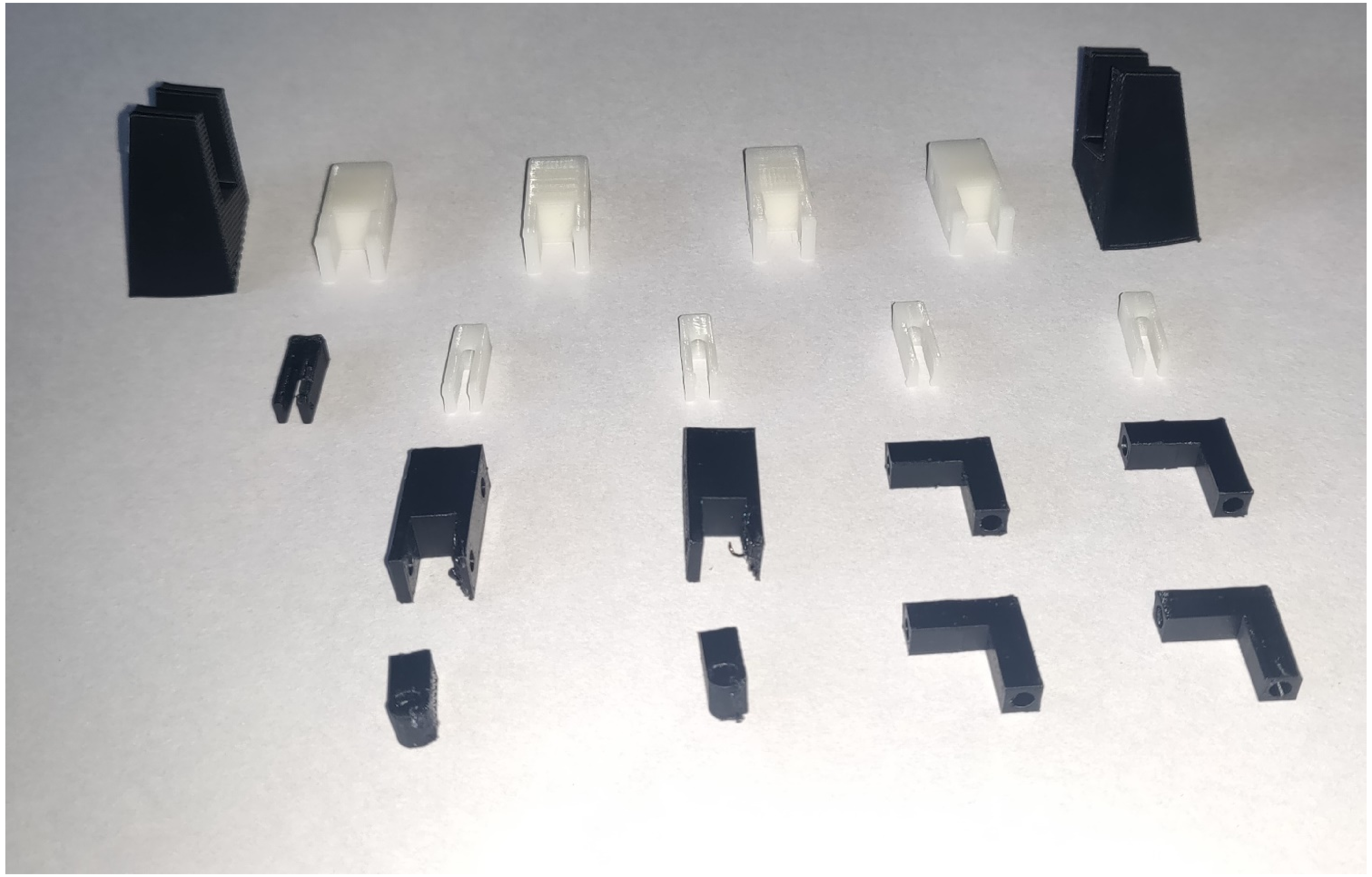


Stern cone with shroud and direction control



Aft dome and 1/3 Main Hull

3D printed parts

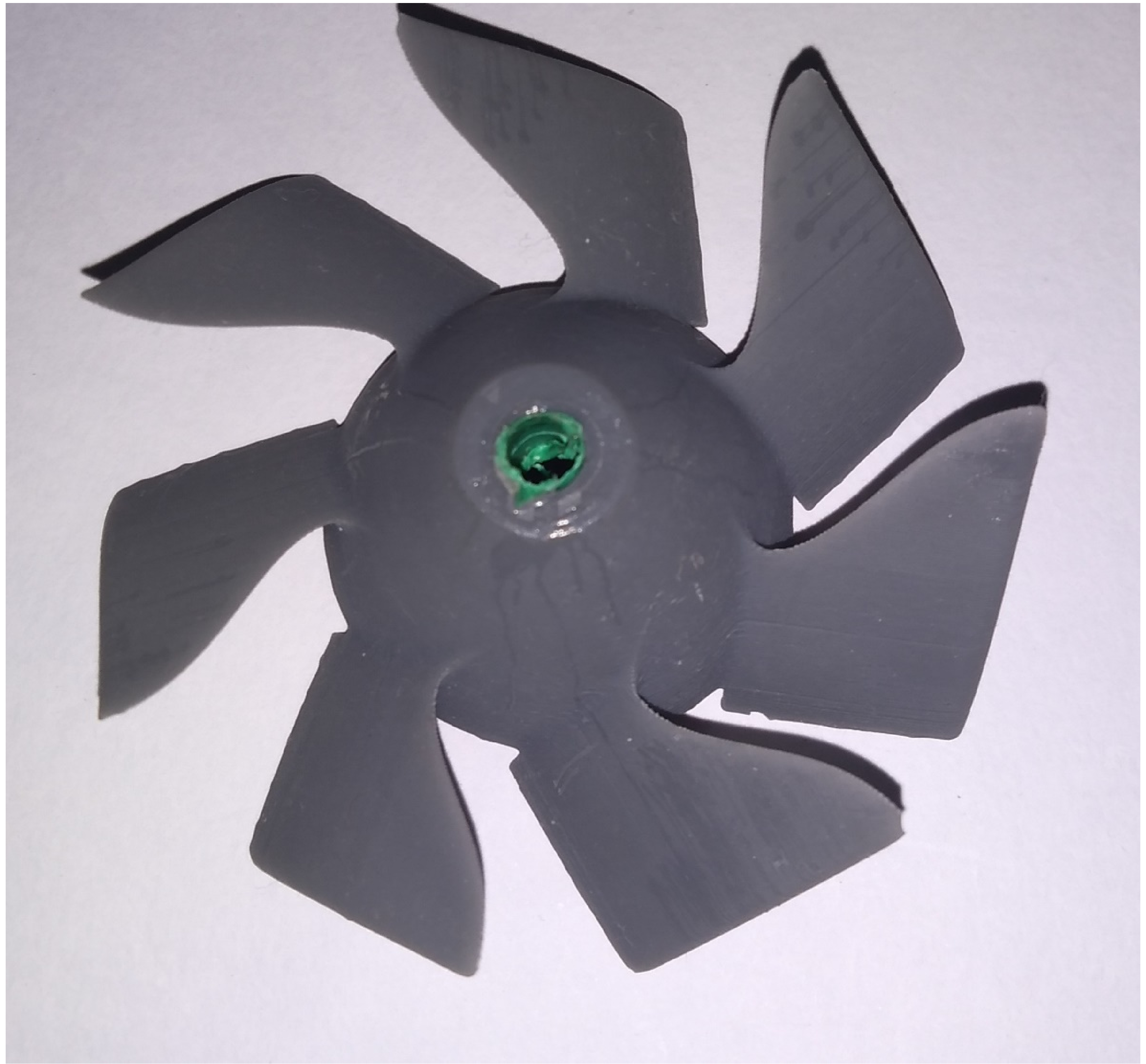


2 hours

3D printed parts

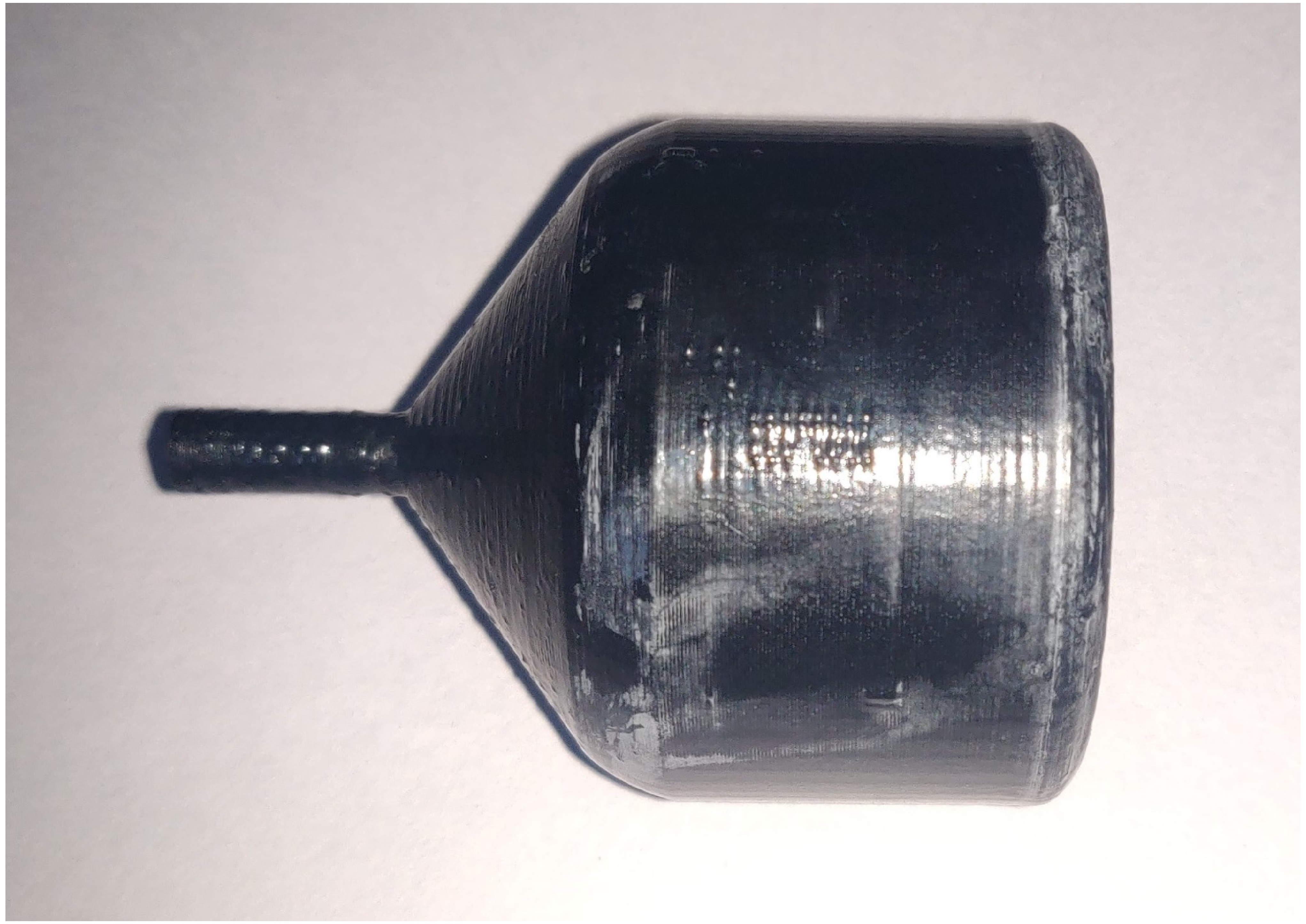
Propellers:

9 hours (FDM Process)



7 hours (SLA)

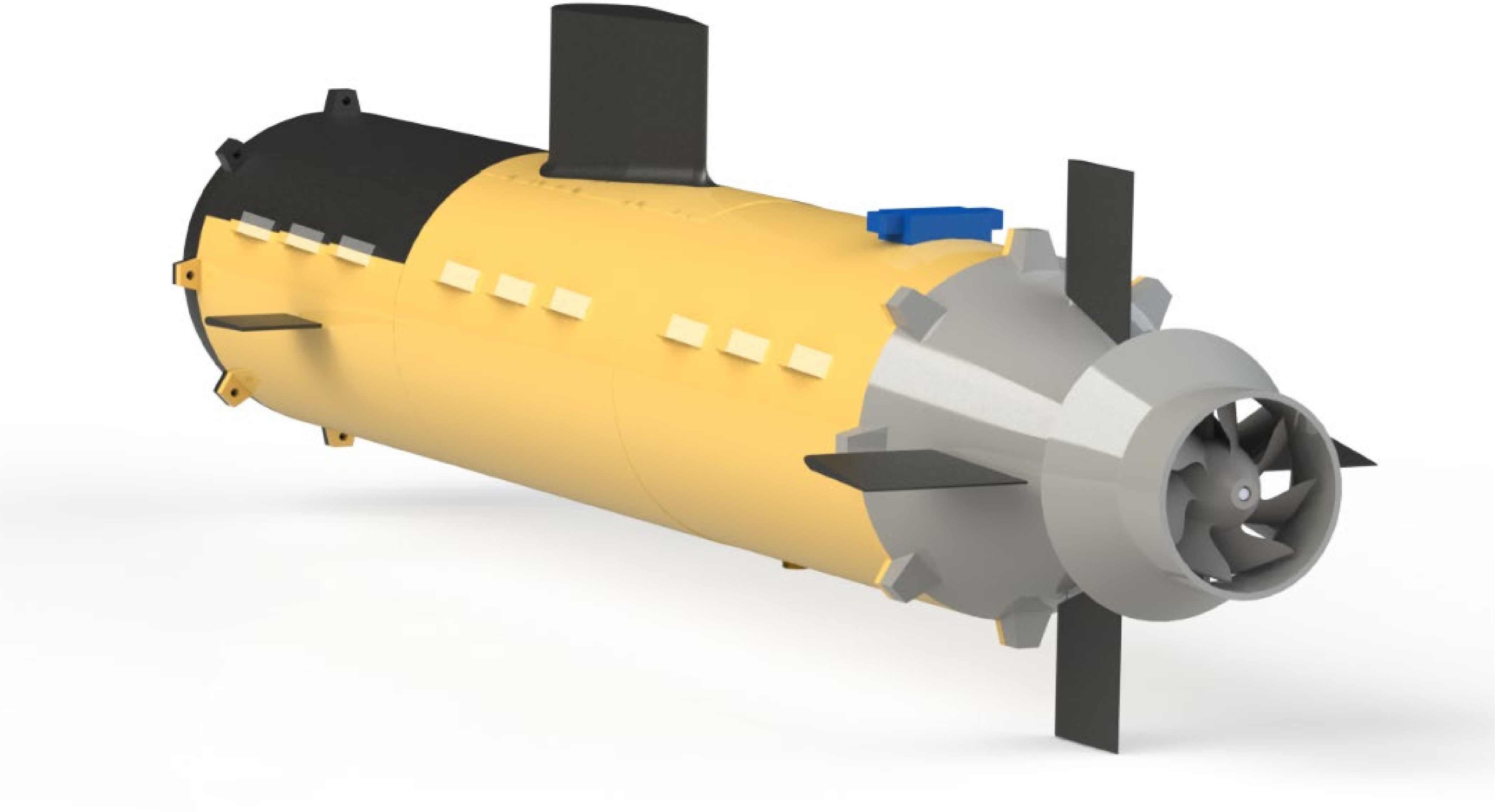
3D printed Test Ballast Tank:



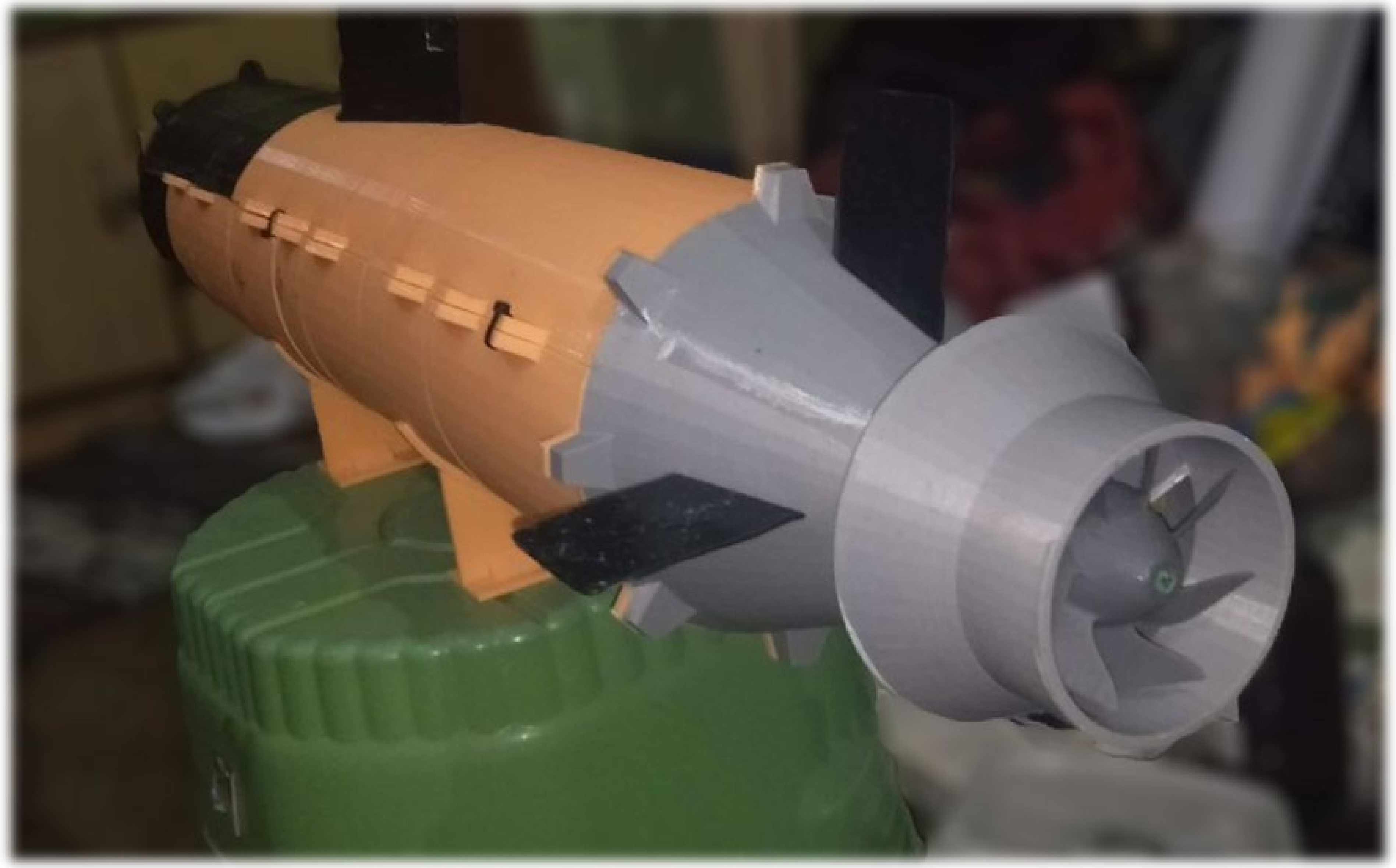
Time taken for printing: 5 hours

Stainless Steel Ballast Tank:

Mechanical structure:

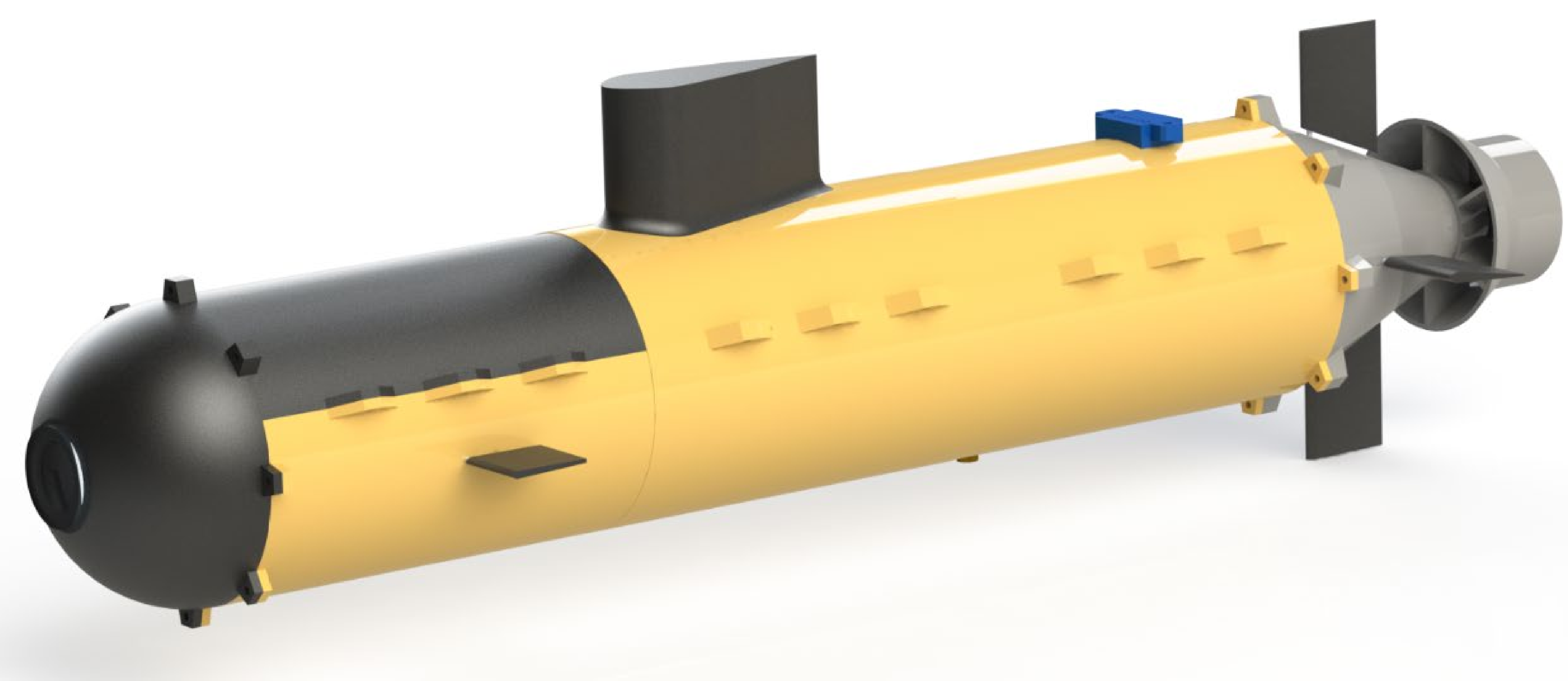


Model for reference



Actual 3d printed model

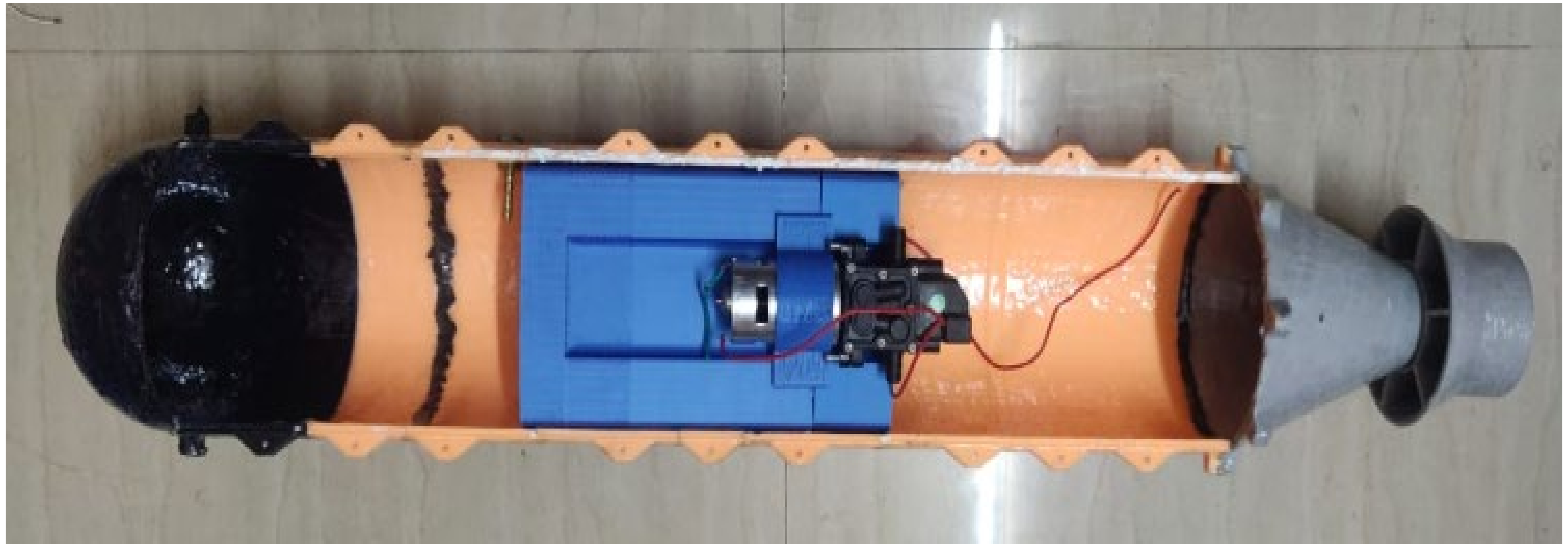
Mechanical structure:

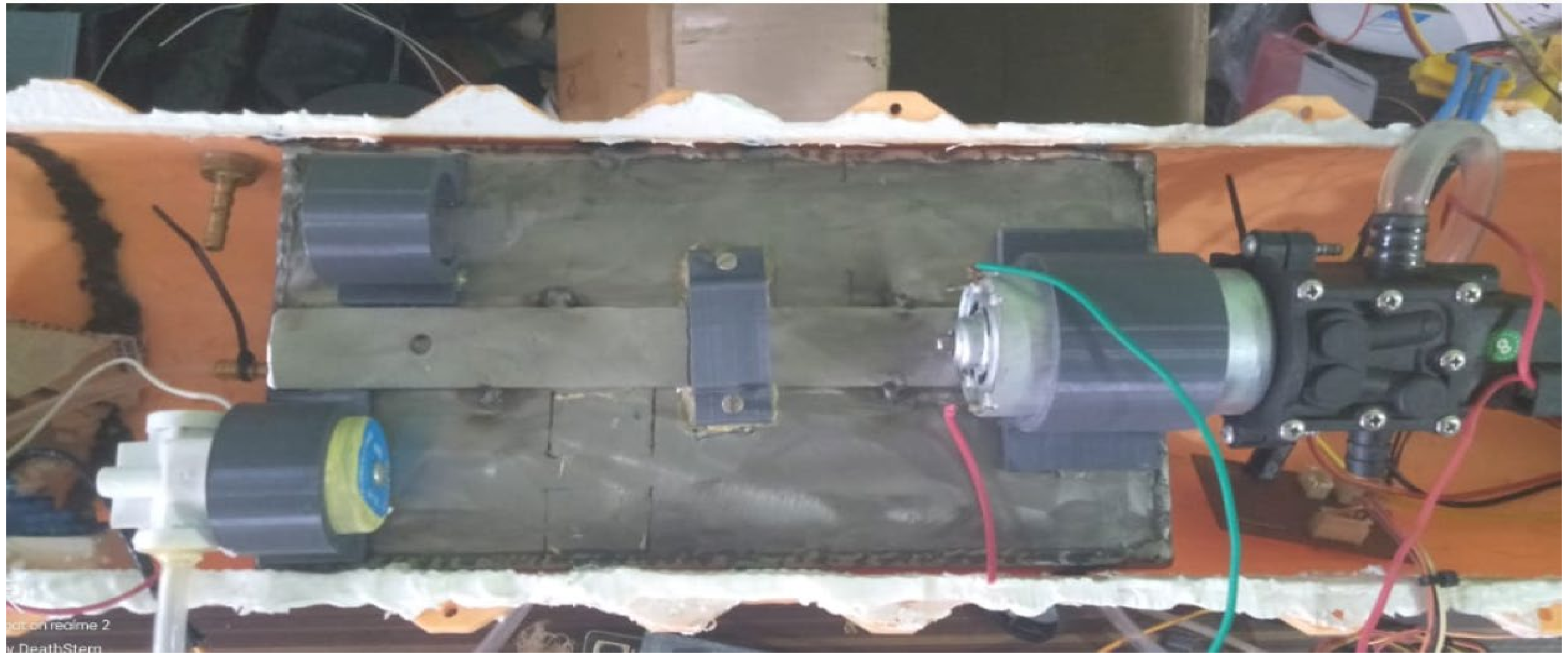


Model for reference

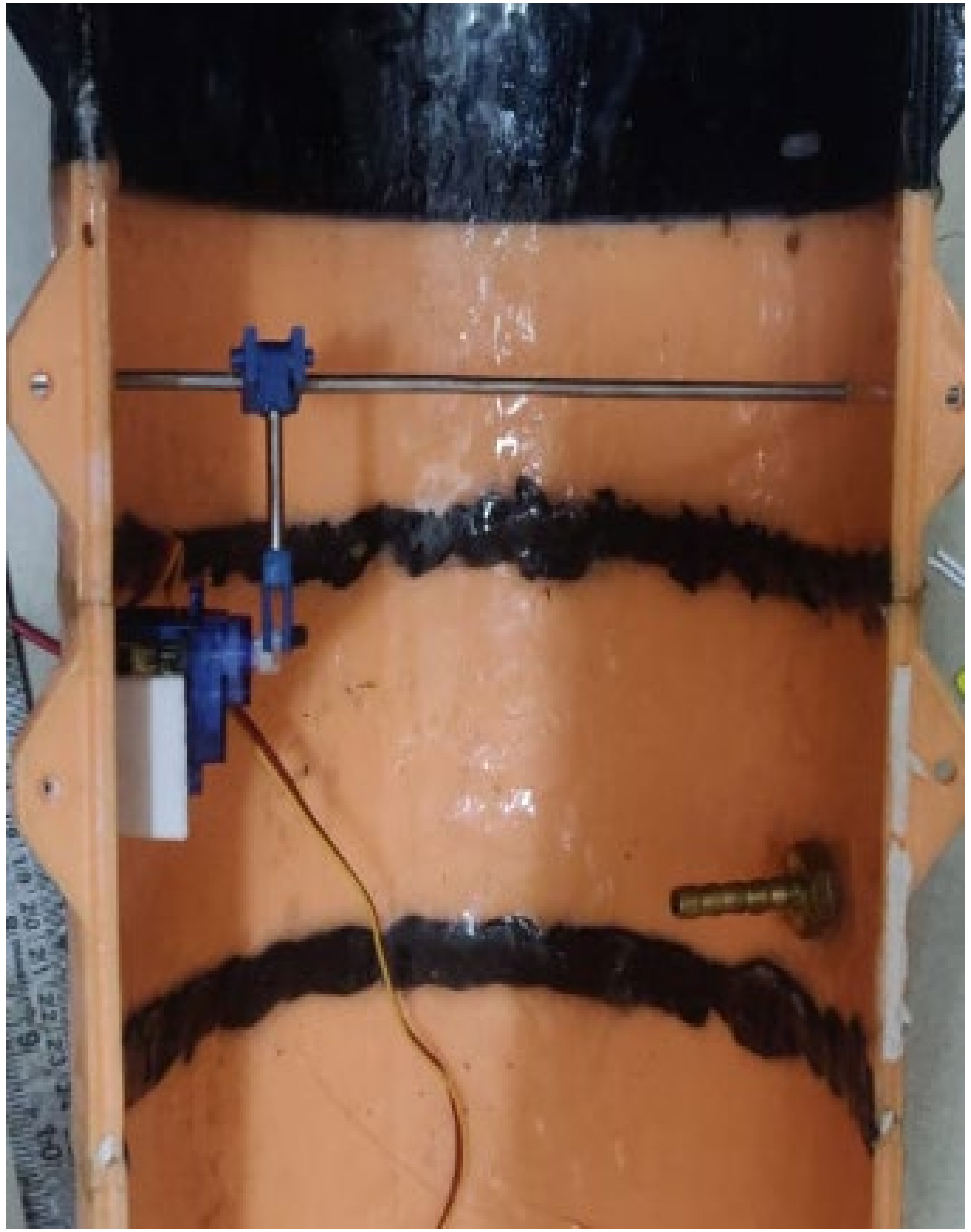
Actual 3d printed model

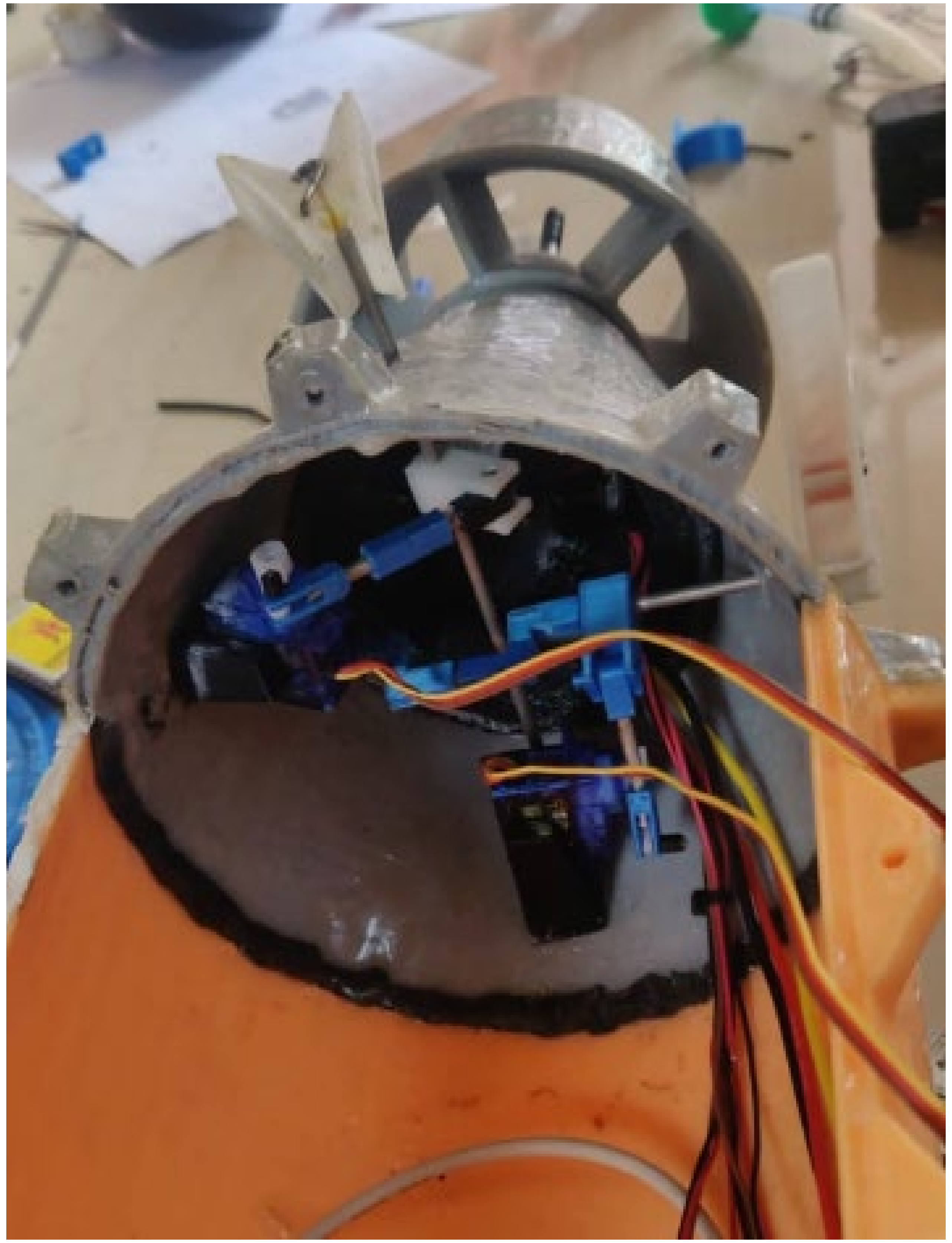
Ballast inside the Submarine hull:





Implemented Rudder and Elevator Mechanism:





Design and implementation of controller for propulsion.

START:

- Init Communication
- Init Clock & Timers

Wait for Control Signal:

- Read Serial Port for control data by indirect addressing.
- Update read data to timer registers

Read Sensors:

- Read Compass Data.
- Read Magnetometer Data.

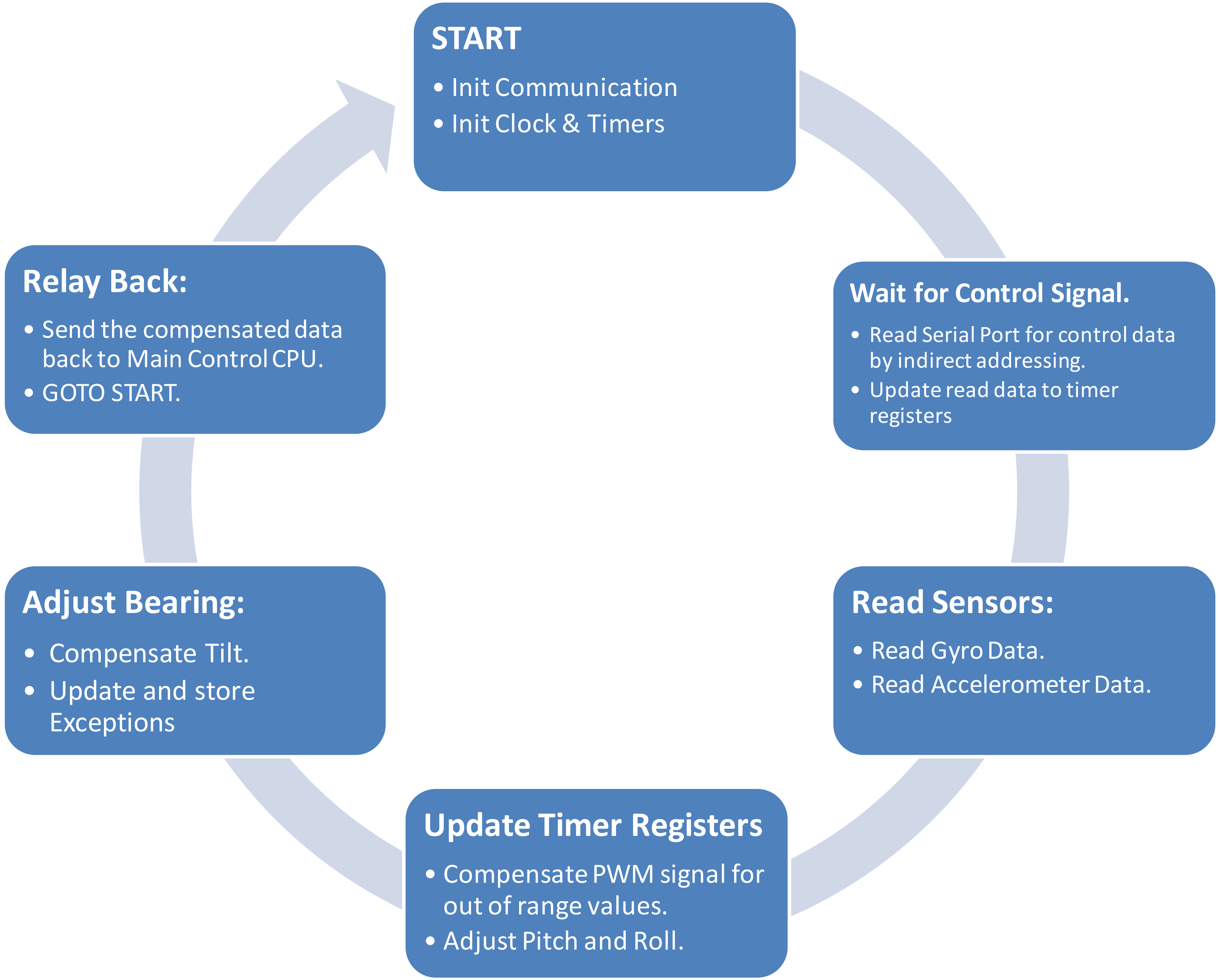
Update Timer Registers:

- Compensate PWM signal for out of range values.
- Update and relay Exceptions

Relay Back:

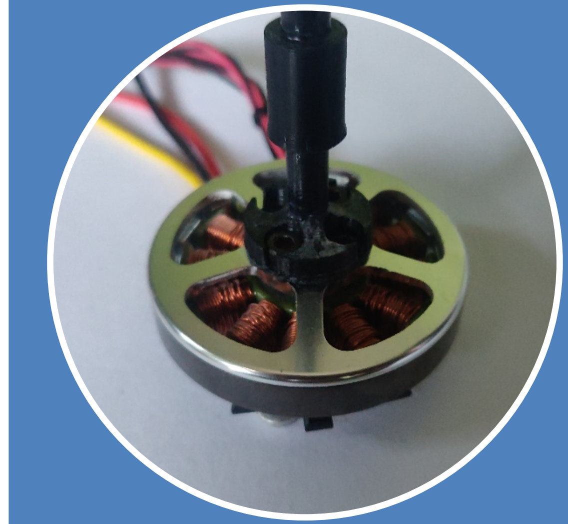
- Send the compensated data back to Main Control CPU.
- GOTO START.

Design and implementation of heading and depth controller.

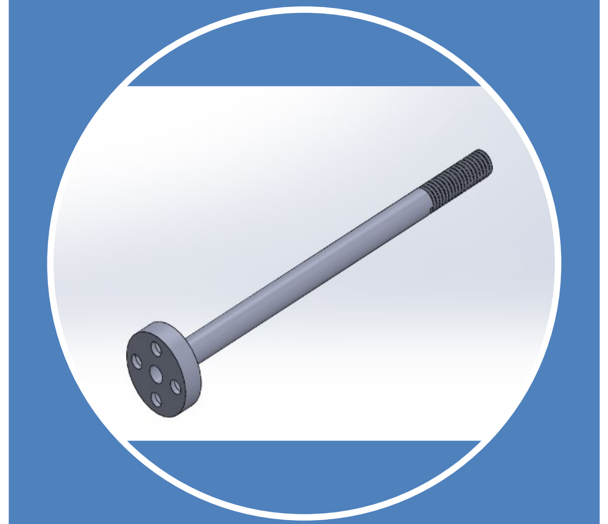


Design and integration of drive system for motor.

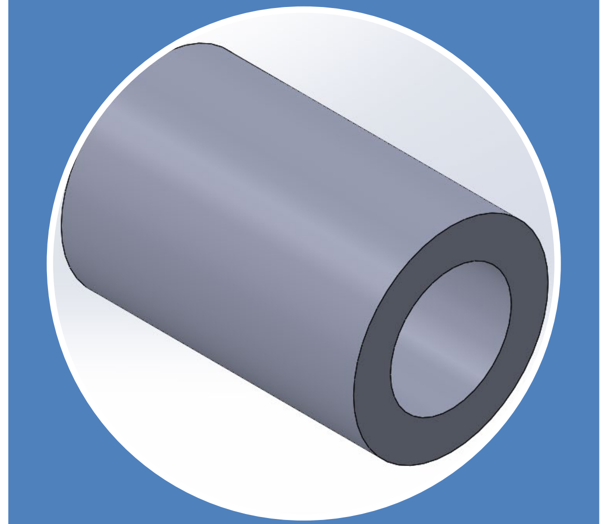
Hall Encoder



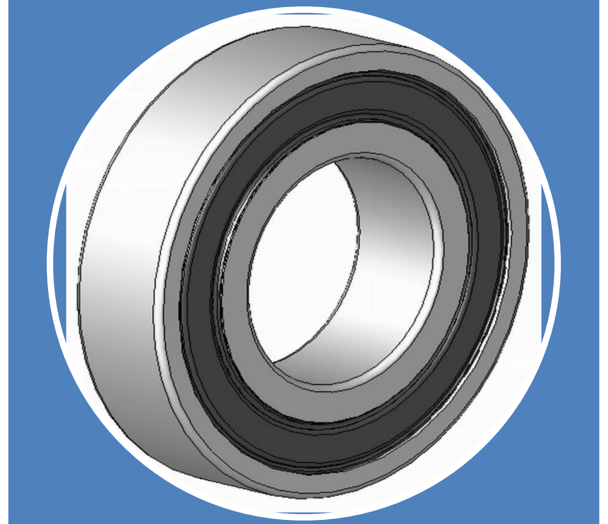
Motor



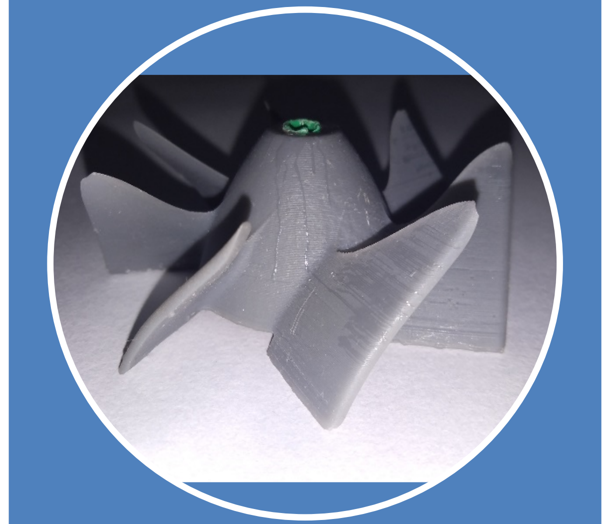
Drive Shaft



Bearing Support Shaft

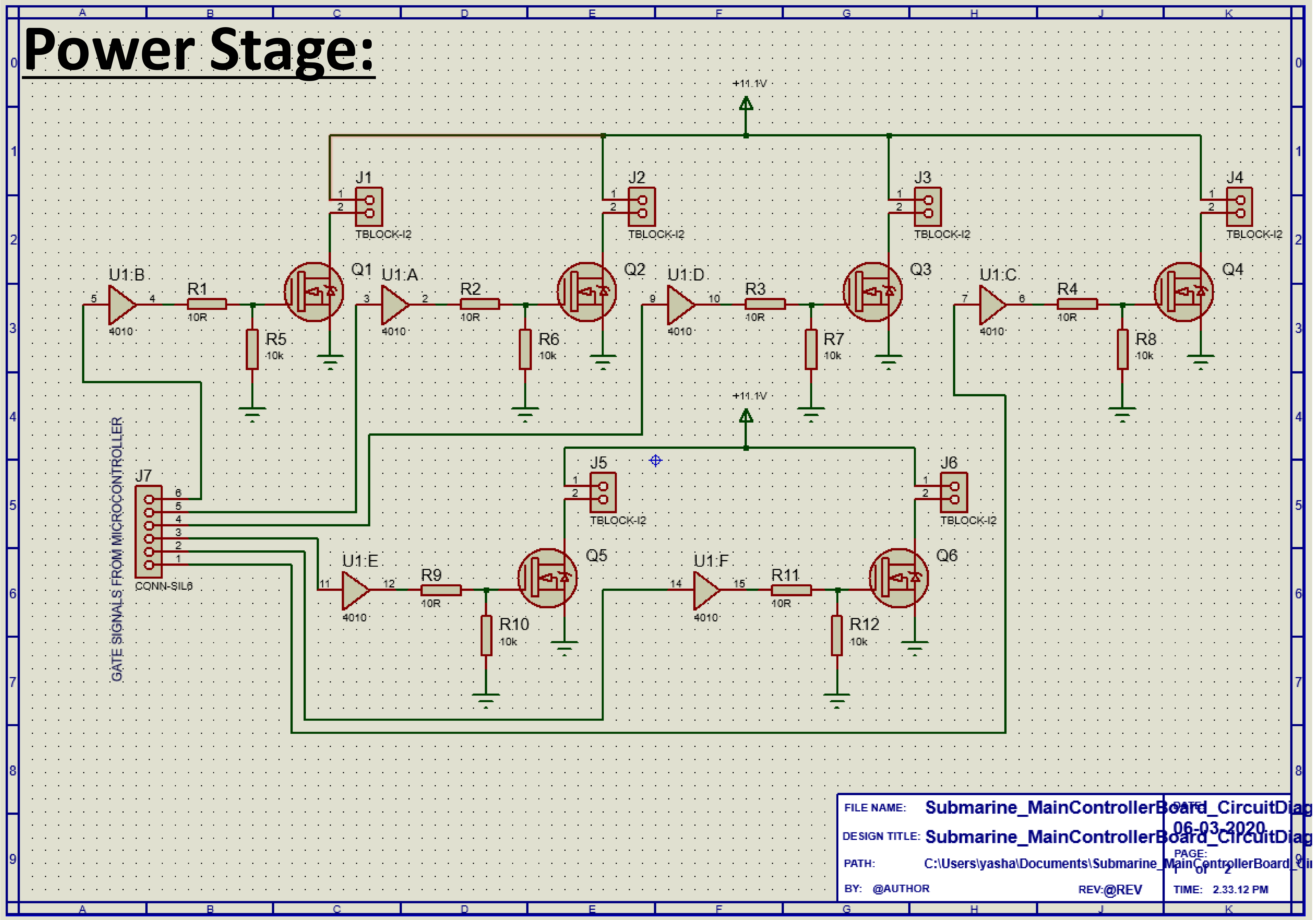


Bearings



Propeller & Lock Nut

Power Stage:



Power Rail

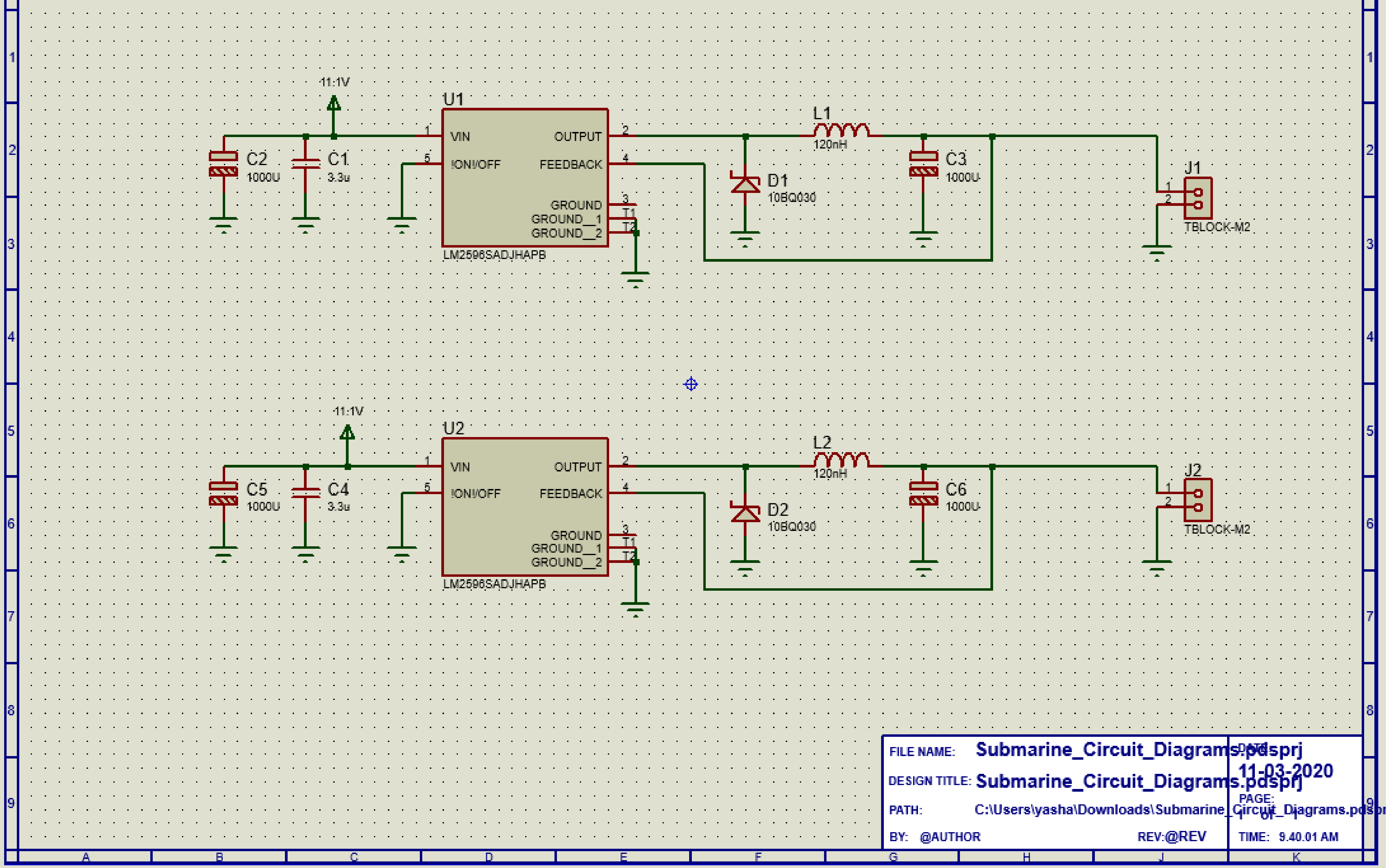
Terminal Blocks

Chopper FETs

- Gate Resistors
- GS Bleeders
- Level Shifters

Battery -

Buck power supply for onboard computers:

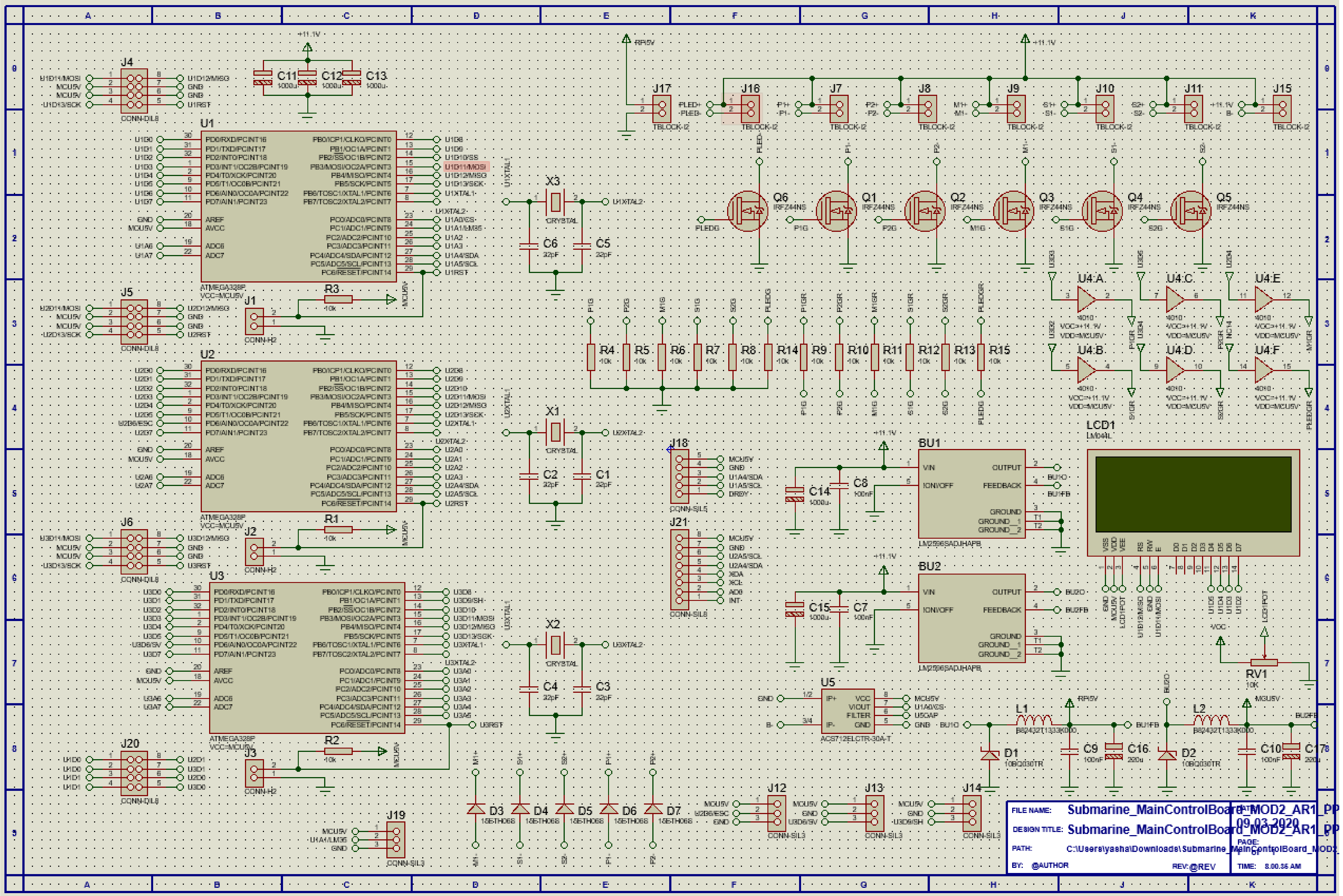


Input
- 3S2P LiPo
- +11.1V

Buck
- LM2596S
- FET Switcher

Output
- Freewheeling Diode
- Inductor
- Capacitor

Schematic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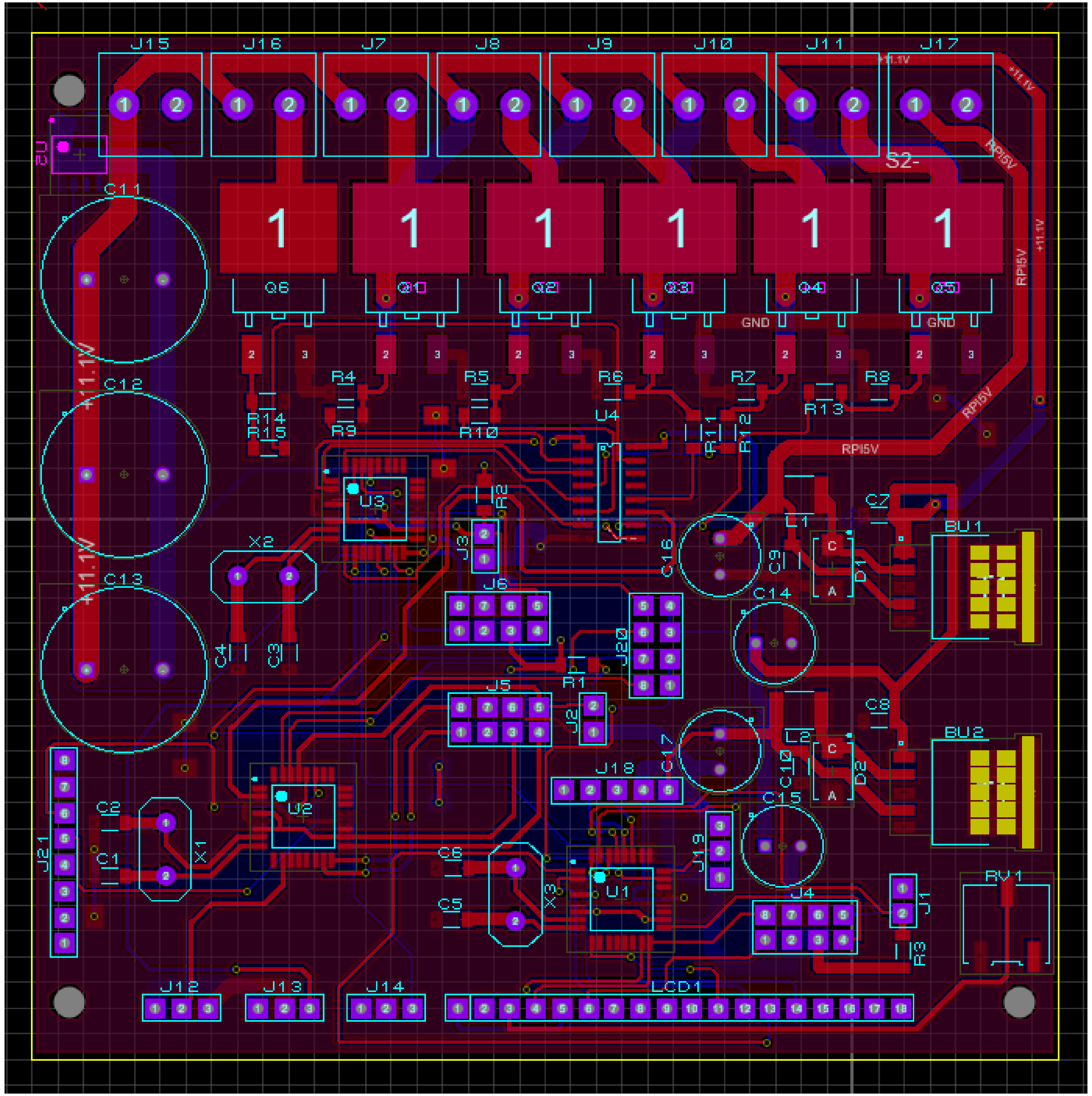
DESIGN TITLE: Submarine_MainControlBoard_MOD2_AR1_PP
BY: @AUTHOR
REV: @REV

PCB layout:


J15
J16
J7
J8
J9
J10
J11
J17
U3
C11
C12
C13
+11.1V
S2-
Q6
Q1
Q2
Q3
Q4
Q5
GND
R4
R5
R6
R7
R8
R13
R14
R15
R9
R10
U4
R11
R12
RPI5V
C7
L1
BU1
X2
U3
R2
J3
C16
C9
D1
C14
J6
J20
C4
C3
R1
J5
J2
C8
L2
BU2
C17
C10
D2
J18
C15
J21
C2
C1
X1
U2
C6
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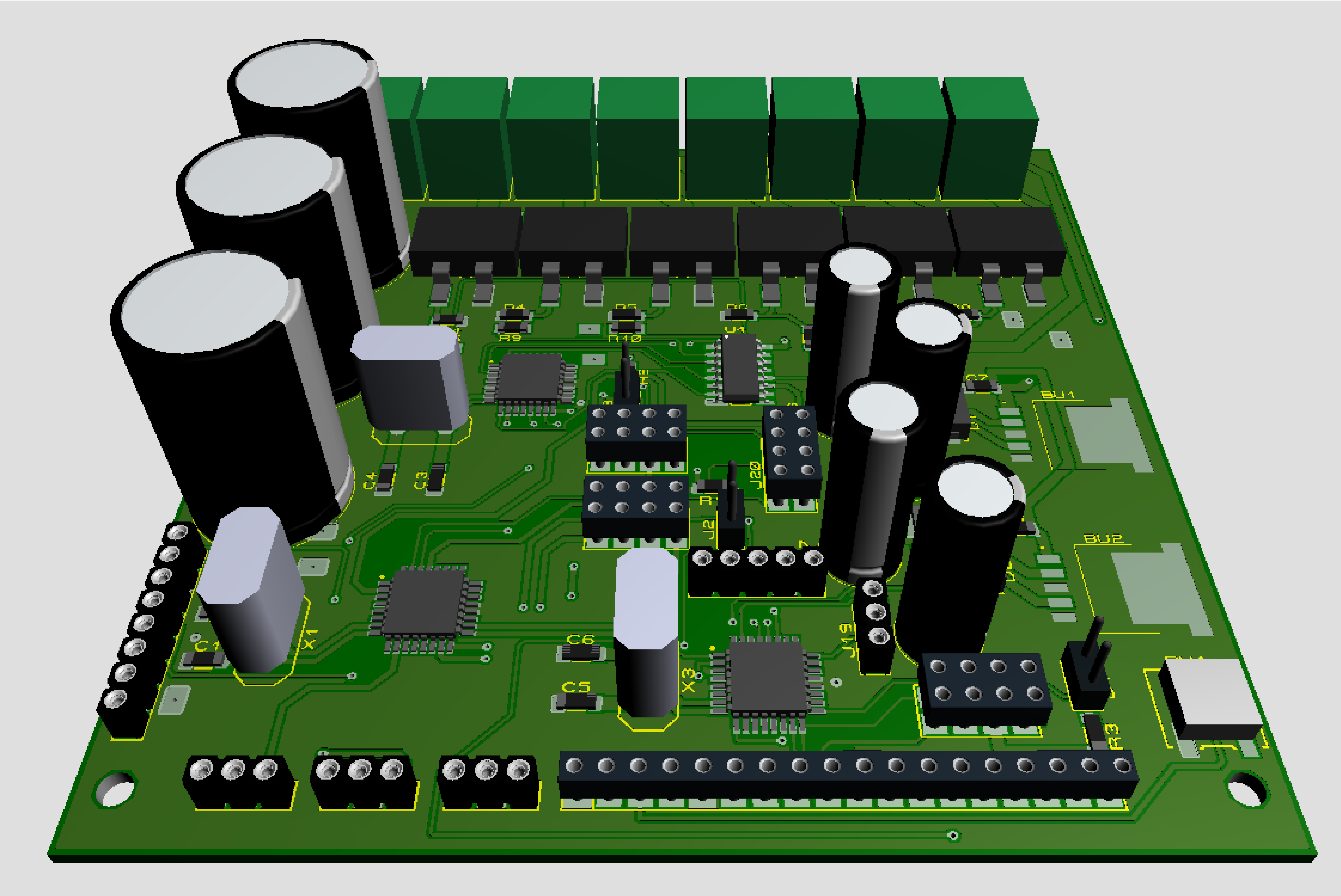
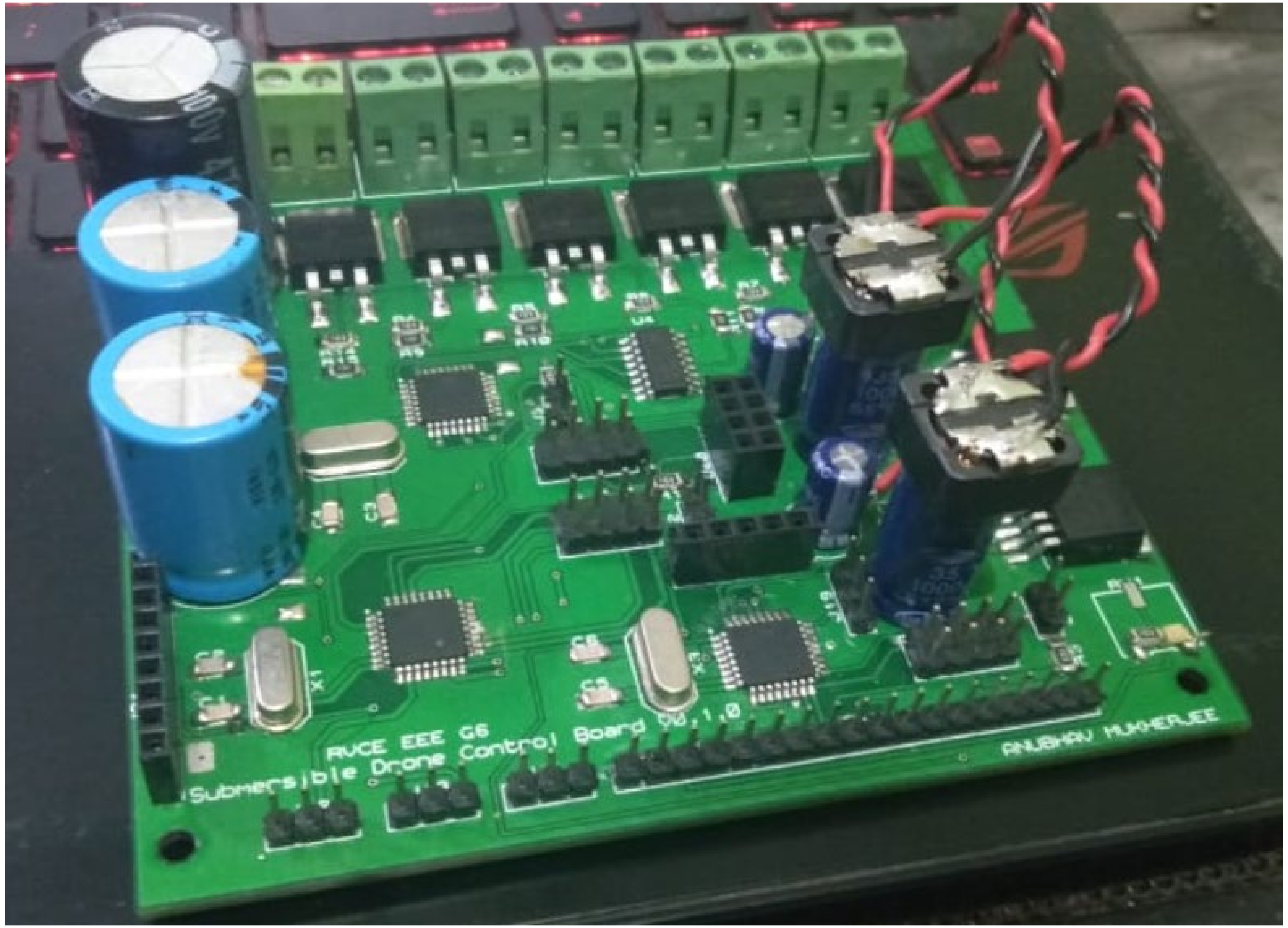
U1
J19
J4
J1
R3
RV1
J12
J13
J14
LCD1

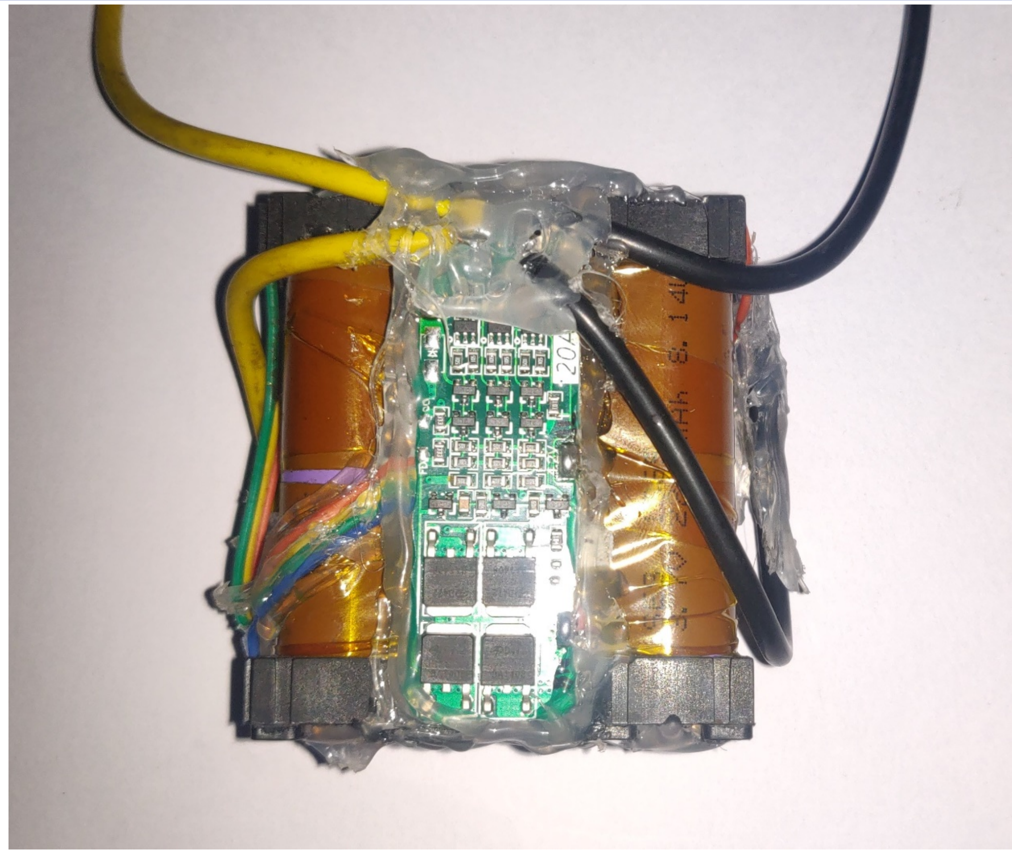
3D View:



PCB after soldering all components:



Energy Storage Design:



3S 2P 11.1v 4600mAh Battery pack with BMS

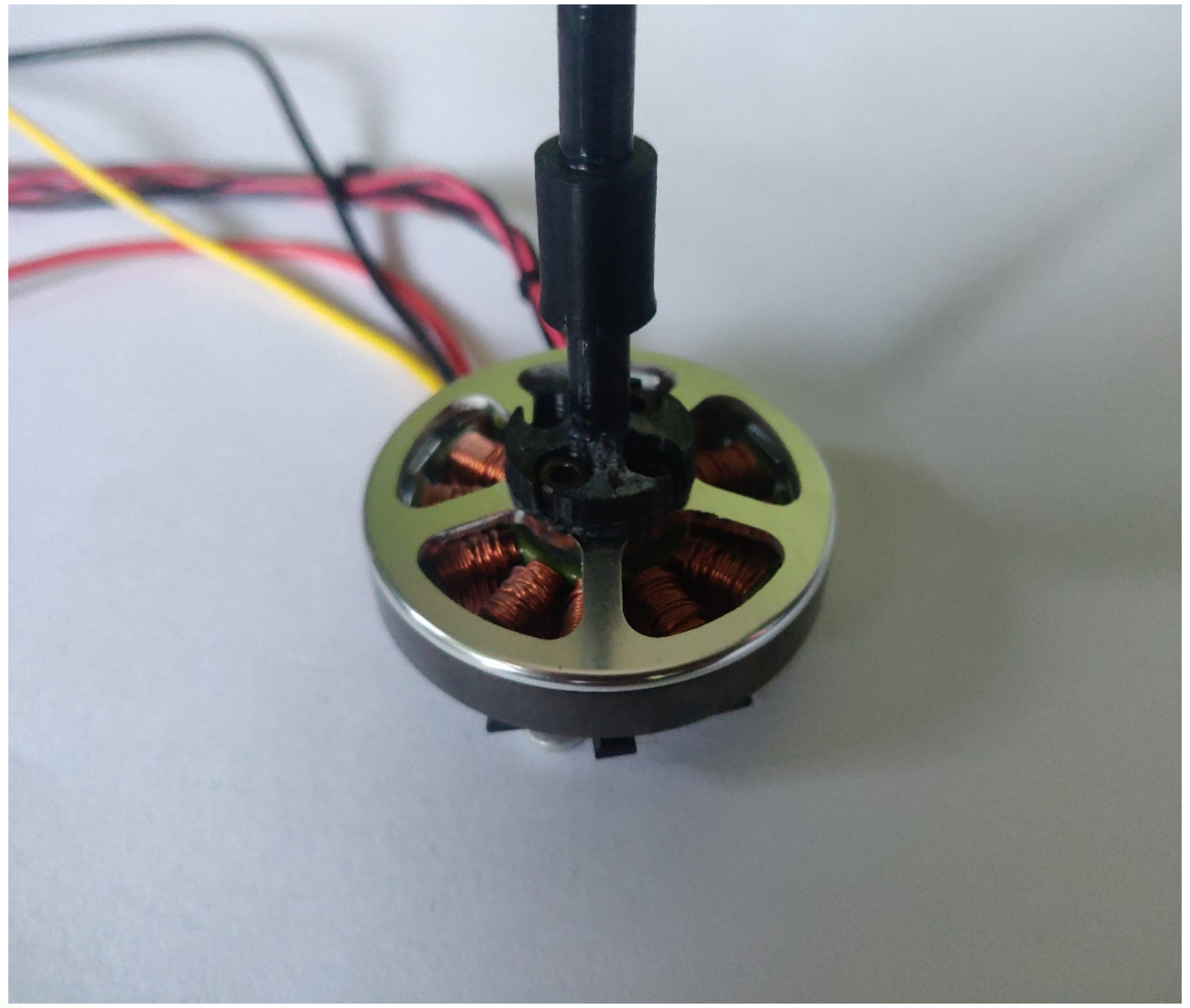
- Battery Type: Lithium Polymer
- Nominal Voltage: 11.1V
- Current Required: ~70A
- Battery Capacity: 8509 mAh ~ 8.5 Ah
- Discharge Coefficient(C-Rating): $\frac{Max.Current\ (I_{\max})}{Capacity}$ = 8.23C ~ 10C
- Cont. Power = $\frac{2\pi NT}{60} = 377.8\ \mathrm{W}$
- Operation time: 15 minutes
- $E_{cont.} = P_{cont} \times T_{op} = 94.45\ \mathrm{Wh}$

Propulsion Design:

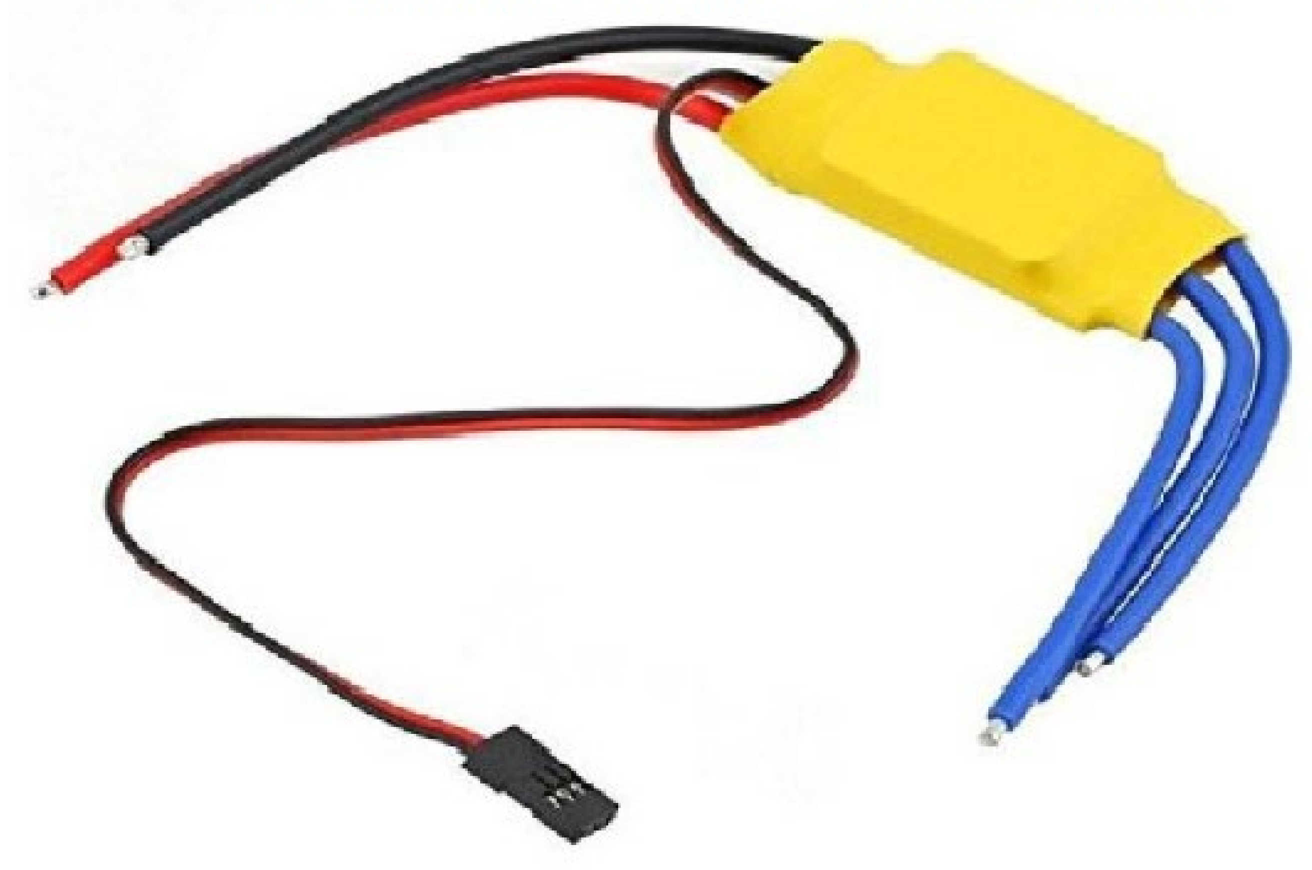
- Motor Type: BLDC
- Winding Voltage: 11.1V
- RPM Required: 3000 – 10,000 RPM
- Voltage Coefficient: K_v=650

- Max. Power = $\frac{2\pi NT}{60} = 755.55$ W
- $P_{cont.}$= **377.8 W**
- I_{max}= $\frac{P_{max}}{V_{batt.}} = 68.08\ A$
- $I_{cont.}$=$\frac{P_{cont.}}{V_{batt.}} = \mathbf{34.04\ A}$

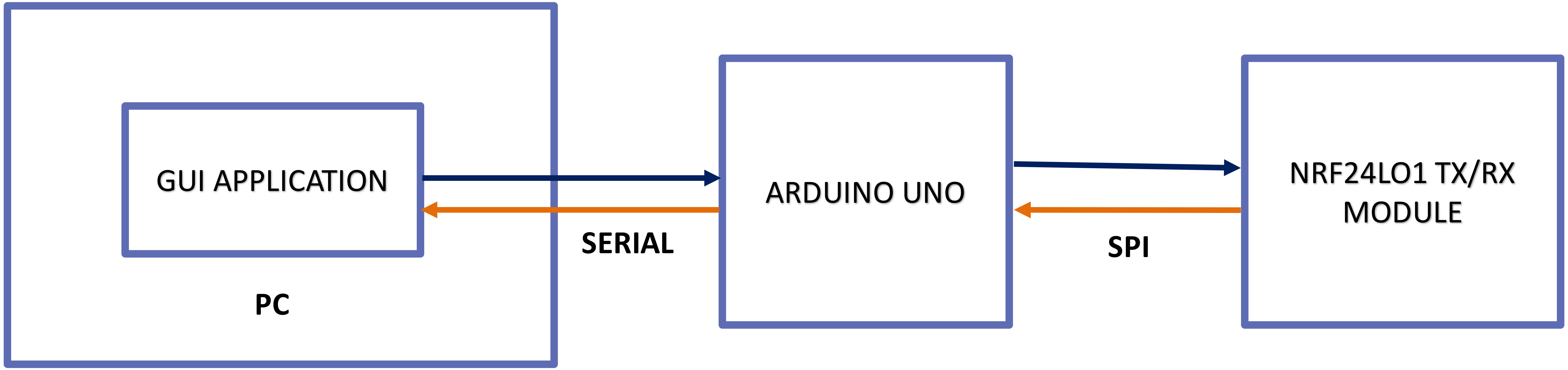
350KV BLDC motor



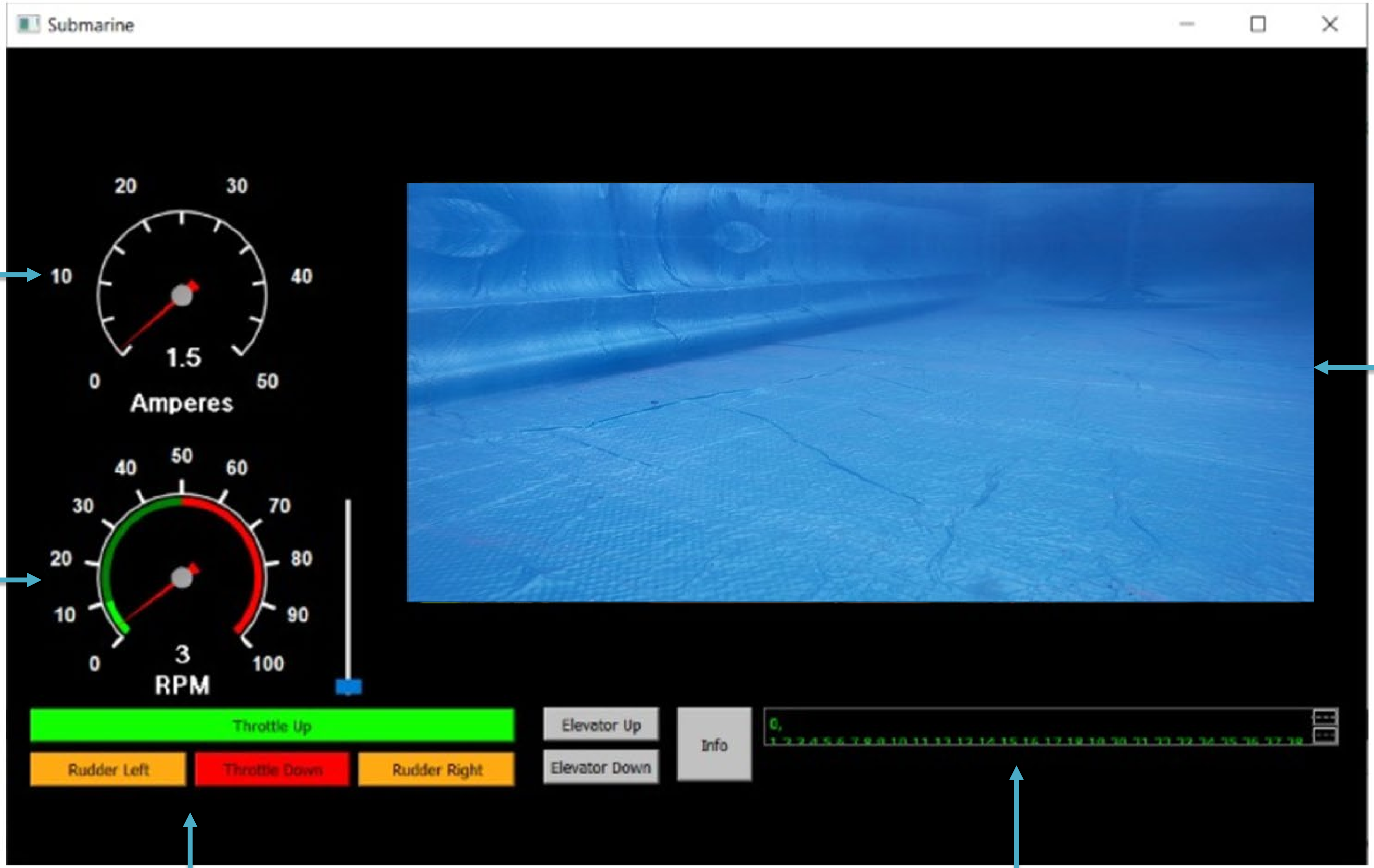
ELECTRONIC SPEED CONTROLLER



Remote controller



Remote controller GUI Application



Ampere gauge

RPM gauge

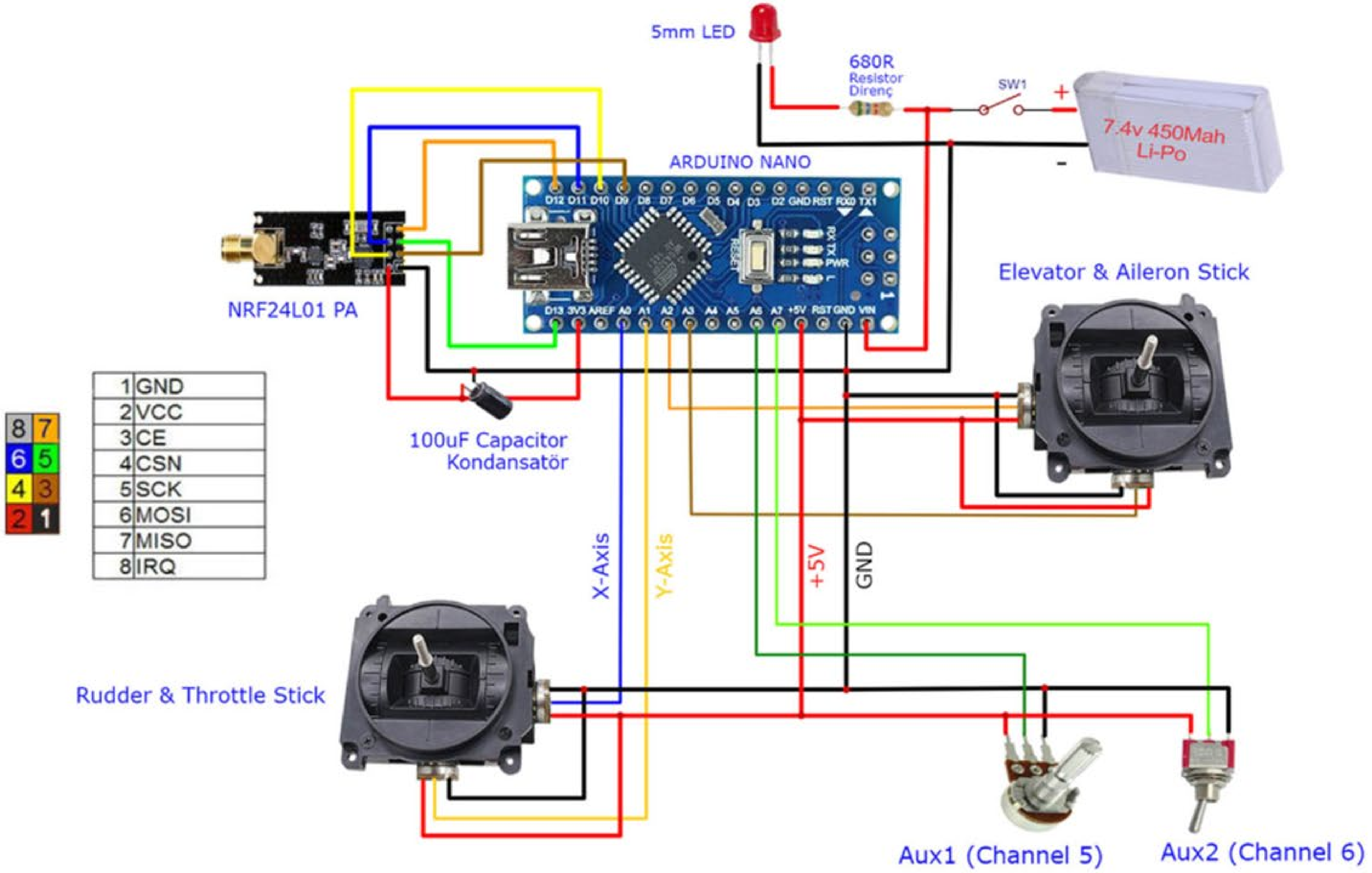
video feed from submarine

control buttons

Serial monitor

Wireless RX TX

Transmitter circuit:



Components:

- Arduino nano
- Joysticks
- LED's
- Resistors
- Potentiometer
- Toggle switch

Wireless RX TX

Receiver circuit:

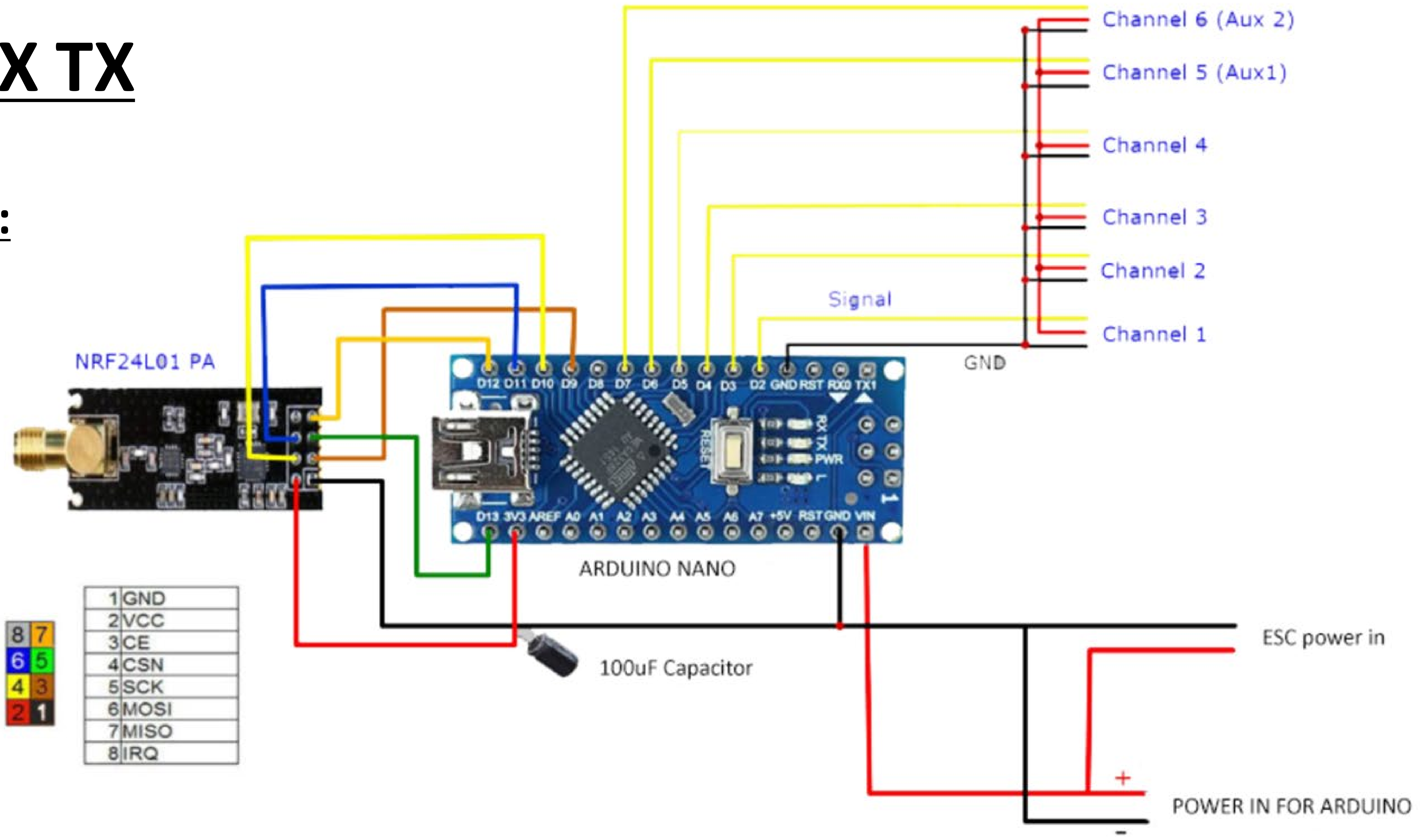


Image Classification

Image Classification is done using deep learning technique which follows training and testing phase.

1.Training phase

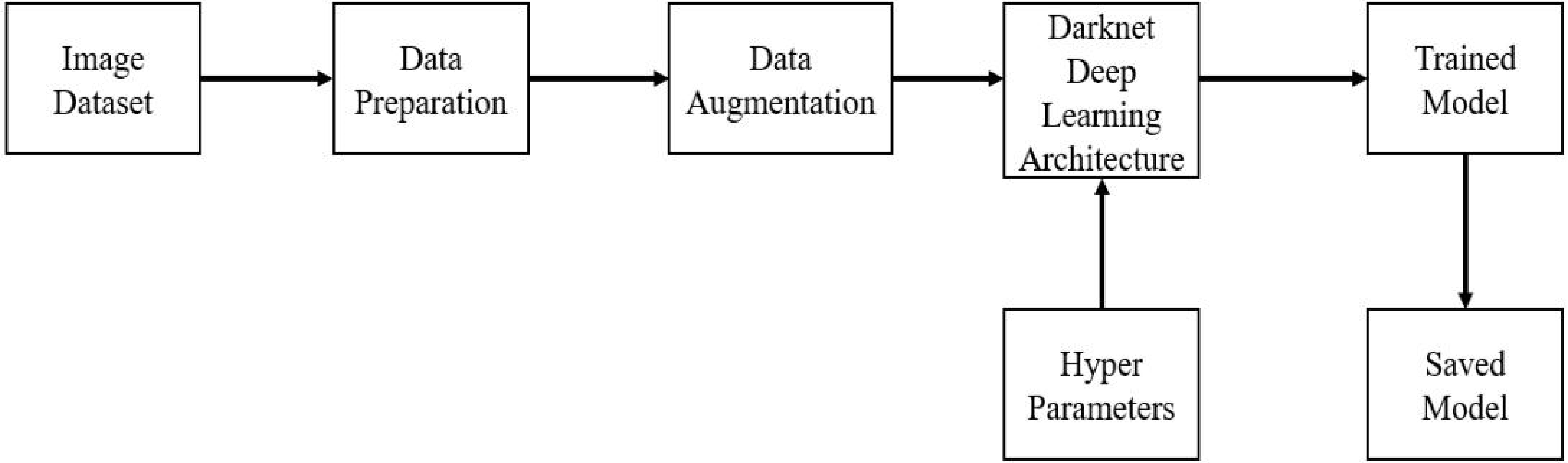


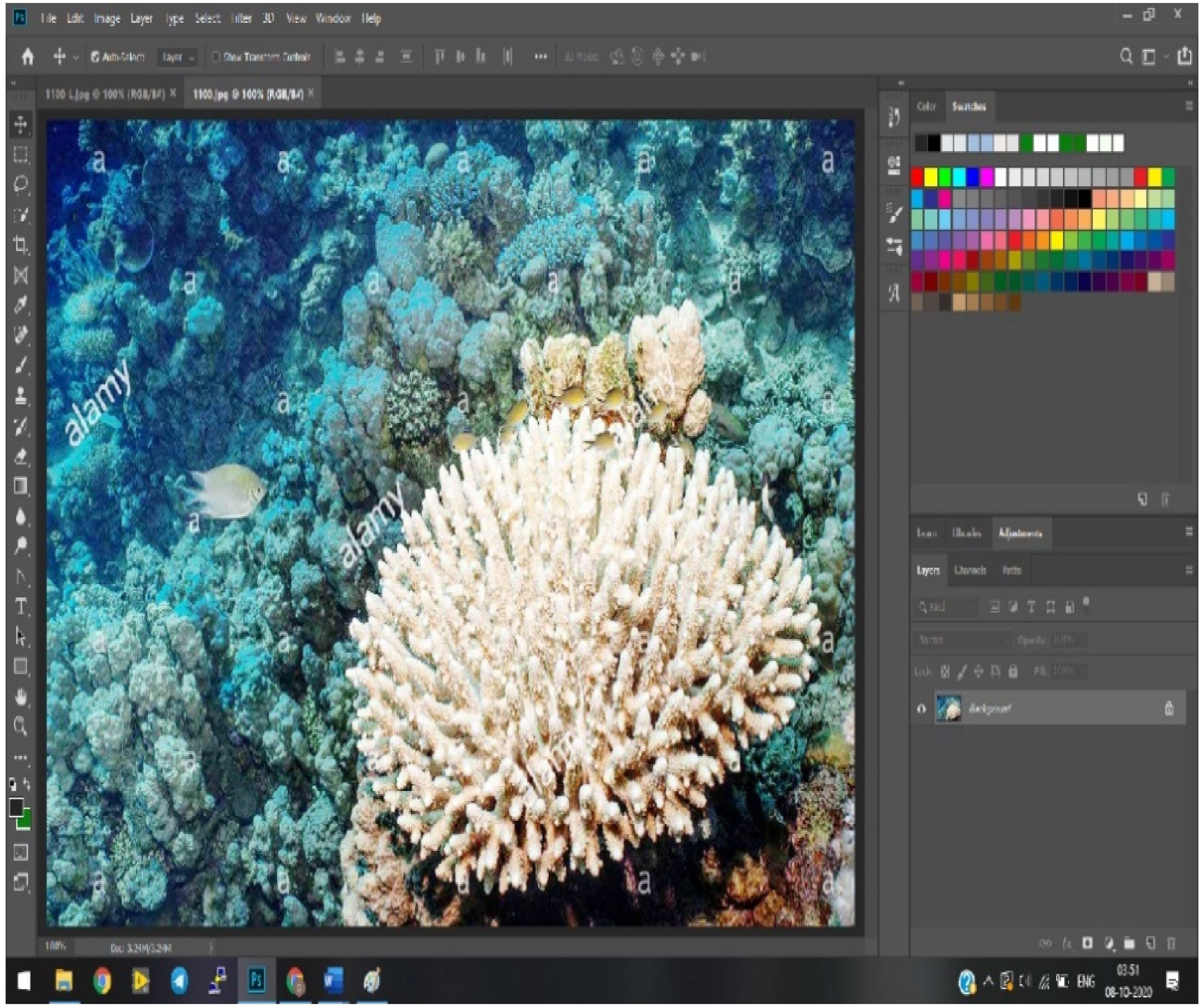
Image Dataset

- The first step is to obtain the dataset of different types of corals. The dataset two types of corals brain coral and the acropora coral are obtained from the google images of 150 nos each.

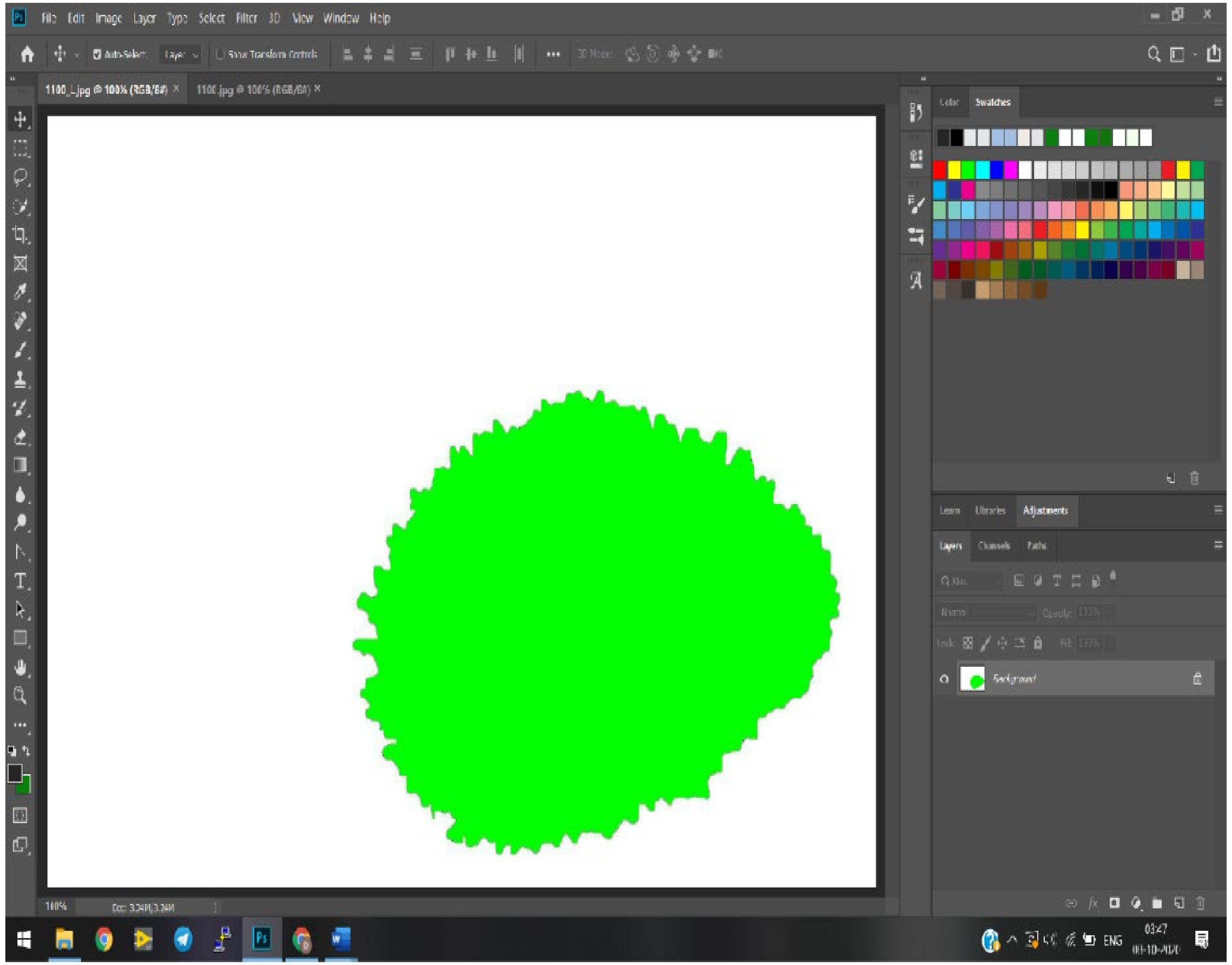
Data Preparation

- In data preparation process images in datasets is filtered out manually and is annotated.
- Annotation is the process of manually defining regions in an image and it is done using the Adobe Photoshop software.

Annotation

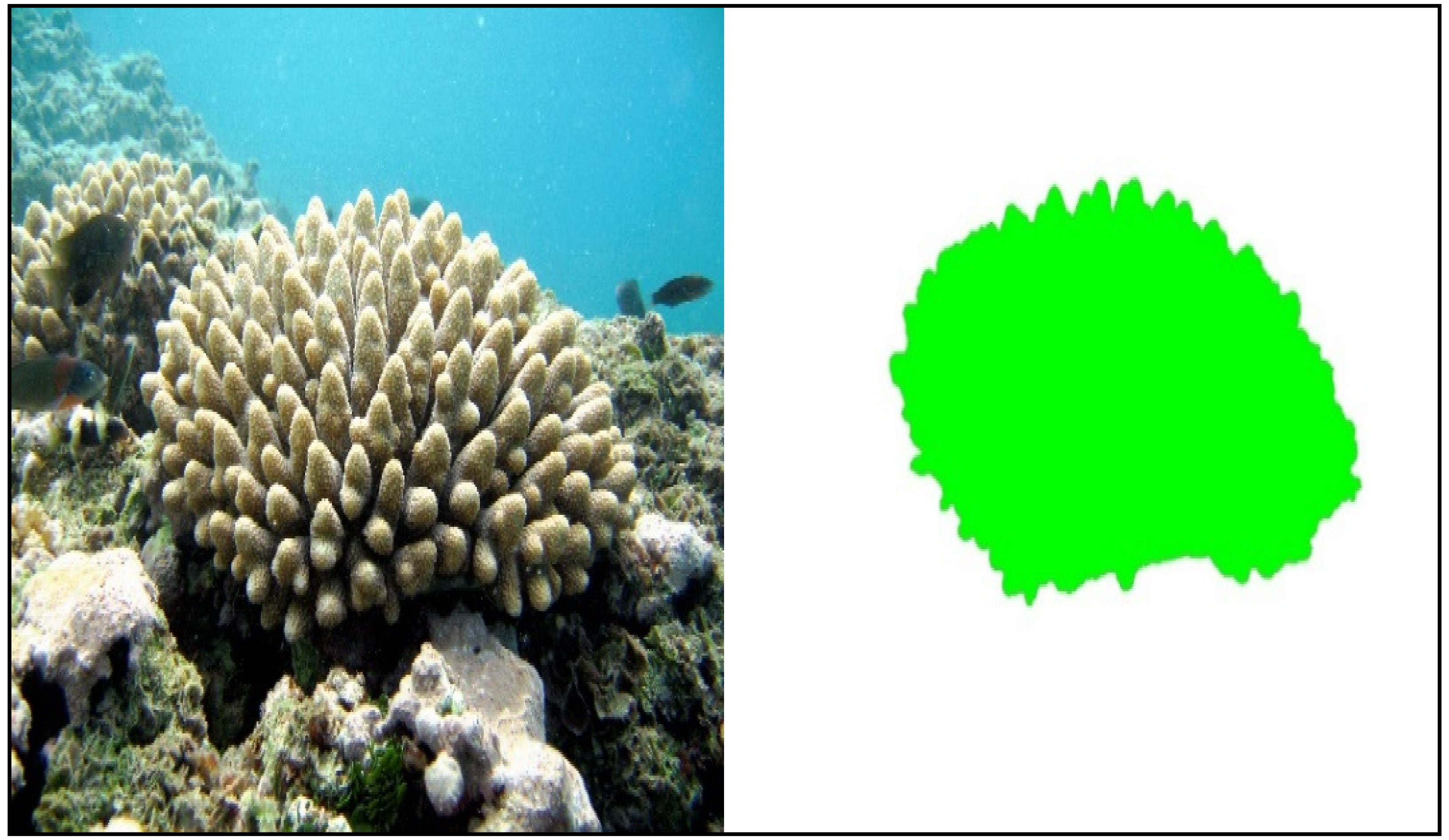


Coral before Annotation



Coral after Annotation

Annotation of acropora and brain coral data sets



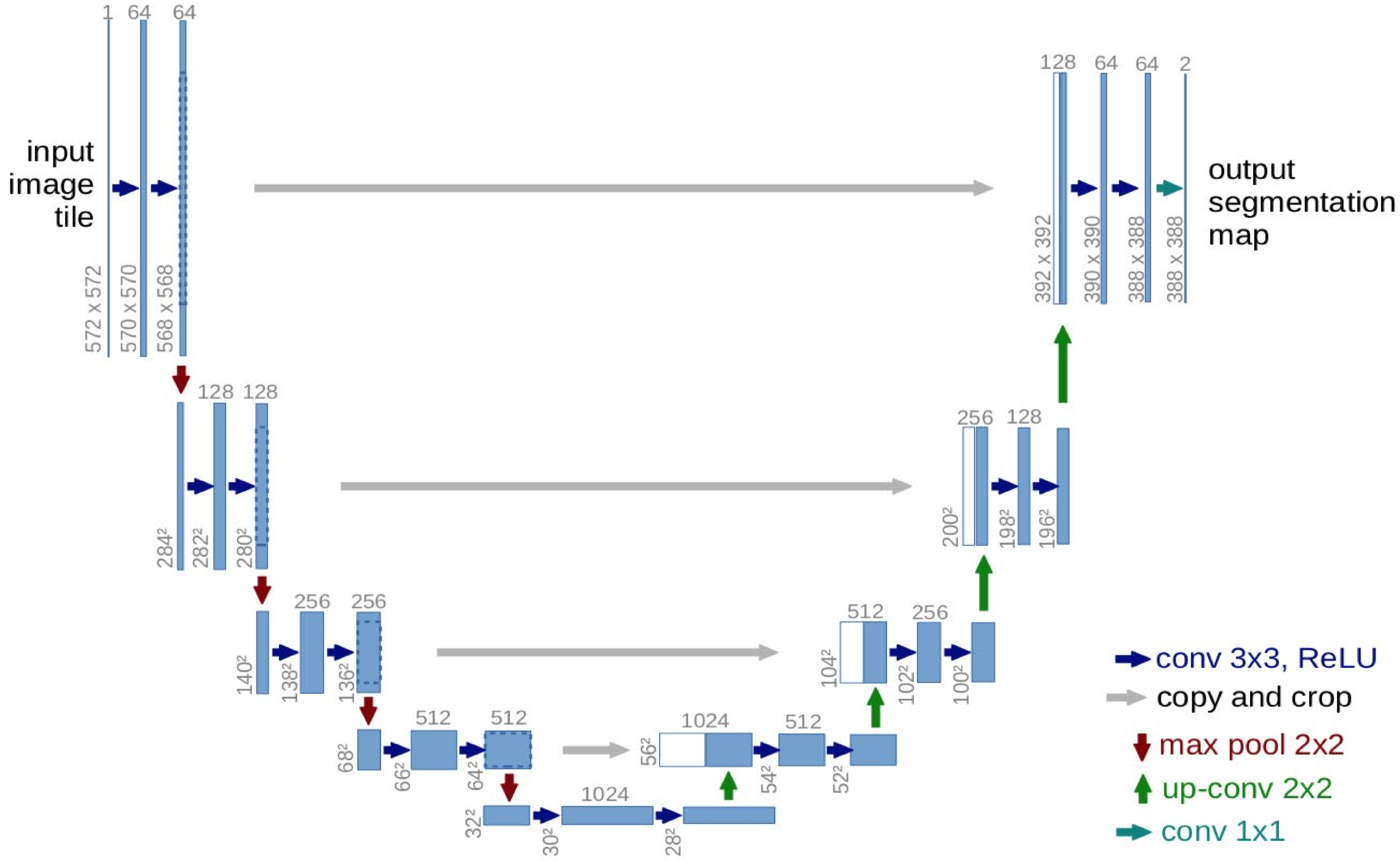
Original and annotated acropora coral

RGB(0,255,0)

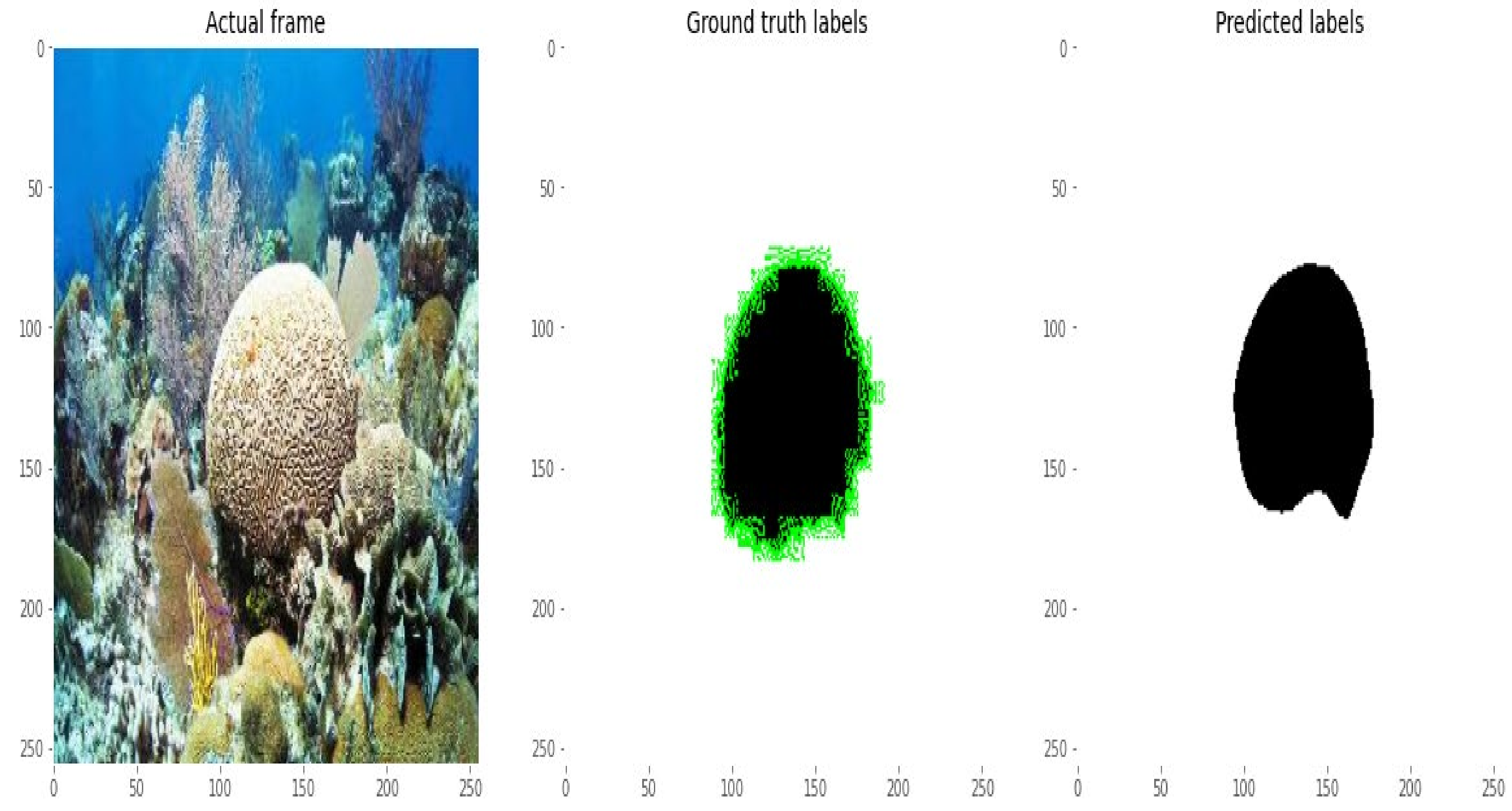
Original and annotated brain coral

RGB(0,0,0)

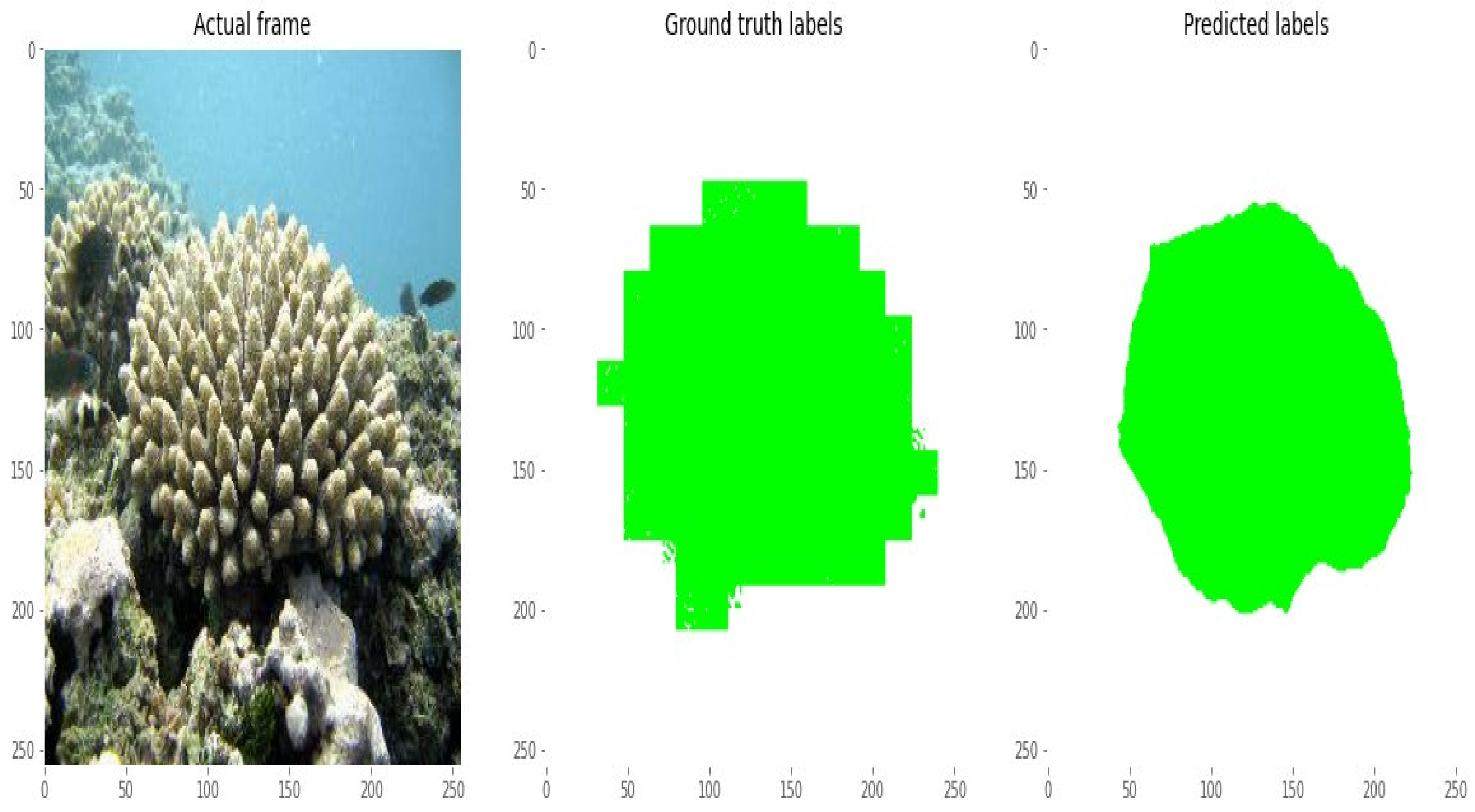
Detection using Keras Segmentation model



Detection Types

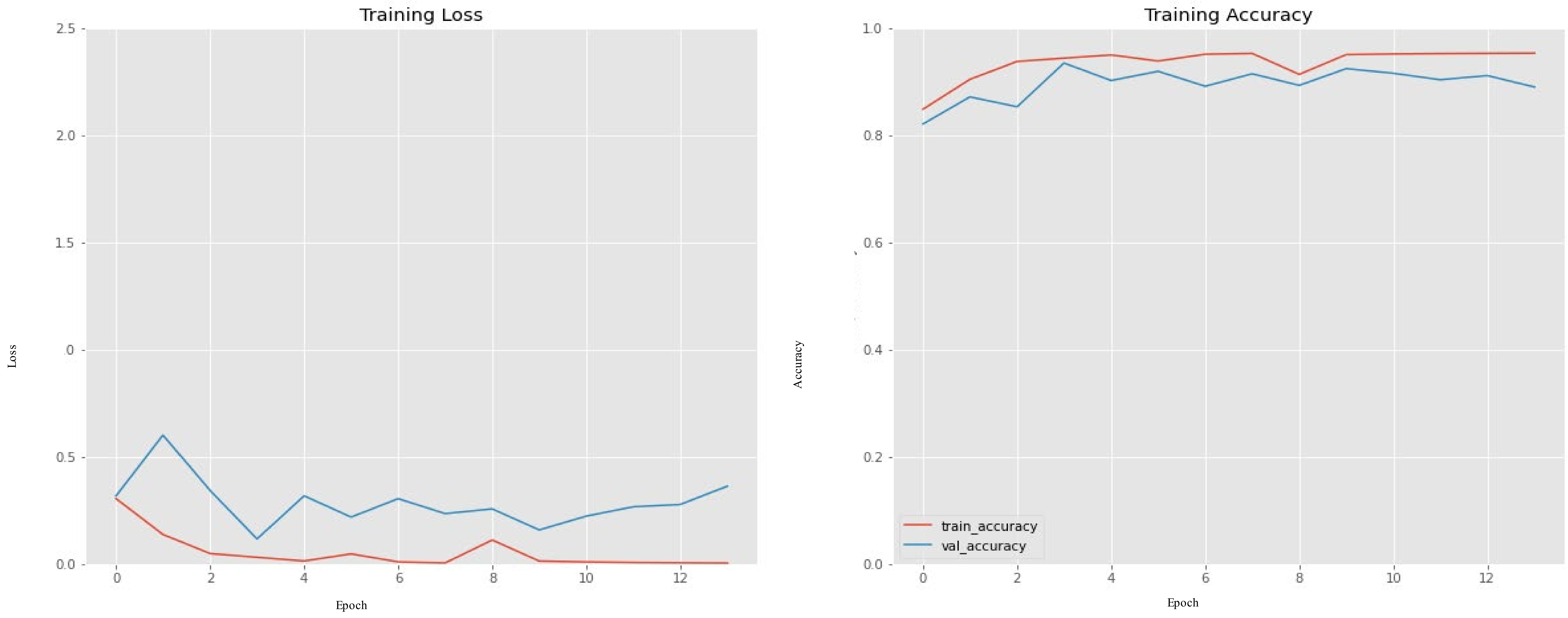


Brain coral prediction

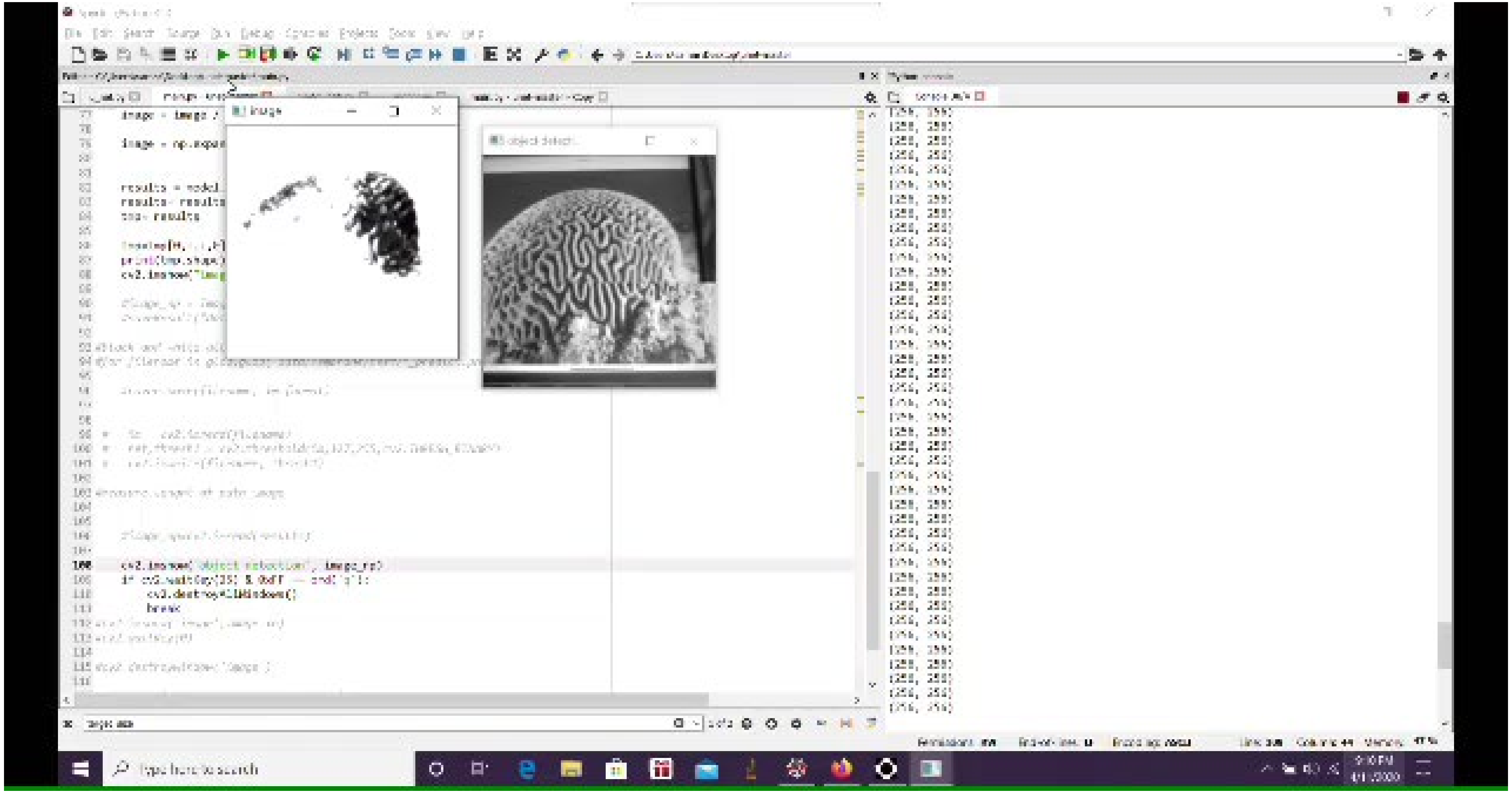


Acropora coral prediction

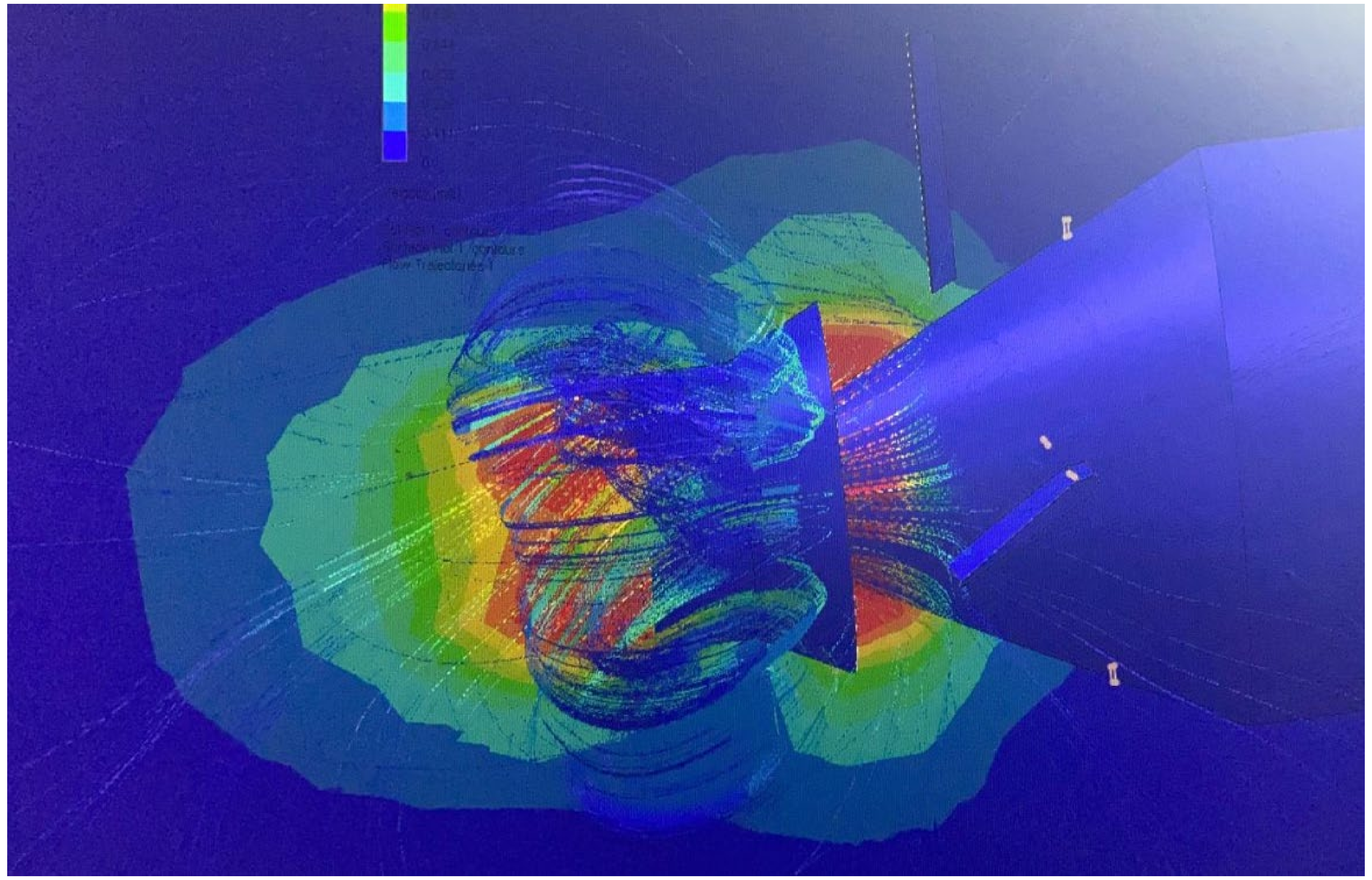
Model Accuracy and Graphs



Accuracy Measurements



Results:



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COST ESTIMATE:

PARTICULARS	COST
Li Poly Battery Pack	6000
BLDC Motor controller	600
Raspberry Pi 4 B (4GB)	4000
BLDC Motors	3000
Ballast Tank	1000
BALLAST PUMPS	500
SERVO MOTORS	500
DIGITAL CAMERA FOR PI	1500
433 Mhz Module + Antenna	500
5.8 Ghz Module + Antenna	1500
PROPELLERS	1000
SUBMARINE HULL	8000
PCB FABRICATION	2000
WATERPROOFING COMPONENTS	2000
MISC-10%	3210
TOTAL	35310