RoboBoat 2022

Design Presentation - Team VYUHA

June 23, 2022

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Meet our team

Thiruvarulselvan Karunanithi

Team Manager

Hull design | Propulsion system | Failsafe system | Control system | Media & Outreach | Computer vision

Saravanan Elangovan

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Krishnan Murugan

Puviyarasu Sakthivel

Nithishwar Dharanipathy

Tharakesvar Padmnaphan

Presentation Outline

Competition requirement

- ➔ Problem statement
- ➔ Team Strategy

Design and Results

- ➔ Hull design
- ➔ Control system
- ➔ Computer Vision
- ➔ Failsafe system

Planning

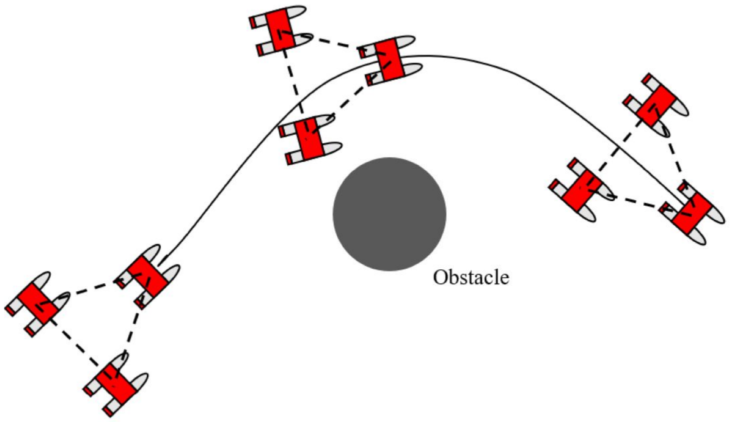
- ➔ Timeline
- ➔ Cost estimation
- ➔ Team roster

Problem Statement

Project Background

Develop an Autonomous Surface Vehicle (ASV) with multiple capabilities

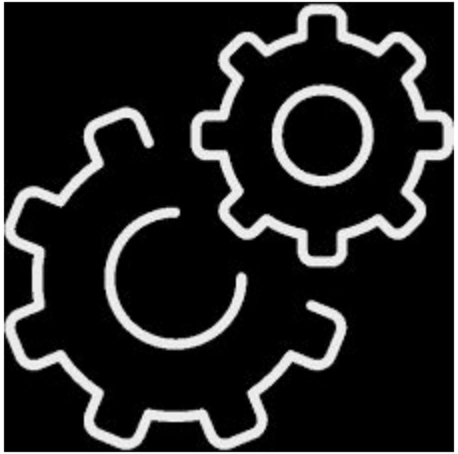
- ➔ Efficient Hull form
- ➔ Navigate towards a destination autonomously
- ➔ Obstacle avoidance capability
- ➔ Maintain spatial orientation while turning
- ➔ Immune from drifting due to water current
- ➔ Object detection and automated path planning

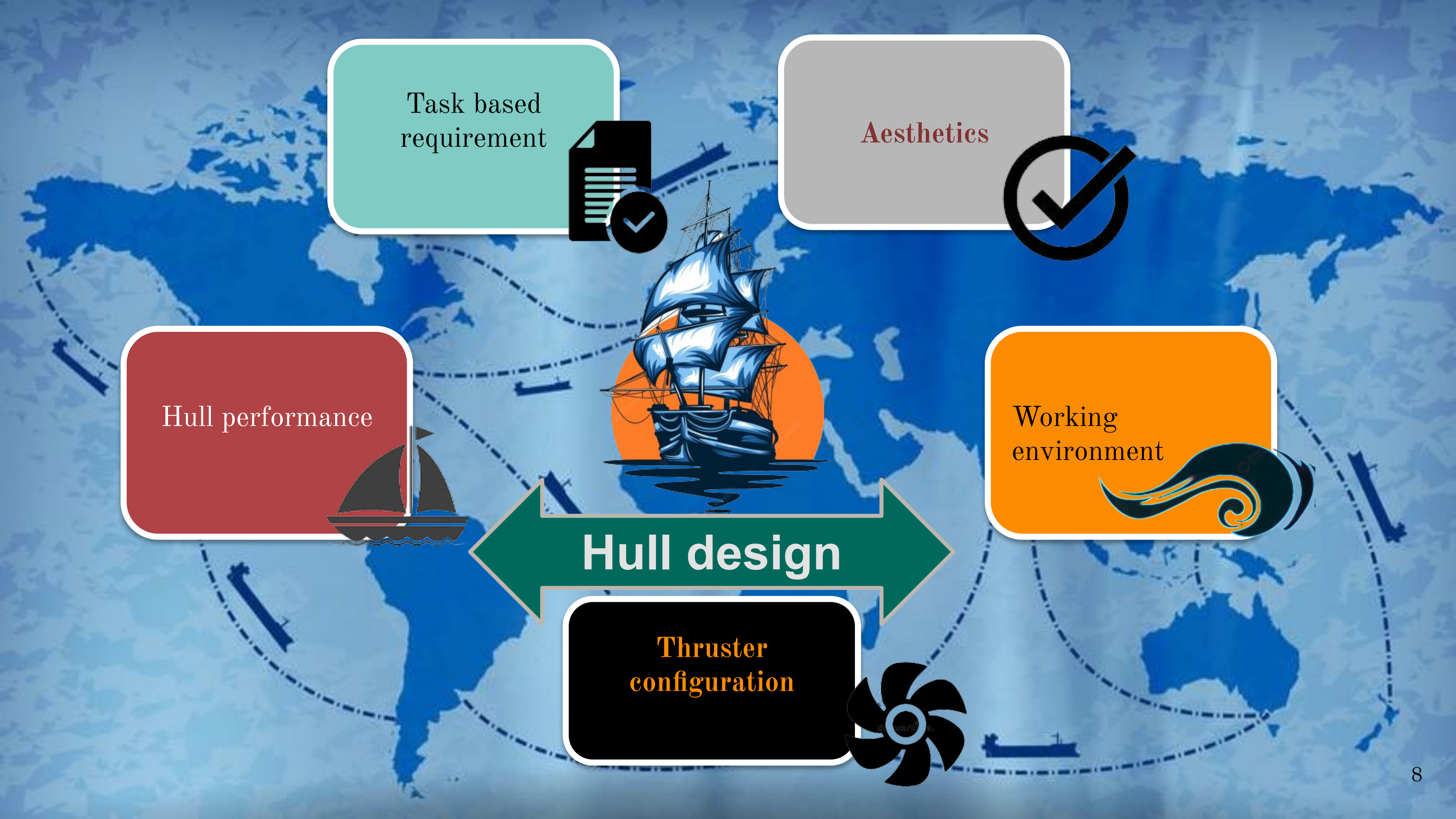


Team Strategy - First time participating in RoboBoat

1. To be competitive
2. Rapid prototyping
3. Make efficient hull form with better maneuverability
3. High priority to tasks that need similar vehicle behaviours

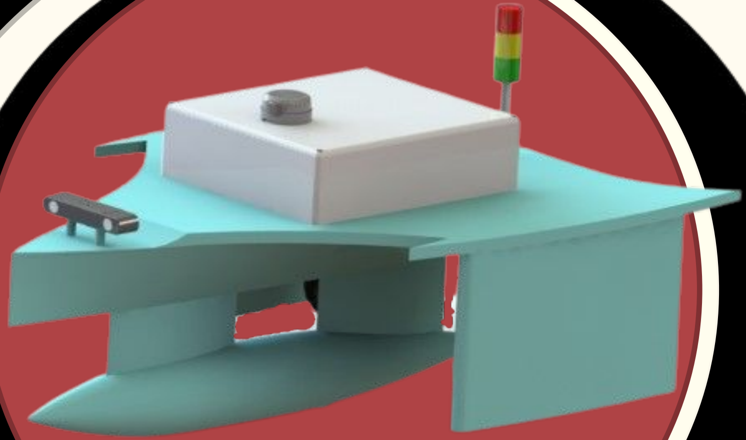
Hull Design




Task based requirement
Aesthetics
Hull performance
Working environment
Hull design
Thruster configuration

Provides smooth ride

Waterplane area: 0.63 times that of the monohull.



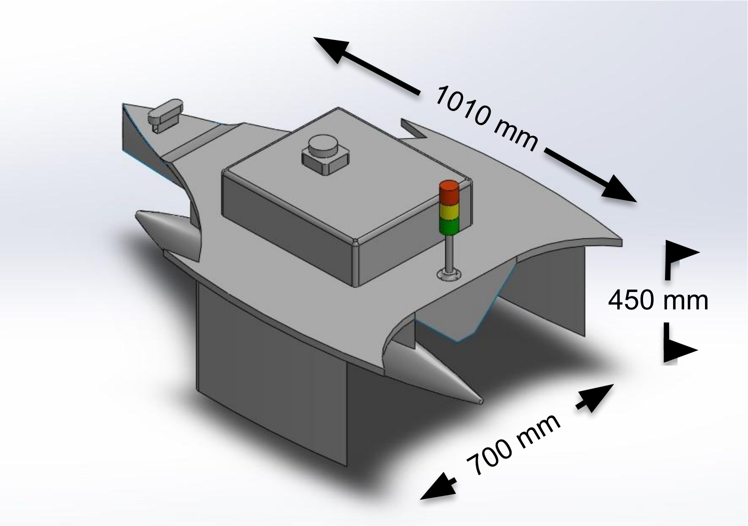
Better stability

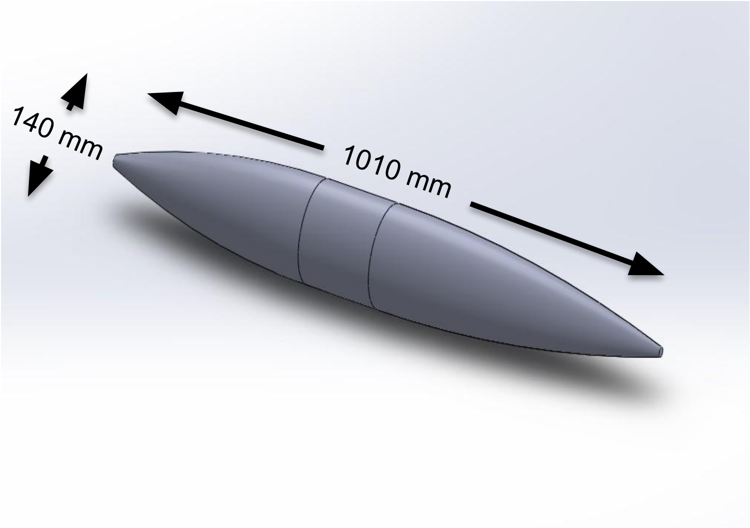
SWASH

Resistance to waves

Boat dimensions :

Dimension	Unit (mm)
Length	1010
Height	450
Width	700



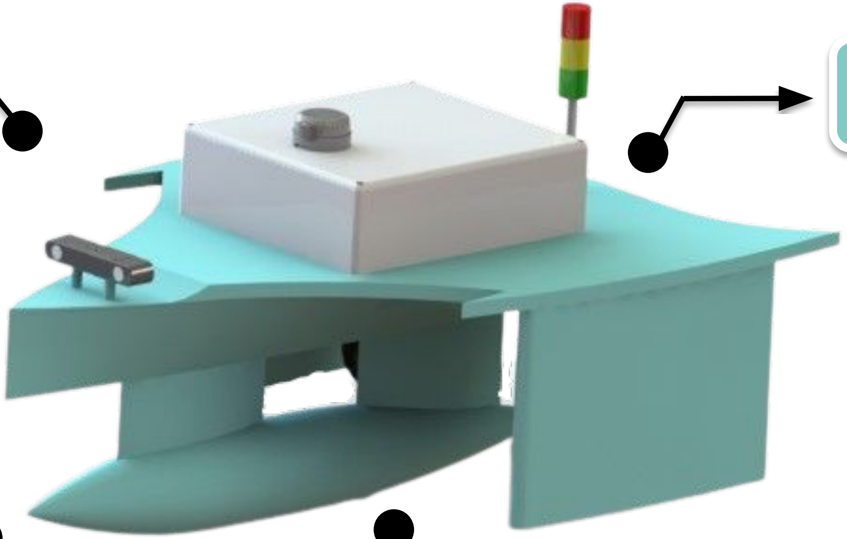


Submerged Hull dimensions:

Dimension	Unit (mm)
Length	1010
Max diameter	140
Min diameter	16.82

3D MODELLING

Total volume 0.0627 m^2

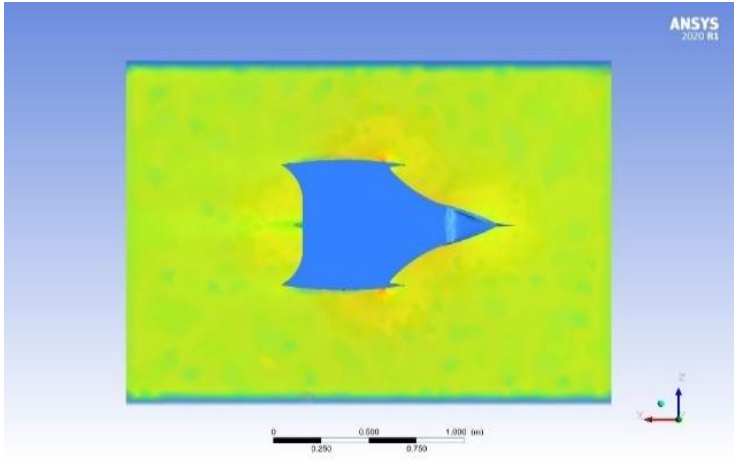


Total surface area 2.3 m^3

Aft length (La):
La = 3.6 D
Fore length (Lf):
Lf = 2.4 D

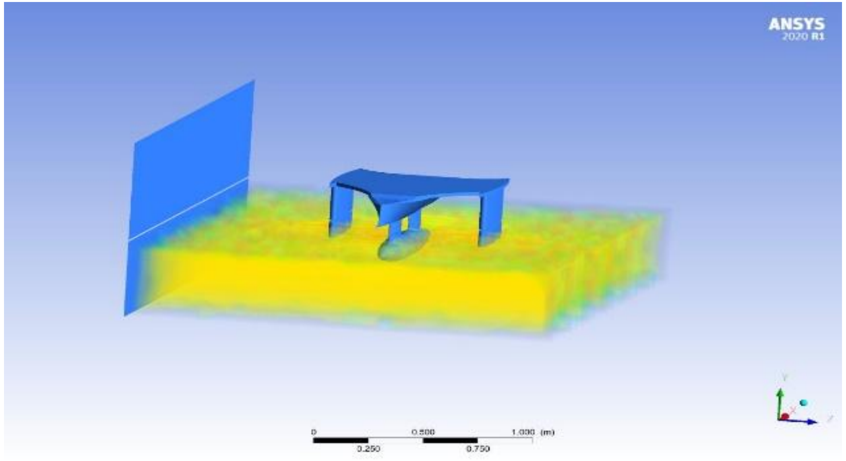
length : diameter
7:1

Hydrodynamic analysis



- ❖ Edges reduced the drag.
- ❖ Better maneuverability.
- ❖ Smooth motion.

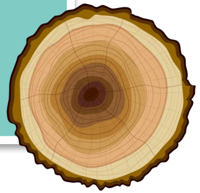
- ❖ Better results with motion of boat.
- ❖ Expected minimal drag.
- ❖ Expected speed.



Molding Process

GFRP (Glass fibre reinforced plastic)

Wooden pattern

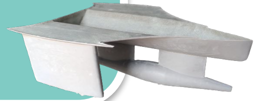


- High strength
- Durable
- Chemical resistive
- stiff

Mould

Easy to shape

Final Pattern



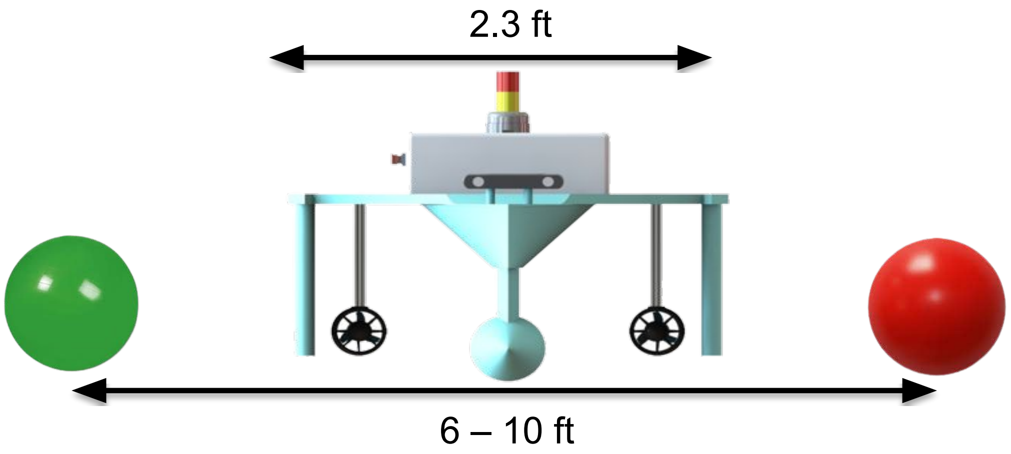
Parameters (as per rule book)

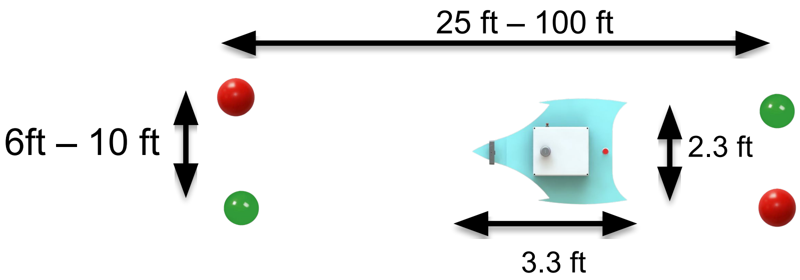
Buoyancy	Positive buoyant
Dimension (L X B X H)	6 X 3 X 3
Total weight	63 Kg(140lbs)
Payload	7 Kg (15lbs)

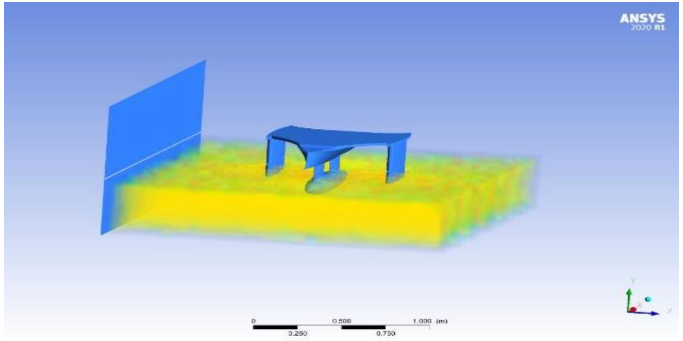
ASV design parameters

Buoyancy	Positive buoyant
Dimension (L X B X H)	3.31 X 2.29 X 1.47
Total weight	11.6 Kg (25.5lbs)
Payload	8 Kg (17.6lbs)

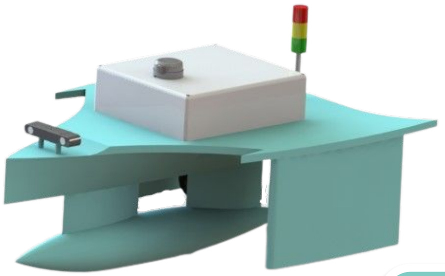
Task based design specifications

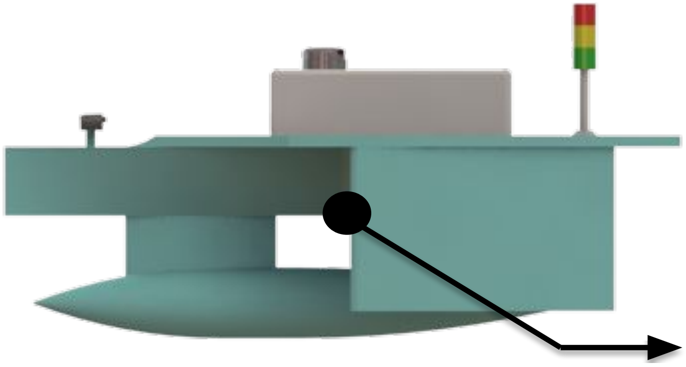






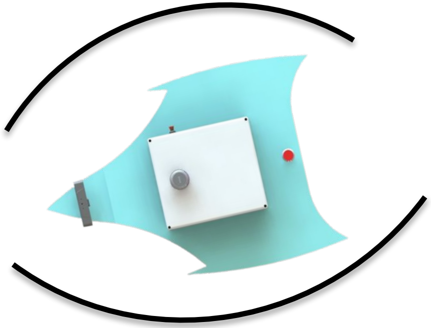
Task based design specifications





Maximum speed is 5 Km/hr

Centre of gravity remains in the lower Portion of the main hull.



Turing radius : 2.12 m

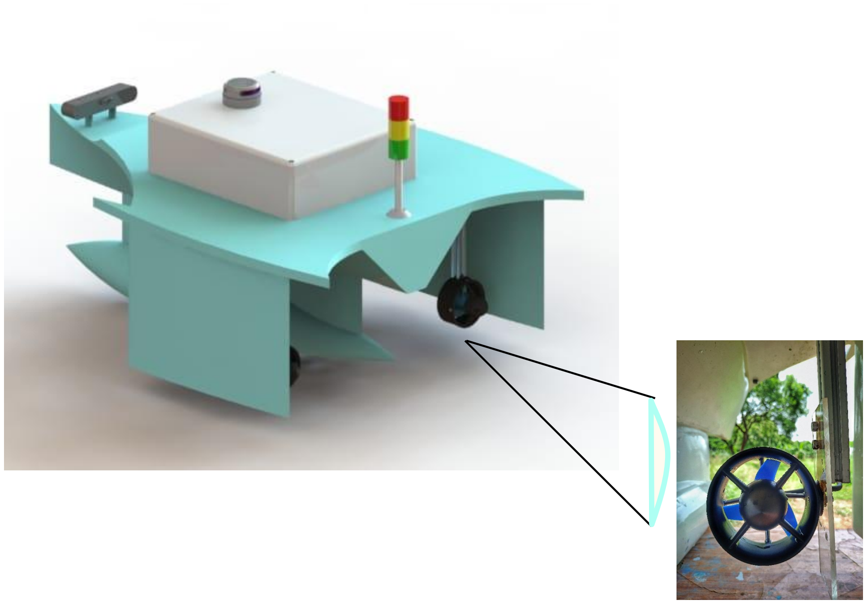
PROPULSION SYSTEM

SRISANTHOSH SEKAR

MANIKANDAN GANESAN

KEERTHIVASAN CHANDRADASS

Propulsion System



Propulsion system- flow diagram

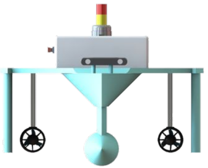
Propulsion system plays a major role in stability and manoeuvrability

Constrains

- Center of gravity
- Buoyancy

Idea

- Electric propulsion
- Outboard drive
- Differential control



ASV Power Requirements

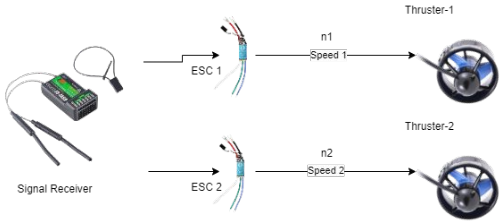
Calculated Power - 195.65W

T200

- Continuous power - 390 Watts
- Operating voltage- 7 to 20 V
- Current – 24 A
- Thrust Force – 52.5N – 67N

ESC

- Current – 0 – 30A
- Operating Voltage – 7-26V
- Transient Response – 400Hz

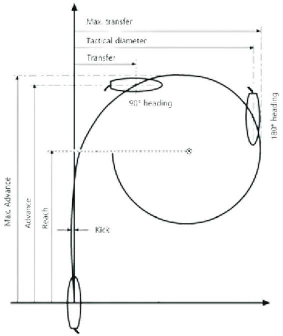


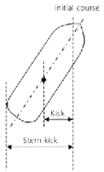
Differential control

- Skid steering
- 2 thrusters – single signal
- 2 channels- linear and turning

Propulsion Highlights

Speed





Direction

Stability - Linear motion

Maximum Speed - 1.38 m/s

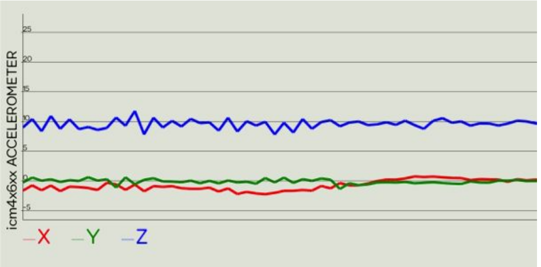
Controlled Behaviour

Stability - Turning

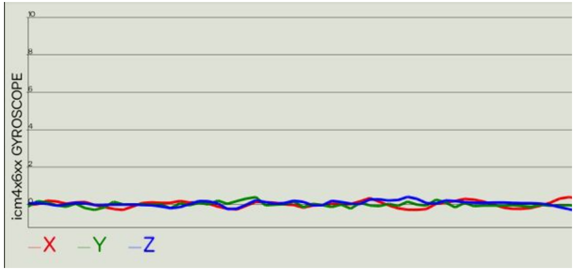
Turning Radius - 2.12 m

Controlled Velocity Compensation

IMU DATA - From Pixhawk controller



Accelerometer

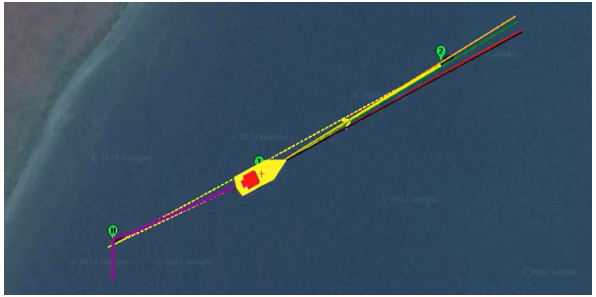


Gyroscope

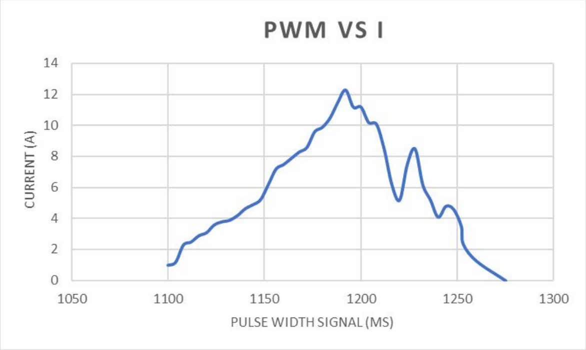
Magnetometer

Orientation

RESULTS

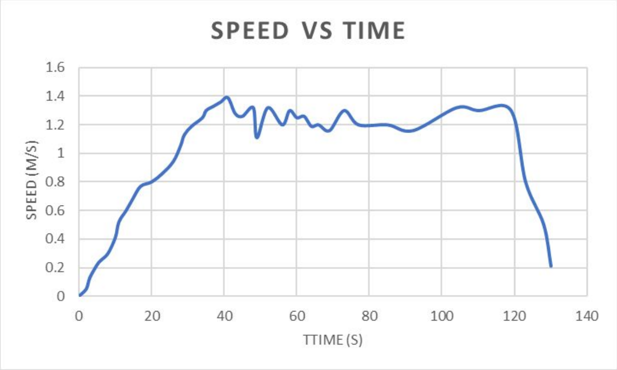


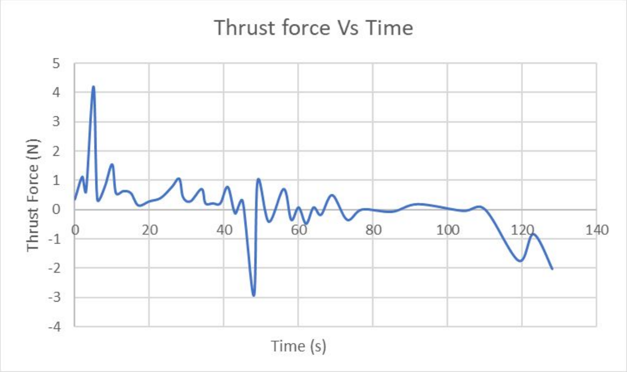
LINEAR BEHAVIOUR OF ESC



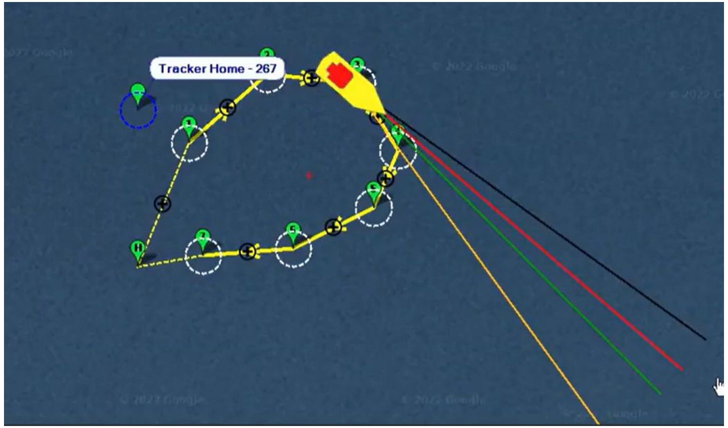
ESC Output Behaviour

Velocity behaviour



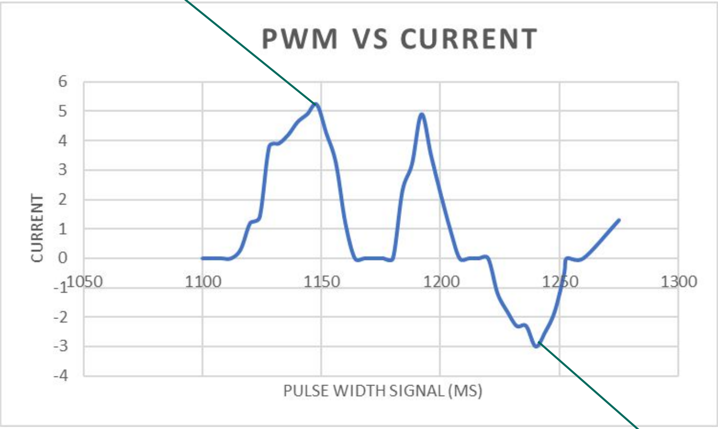


Thrust behaviour



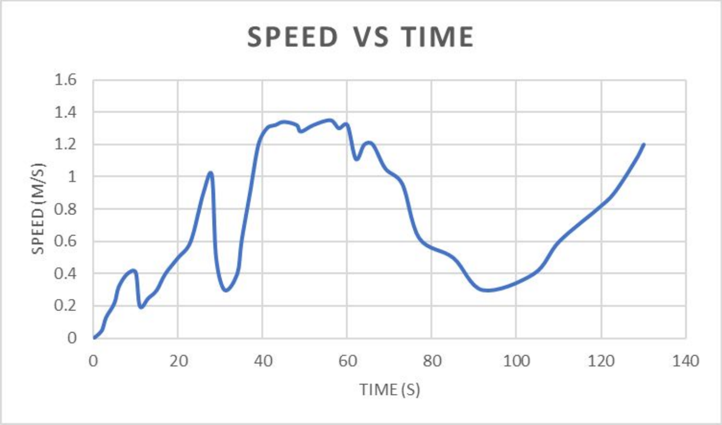
TURNING BEHAVIOUR OF ESC

Right Turn



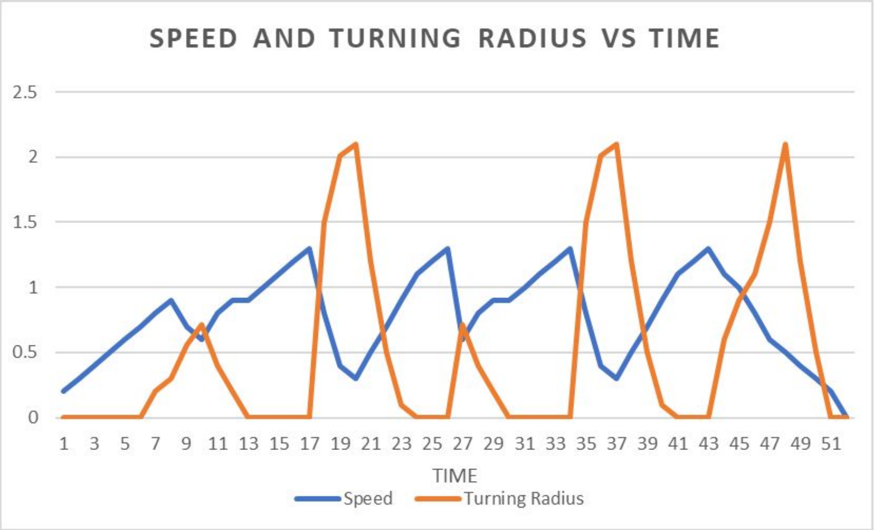
ESC Output Behaviour

Left Turn



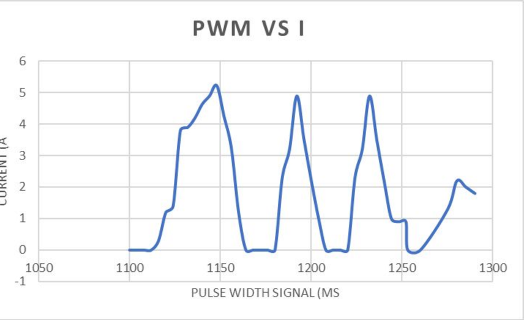
Velocity behaviour

AUTONOMOUS BEHAVIOUR FOR ONE DRIVE CYCLE

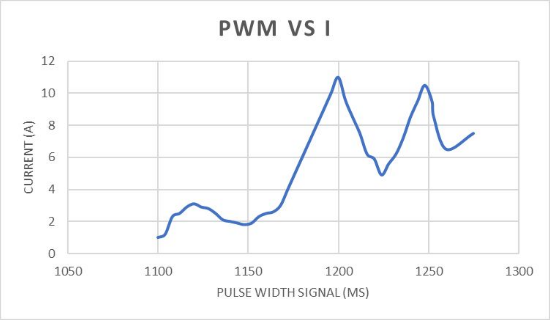


Turning radius and speed characteristics

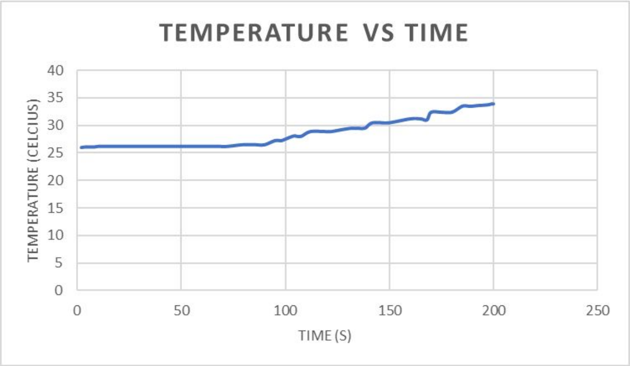
Overall results



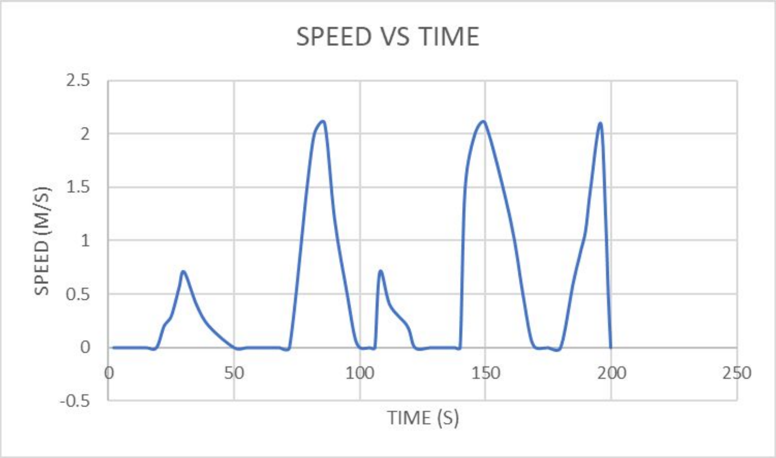
TURNING SPEED



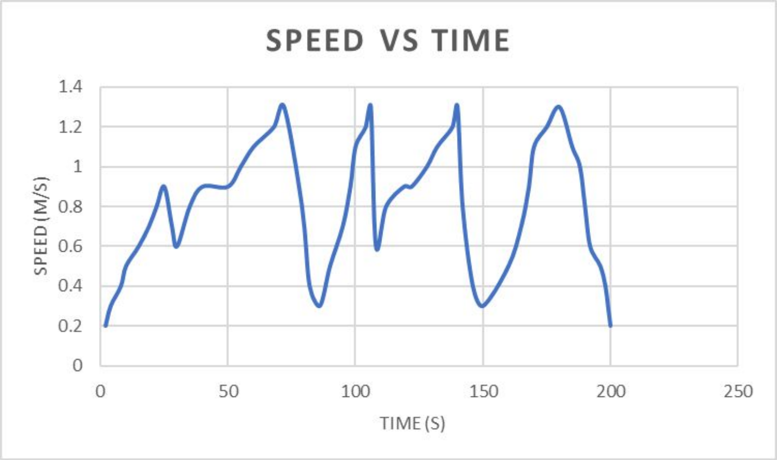
LINEAR SPEED



TEMPERATURE BEHAVIOUR



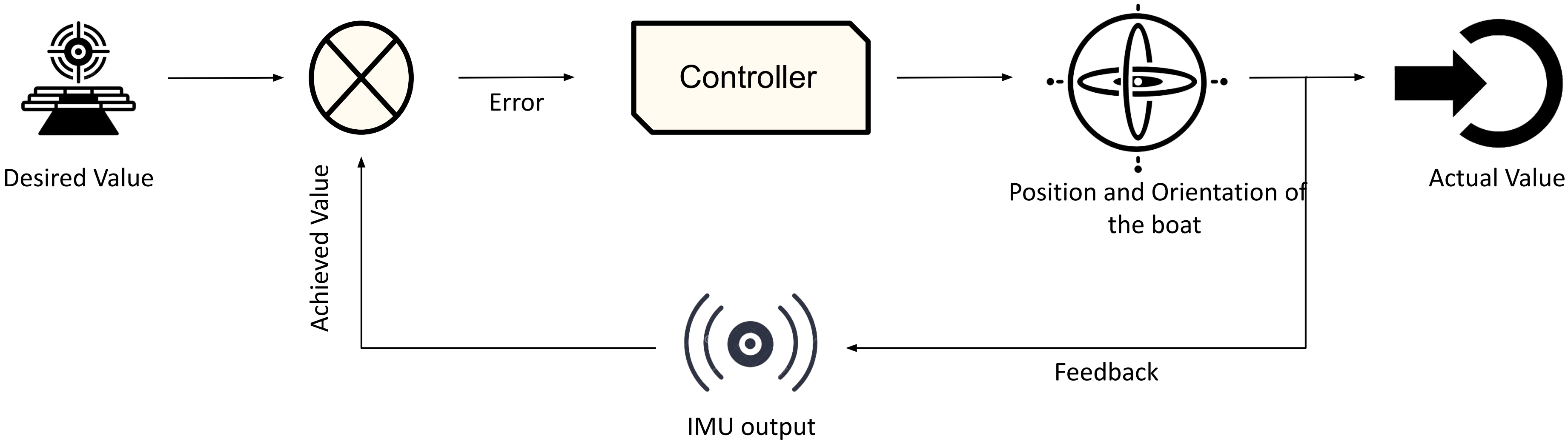
TURNING SPEED



LINEAR SPEED

CONTROL SYSTEM

Control System Model



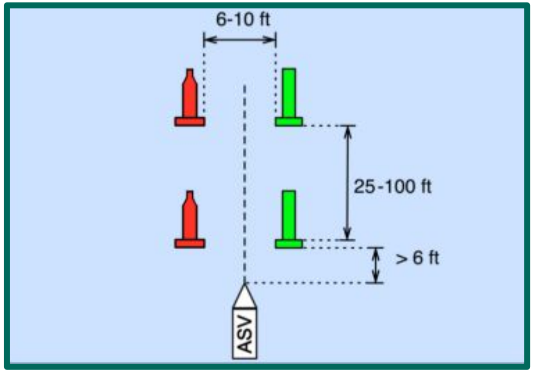
Pixhawk 2.4.8 Controller

The pixhawk control system is

- Reliable
- Robust
- Inbuilt IMU
- Supports multiple sensors
- Computer interface support
- Radio communication enabled

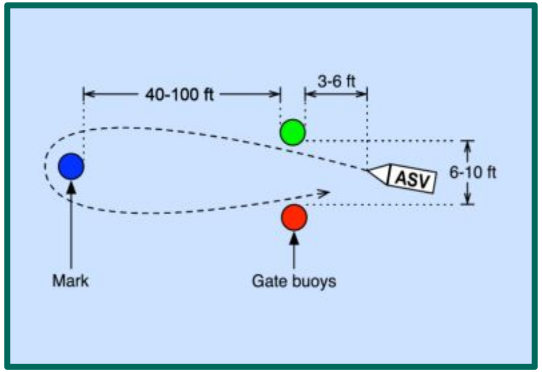
Competition Strategy

NAVIGATION



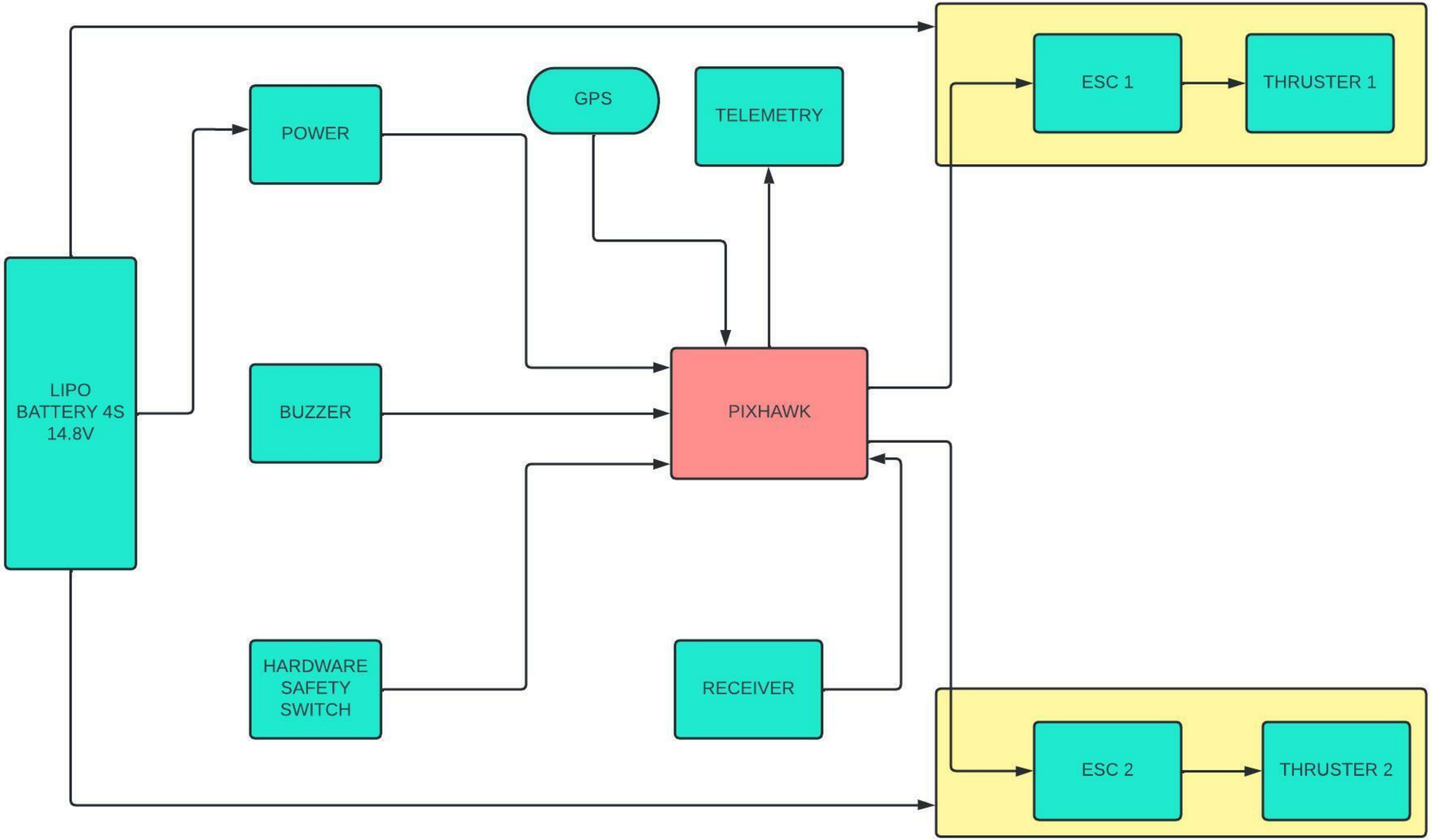
- **Navigate between the gates without colliding**
- **Adding waypoints for boat navigation**
- **The L1 Controller assists the boat in maintaining its course.**

SNACK RUN

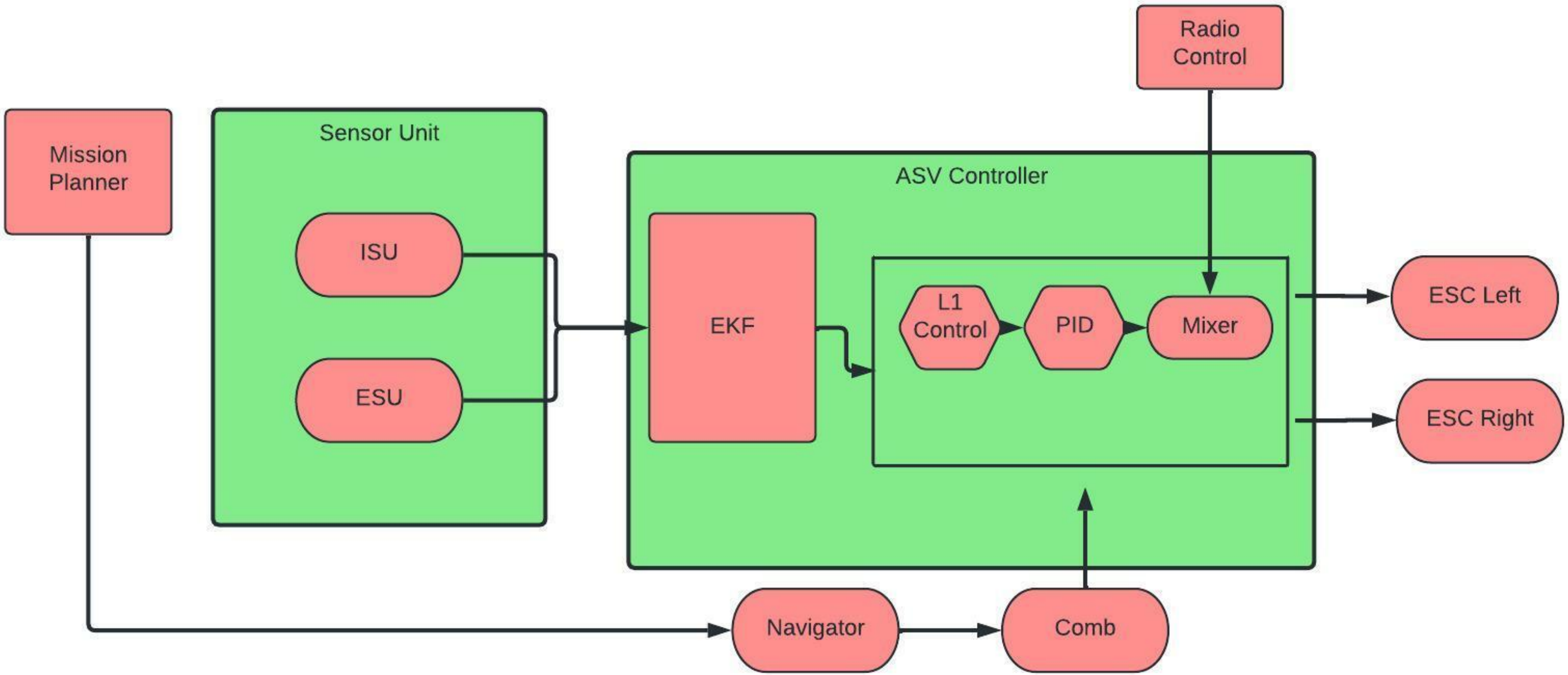


- **Enter and escape through the same gate buoy as soon as possible**
- **IMU gives the exact data to PID controller**
- **PID keeps the boat stable in water**

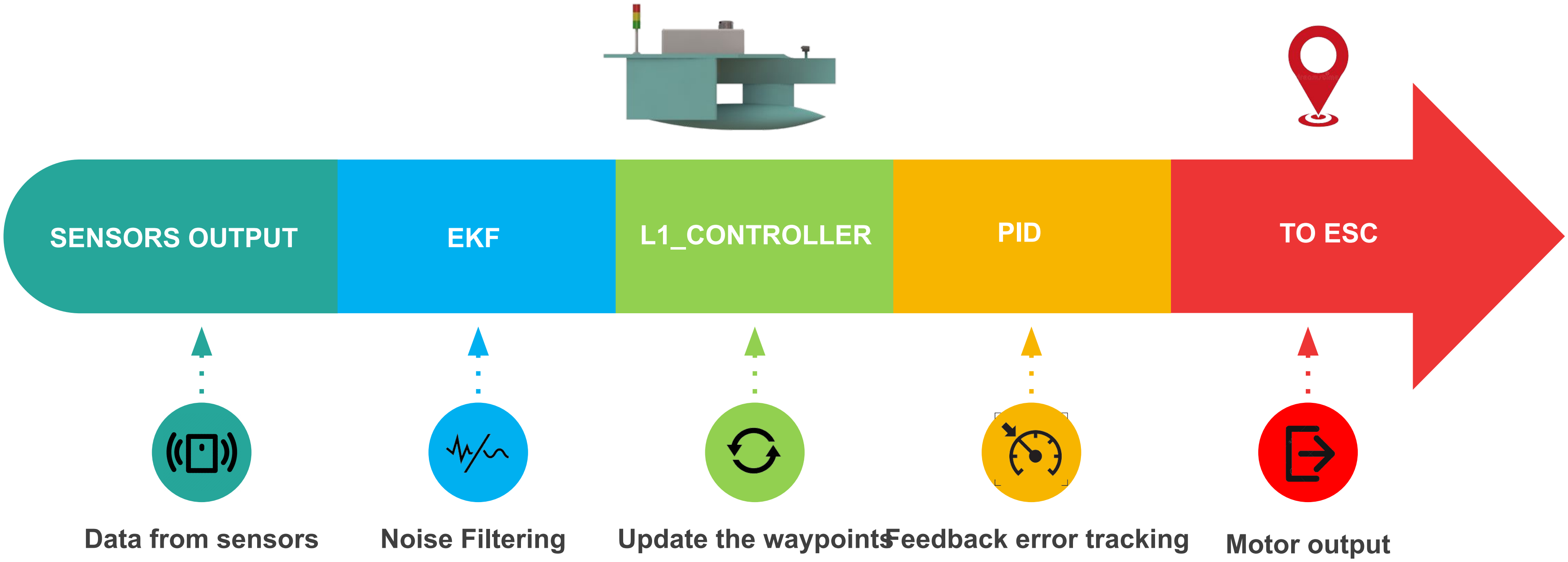
Electrical Architecture



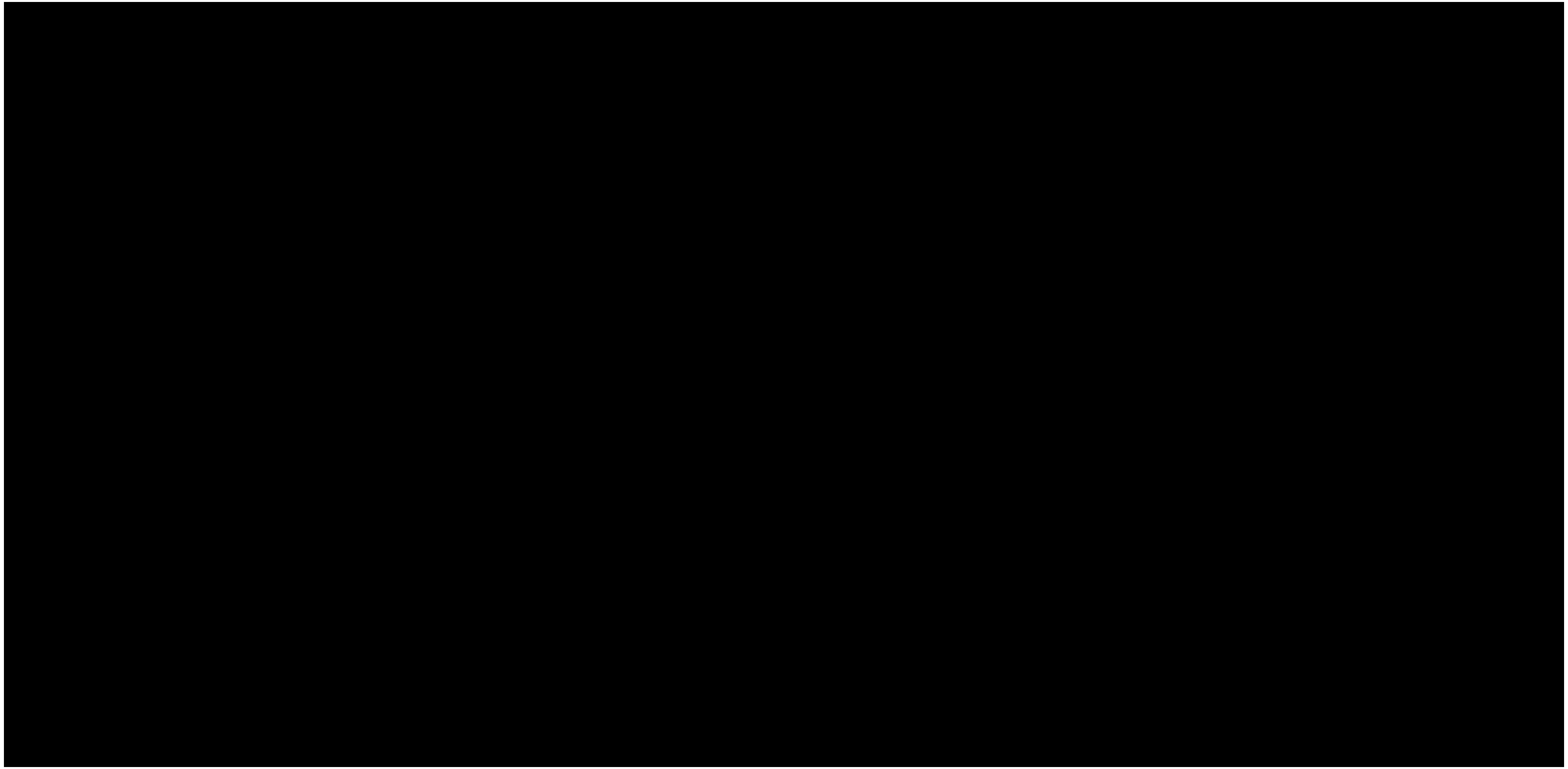
Control System Architecture



Navigation:


SENSORS OUTPUT
EKF
L1_CONTROLLER
PID
TO ESC
Data from sensors
Noise Filtering
Update the waypoints
Feedback error tracking
Motor output

Navigation:

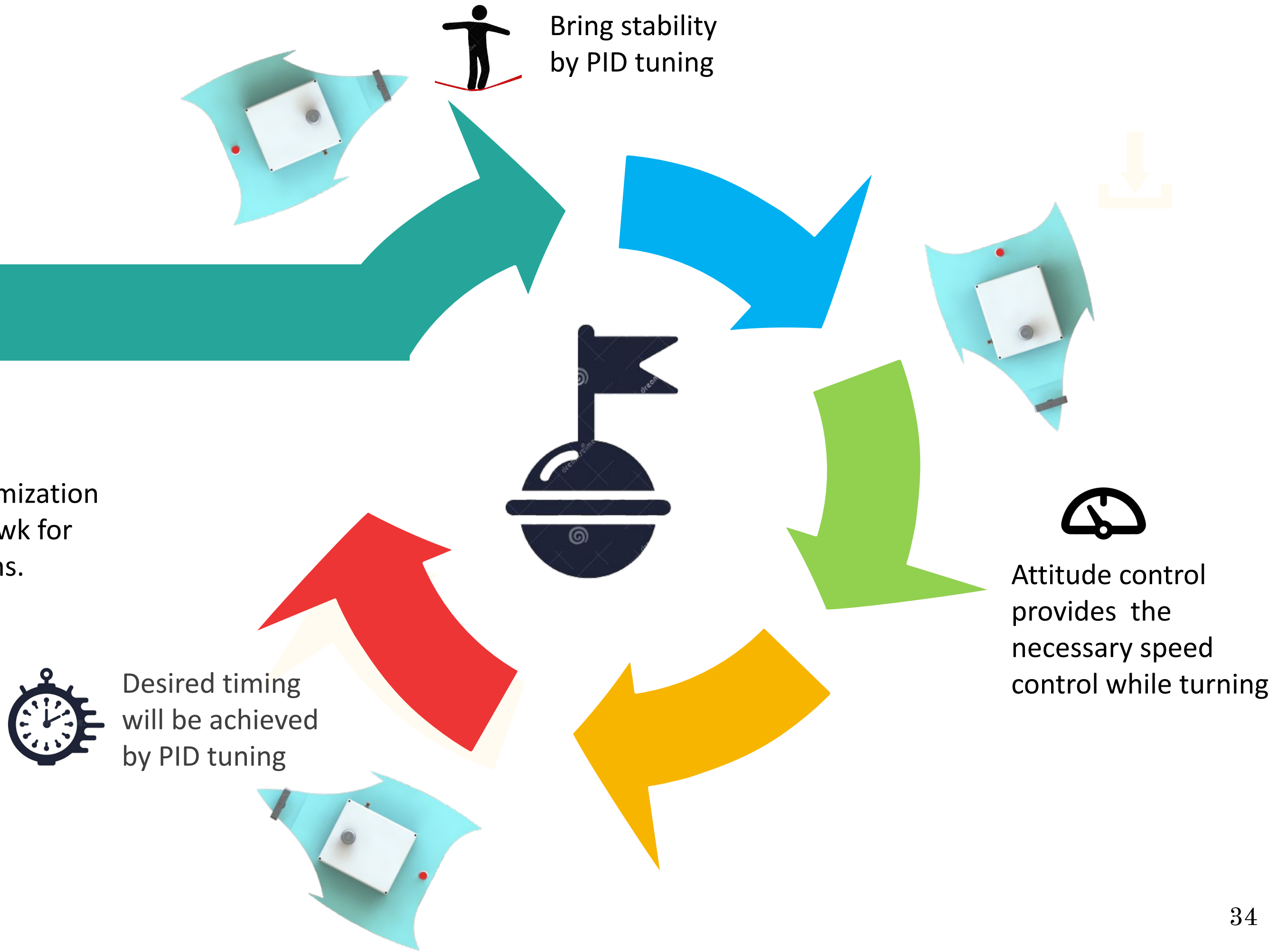


Navigation task testing video on mission planner software

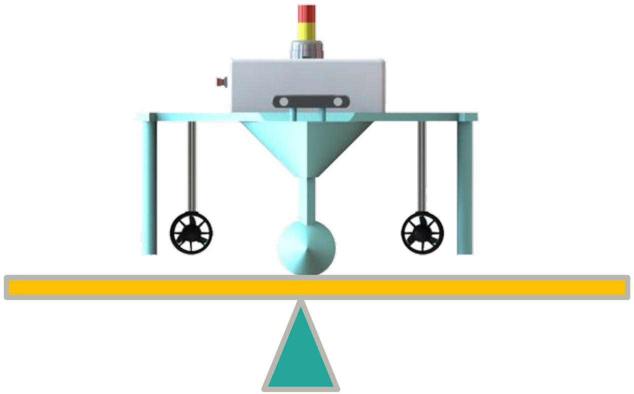
PID Tuning

Attitude Control

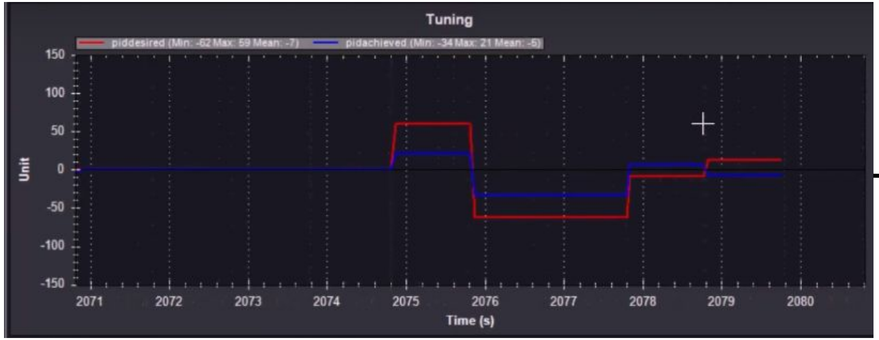
Multi-objective particle swarm optimization (MOPSO) algorithm is used in pixhawk for position and attitude control systems.



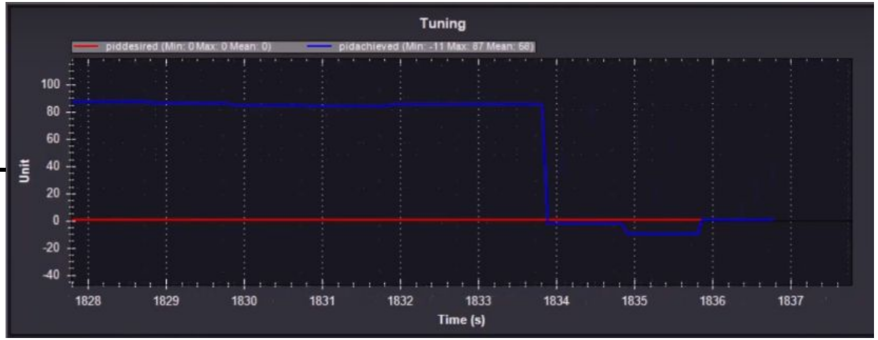
PID Tuning



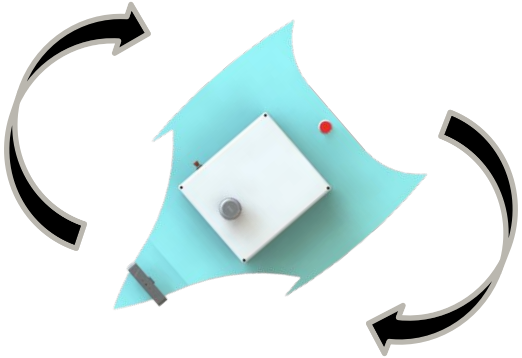
- **PID tuning.**
- **Equalize the PID achieved and PID desired.**



TUNING



- **Turn rate tuning.**
- **For smooth turning of boat.**



PID Tuning - Attempts

01

Attempt 1
Time Taken: 52s

Turning Radius: 3m

02

Attempt 2
Time Taken: 49s

Turning Radius: 2.7m

03

Attempt 3
Time Taken: 40s

Turning Radius: 1.3m

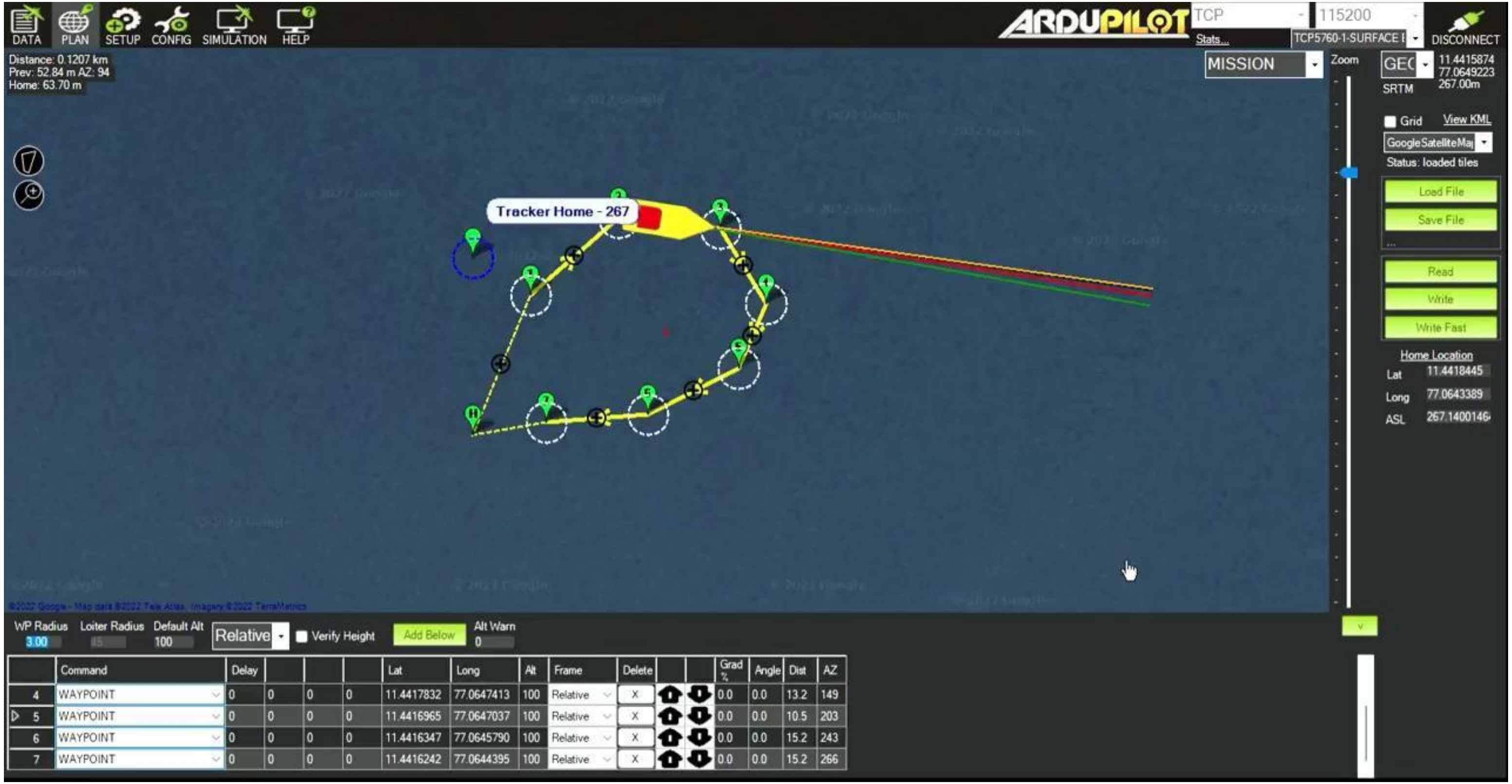
Attempt 4
Time Taken: 44s

Turning Radius: 2.12m

Distance - 145ft

Speed - 1.2m/s

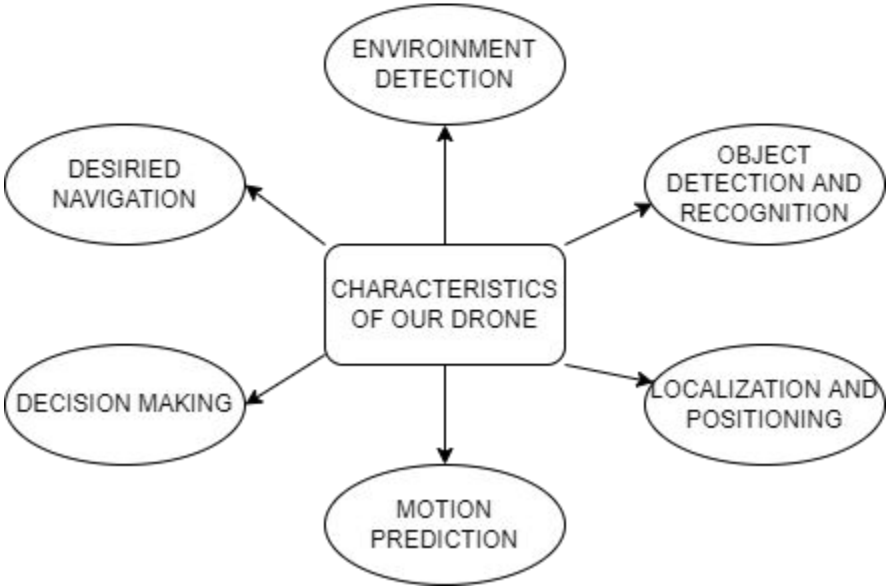
Snack Run



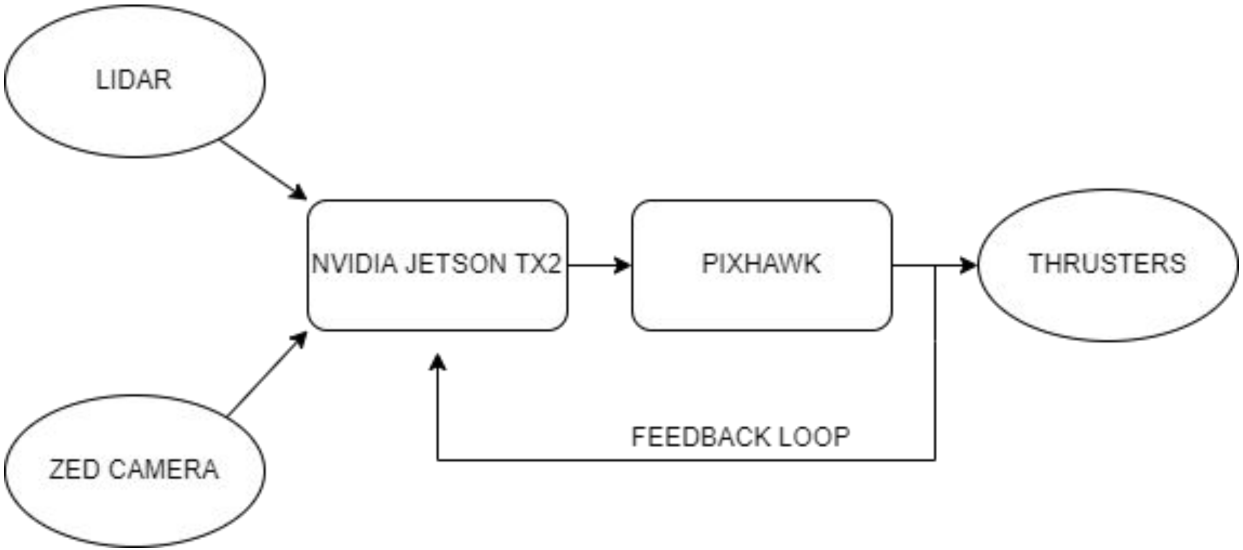
Snack run challenge testing video on mission planner software

COMPUTER VISION

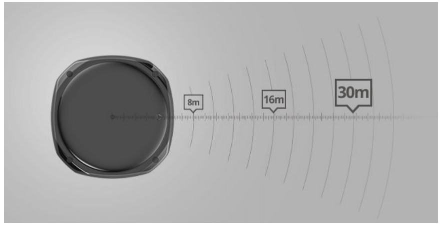
Basic Characteristics of our Boat:



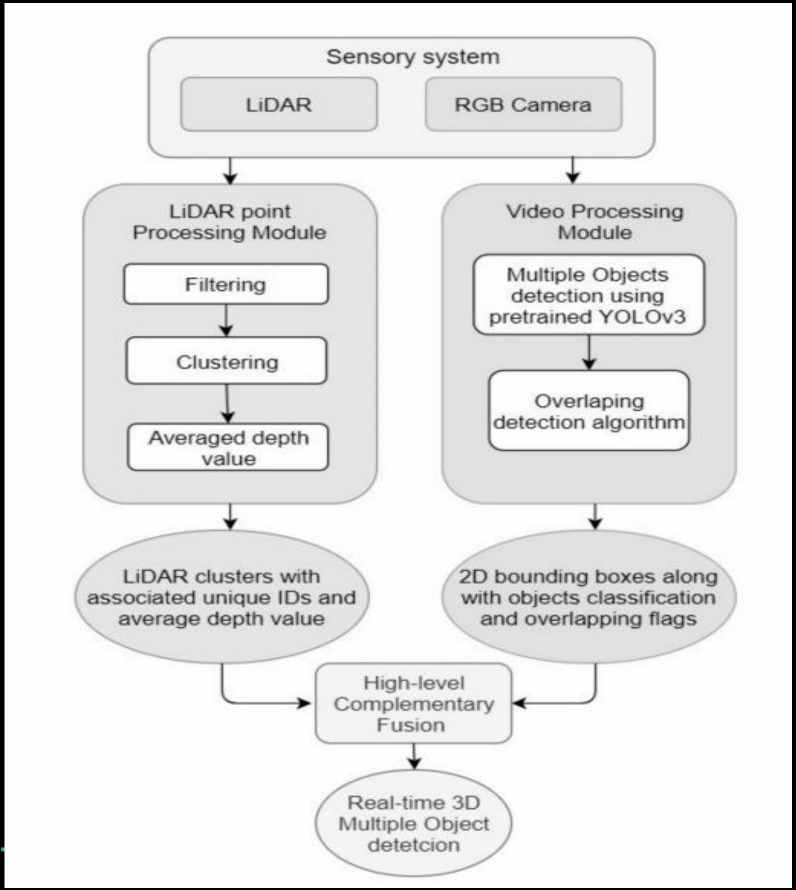
Computer Vision system Overview:



Computing interfacing:

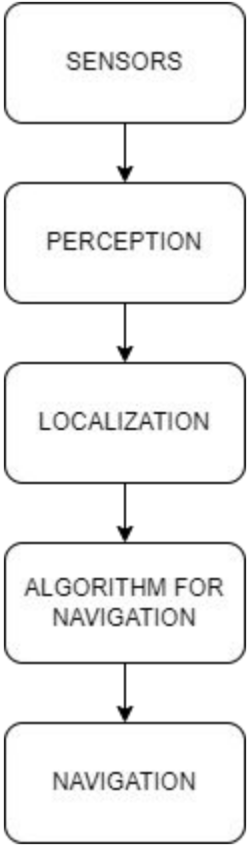
NVIDIA JETSON TX2	RPLIDAR S2	ZED 2i
		
Specifications: ● 256-core NVIDIA Pascal ● Dual core NVIDIA 2 CPU ● Quad Core ARM-A57MP core ● 8GB 128-bit LPDDR4 Memory ● 32GB eMMC5.1	Specifications: ● 32000 Samples per Second ● 30m Detection Range ● IP65 water proofed ● Outdoor LIDAR	Specifications: ● 2k - 50fps video output ● Depth fps upto 100Hz ● Depth FOV- 110° X 70° X 120° max ● Detection range upto 20m

Perception

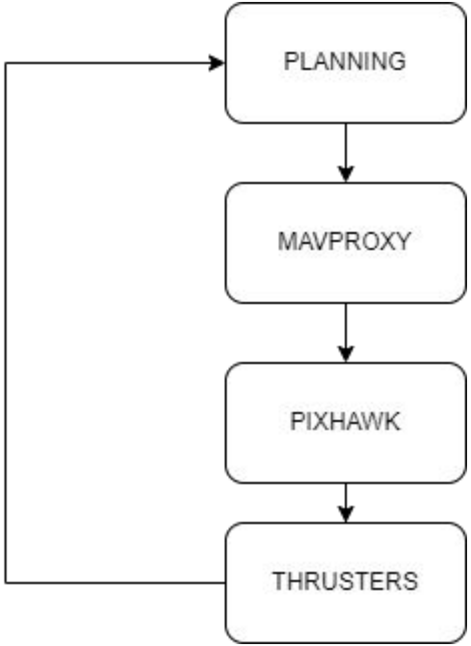


Sensory system
LiDAR
RGB Camera
LiDAR point Processing Module
Filtering
Clustering
Averaged depth value
Video Processing Module
Multiple Objects detection using pretrained YOLOv3
Overlaping detection algorithm
LiDAR clusters with associated unique IDs and average depth value
2D bounding boxes along with objects classification and overlapping flags
High-level Complementary Fusion
Real-time 3D Multiple Object detetcion

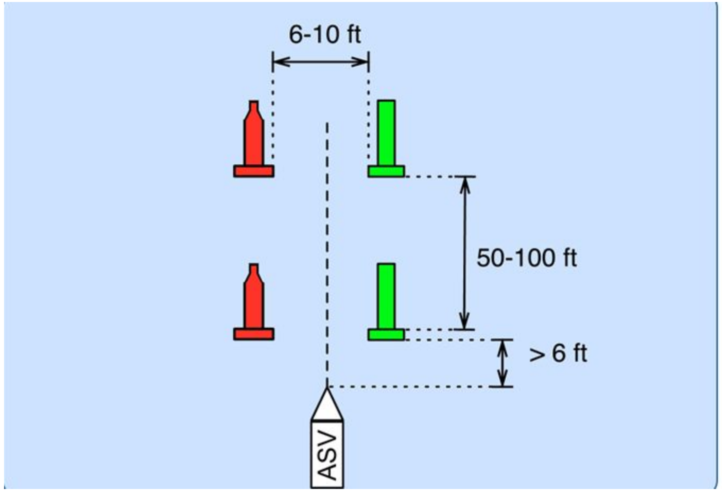
Planning

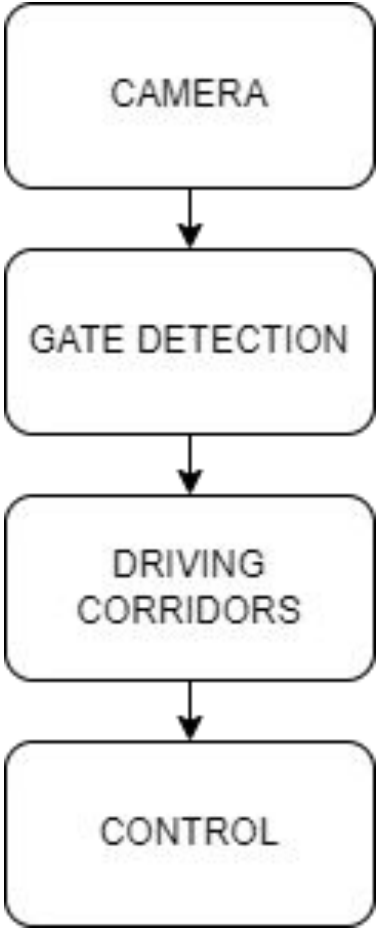


Control

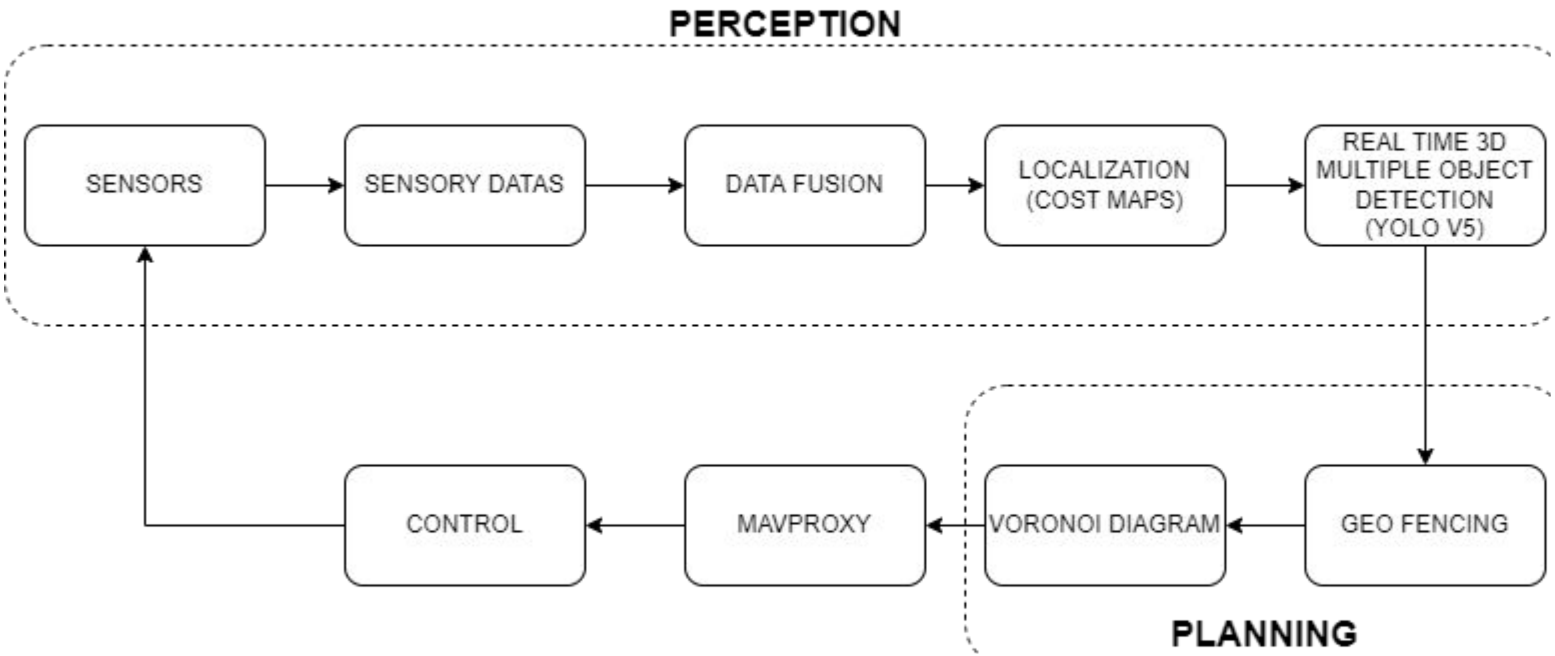


Gate Detection :

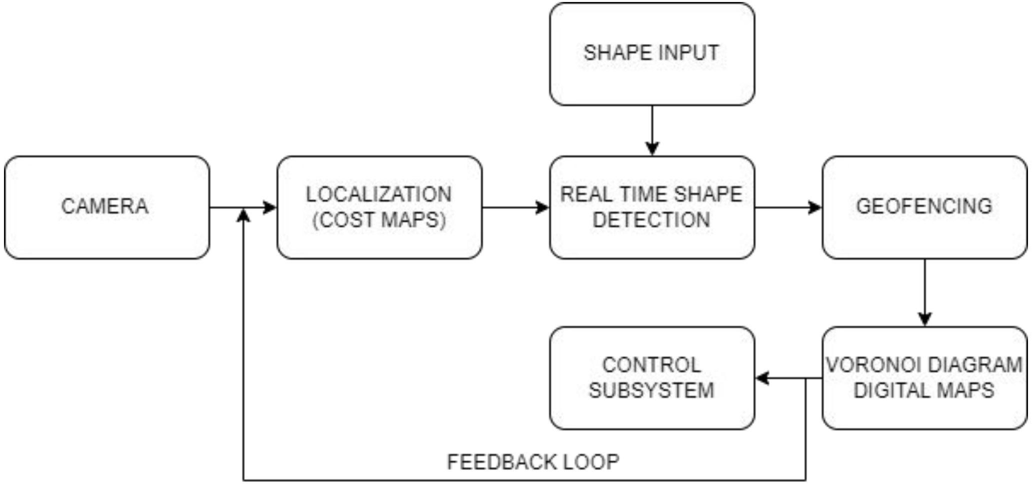


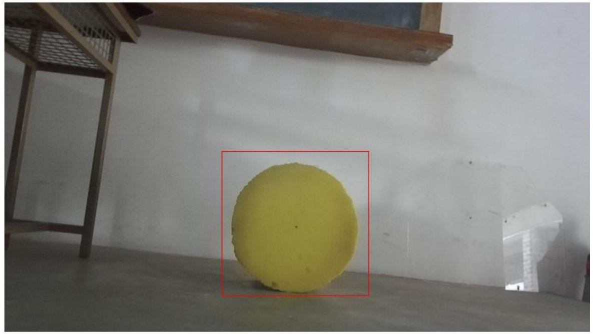


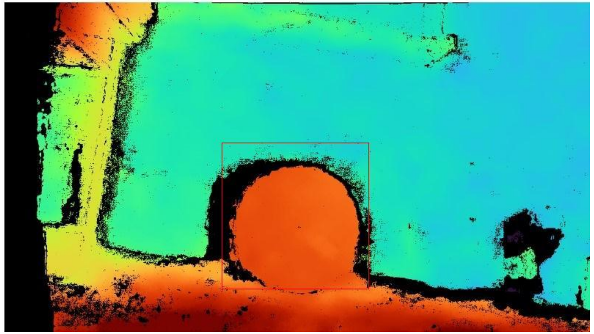
Obstacle Avoidance



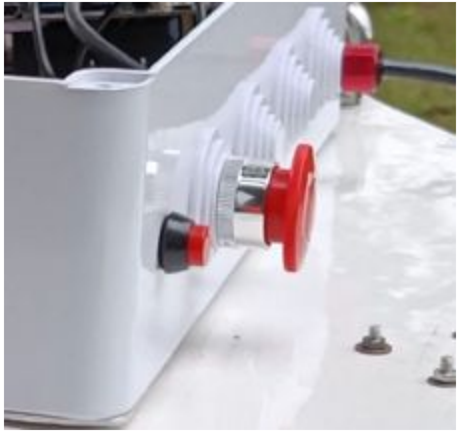
Shape Detection and Navigation

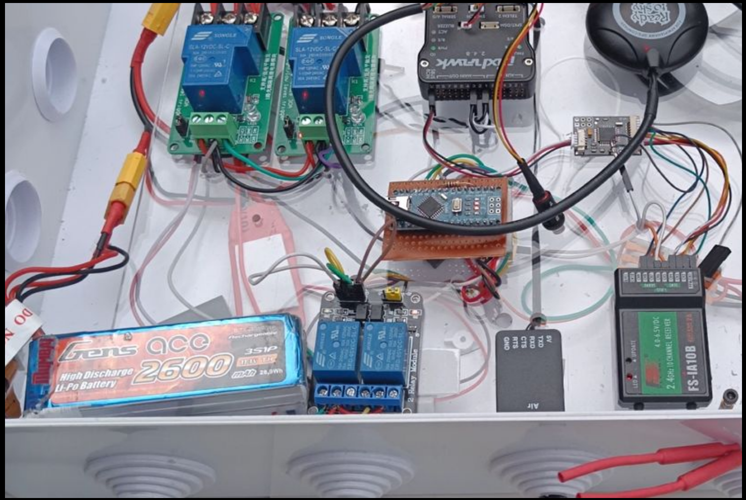






FAILSAFE SYSTEM





Fail Safe

Primary Function

The system is to cut the power to motors with an onboard or a remote button in the event of emergency

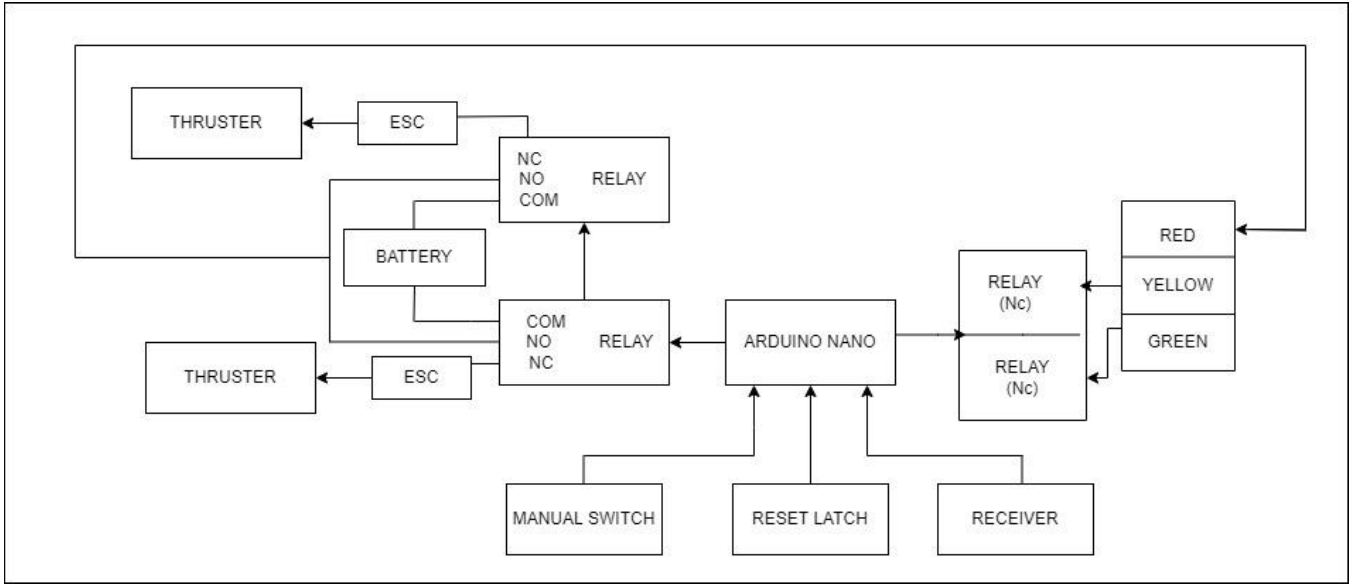
Our Fail-Safe system includes a onboard kill switch and a off board (remote) kill switch

Shutdown Time	< 0.05 secs
Power Consumption	< 20mA
Operating Voltage	5 V
Radio Freq (Remote)	2.4 GHz
Load Voltage	24 V
Load Current	30 A

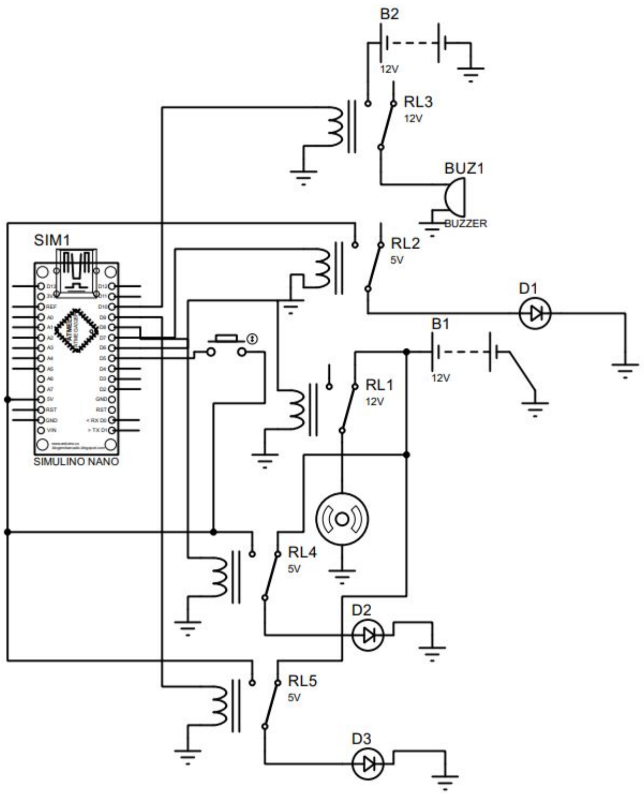
Safe Failure Modes

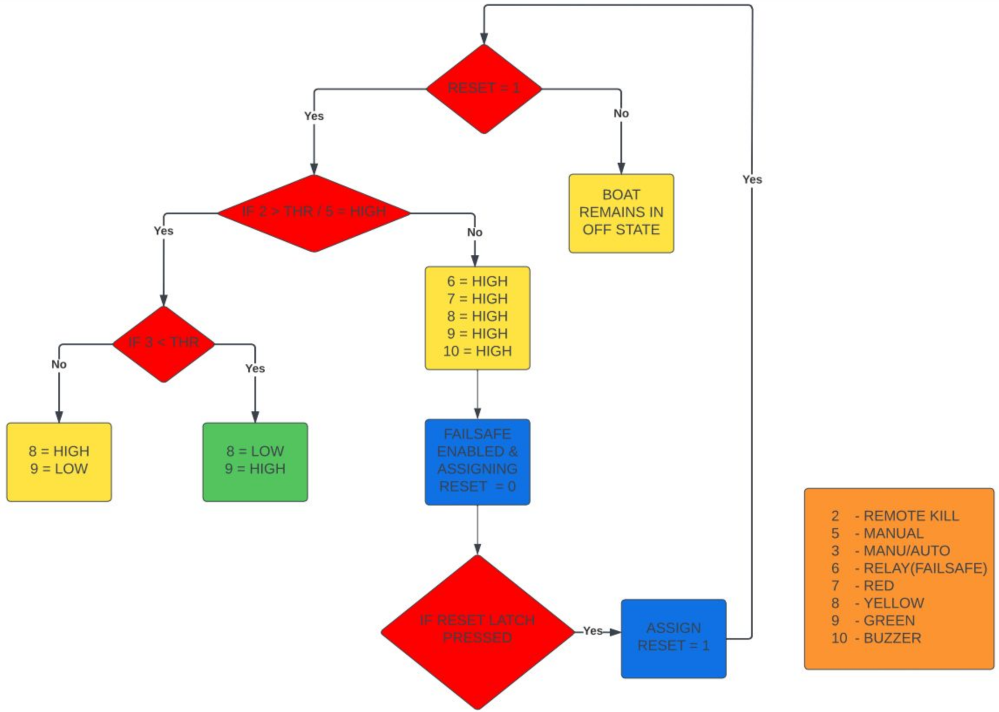
- Manual Triggering
- Remote Triggering

Block diagram of FailSafe Unit



FailSafe Circuit and Algorithm





Timeline

Project Planning

Task	Progress	Estimated Completion
Design, Analysis and Simulation of the subsytems	100%	Week 1 - 5
Hull Fabrication	100%	Week 6
Thruster mounting	100%	Week 7
Electronics assembly	100%	Weeks 6 - 7
Failsafe system assembly	100%	Week 8
Control system configuration & Tuning	100%	Weeks 8 - 9
Cable management	100%	Week 7 - 8
Sensor mounting	100%	Week 9
OBC & Controller interface	100%	Week 9
Final testing of the systems and Validation	80%	Weeks 10 - 12

Status Indicators

Colour	Mode
Yellow	Manual Operation
Green	Autonomous Operation
Red	FailSafe Enabled

1. Status Indicators are incorporated with the FailSafe System

2. The purpose of them is to indicate the current status of the ASV

Budget

Project Planning

Category	Amount
Hull form	835 USD
Power system	173 USD
Propulsion	236 USD
Failsafe system	125 USD
Computing	768 USD
Sensors	1300 USD
Enclosure and accessories	67 USD

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