FAMU-FSU
College of
Engineering

NSWC - RoboBoat

Team 521

February 2, 2024 | Virtual Design Review 4

Team Introductions (ME)

Ivanna Caballero
Materials Engineer

Andly Jean
Mechatronic Engineer

Nicholas Norwood
Mechanical Systems Engineer

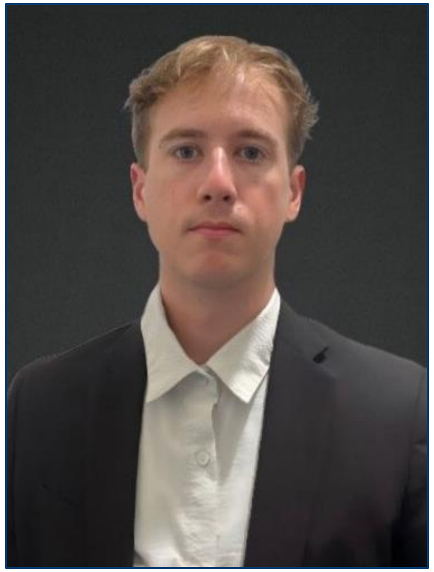
Makenzie Wiggins
Design Engineer

Ivanna
Caballero

Team Introductions (EE)

Sophia Barron
Electrical Systems Engineer

Michael Fitzsimmons
Electronics Engineer



Lucca Meyer
Test Engineer

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Ivanna
Caballero

Sponsor and Advisor

Engineering Mentor/Sponsor
Dr. Damion Dunlap
Navy Surface Warfare Center

Academic Advisor
Dr. Shayne McConomy
Senior Design Coordinator

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Ivanna Caballero

Project Objective

The objective of this project is to design, build and program an autonomous surface vehicle capable of completing several tasks in the following categories:

- Navigation
- Detection
- Object avoidance
- Conduct two-step behavior

Background

RoboBoat

- Program at RoboNation
- An international student competition
- Design autonomous, robotic boats to navigate through a challenge course
- Tackle tasks that mimic real-world challenges

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Customer Needs

- Navigation System
- Safety System
- Power/Battery System
- Weight/Size Restraint
- One Major Task

Ivanna
Caballero

Key Goals

- Reliable Safety System
- Accurate Navigation System
- Modular Code Architecture
- System Designed Around Modular Components

Ivanna Caballero

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Ivanna Caballero

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Assumptions

- Access to Senior Design Lab/Machine Shop
- ASV will comply with RoboBoat Rulebook
- Access to previous Technical Reports
- Competition will be in February 2024

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Assumptions

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- Weather is beyond our control
- Battery will have full charge prior to start
- Safety Inspection
- One task required to Compete

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Targets and Metrics

- Structure
- Locomotion
- Safety
- Navigation
- Power Systems
- Object Detection

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Critical Targets

Size:
≤ 6 ft x 3 ft x 3ft

Weight:
≤ 140 lbs

Battery Life:
> 30 min

Autonomous Navigation:
True

Kill Switch Integration:
True

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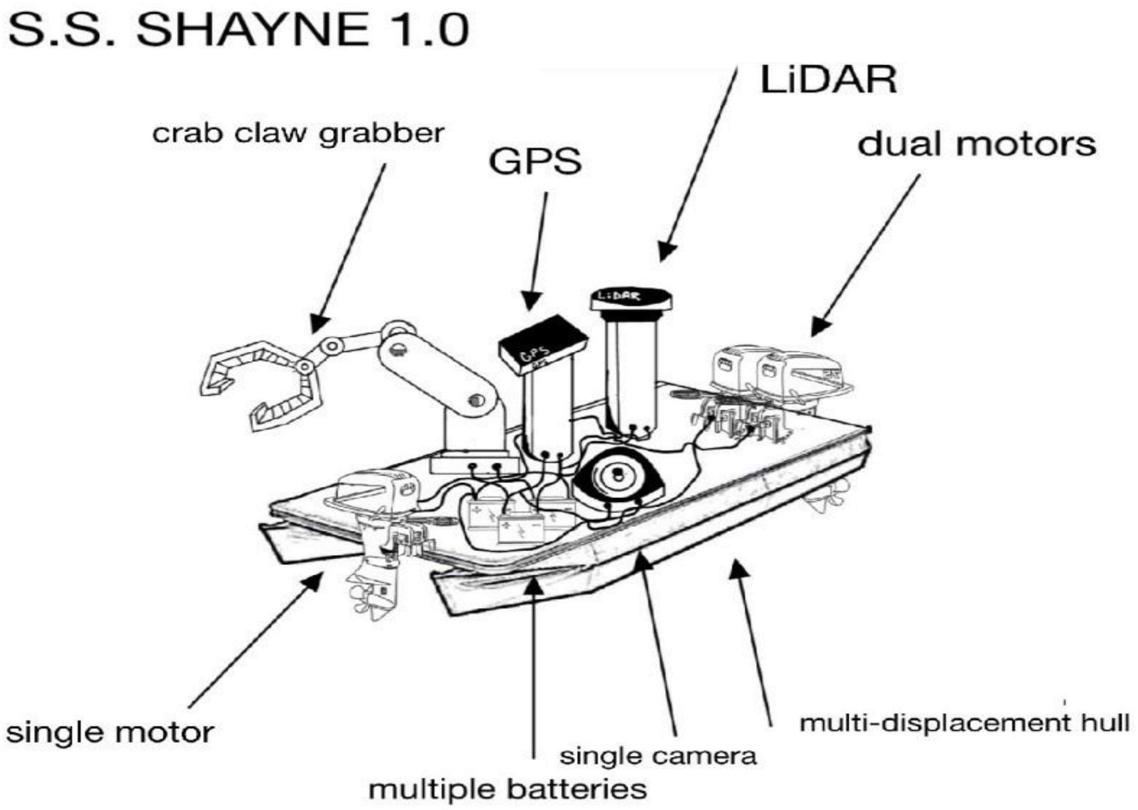
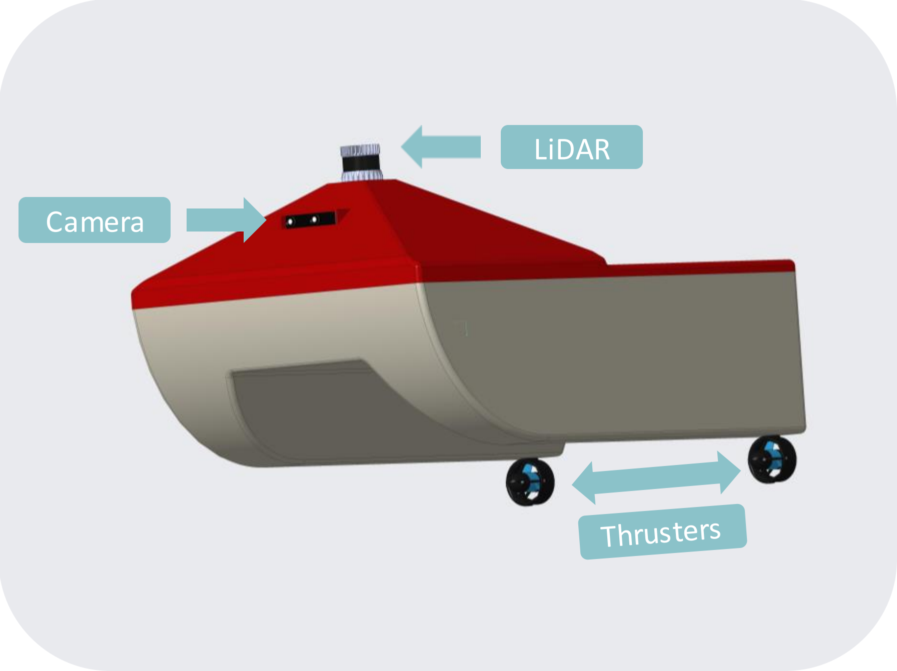
Initial Design



Makenzie Wiggins

Current Work
Structure

- LiDAR and camera elevated
- Hinged lid
- Based on 2019 1st place RoboBoat team



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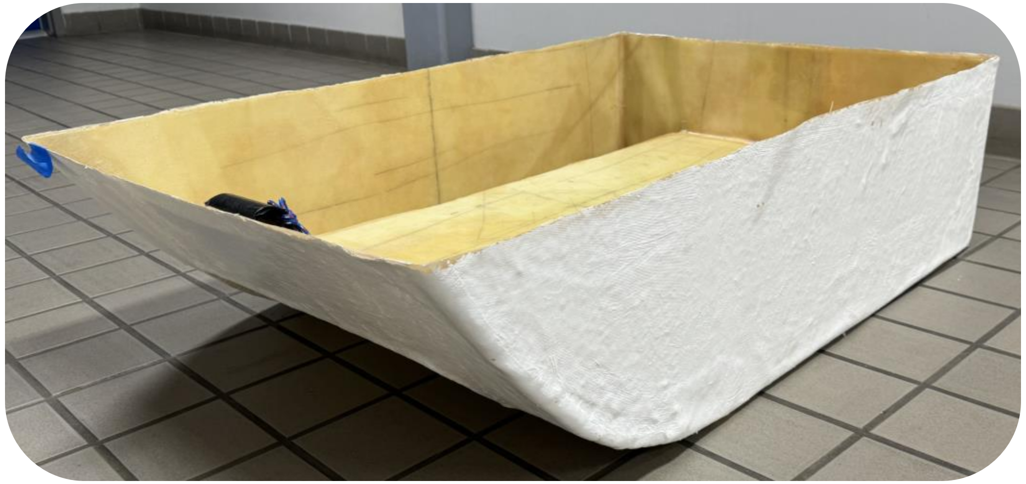
Makenzie Wiggins

Current Work

Structure

- Tested hull with 30 lbs. weight in water
  - Leaks
- Reinforce and add top



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Makenzie Wiggins

Current Work

Navigation

- Currently working on LiDAR Troubleshooting LiDAR connection
    - Ouster (firmware)
    - Outdated (1st version)
    - Velodyne LiDAR from Panama City Campus
  - Nvidia Jetson
    - Locked with password
    - Reaching out for password right now
    - Will try and flash (SDK Manager)

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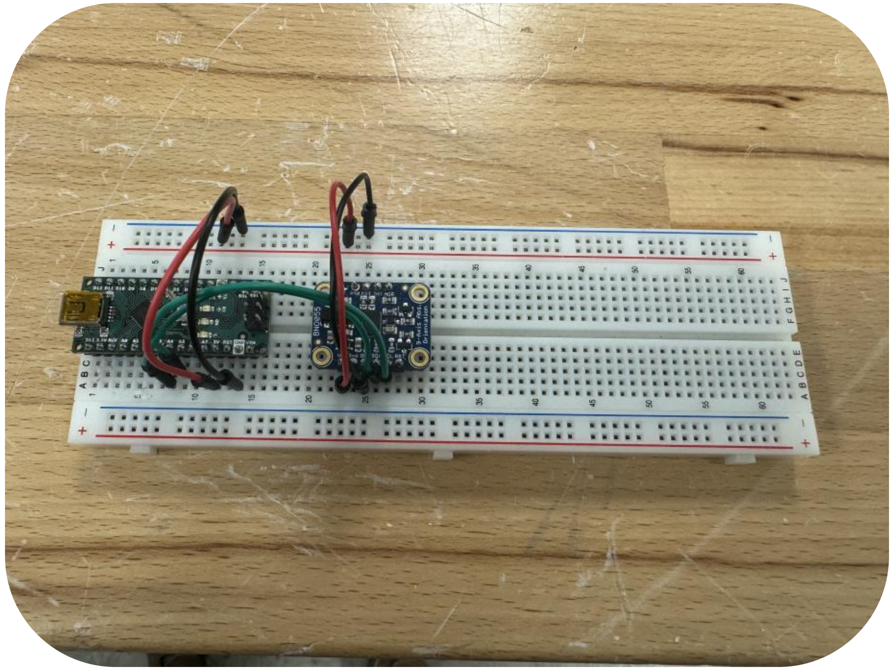
Makenzie Wiggins

Current Work

Navigation

- IMU
  - Wired and tested
  - 9-axis (x, y, z)
    - Accelerometer
    - Magnetometer
    - Gyroscope



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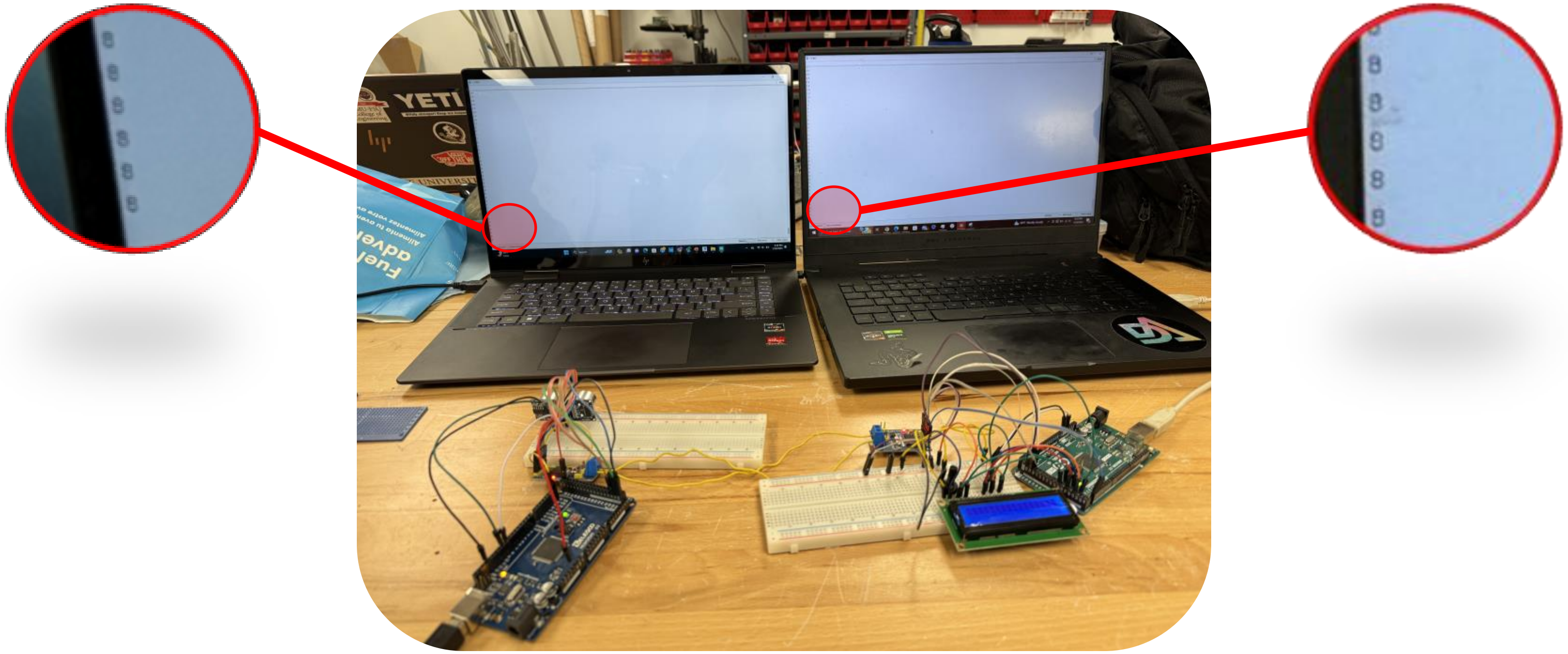
Current Work
Modular

- CANBUS fully implemented
  - Facilitate the implementation for modular components



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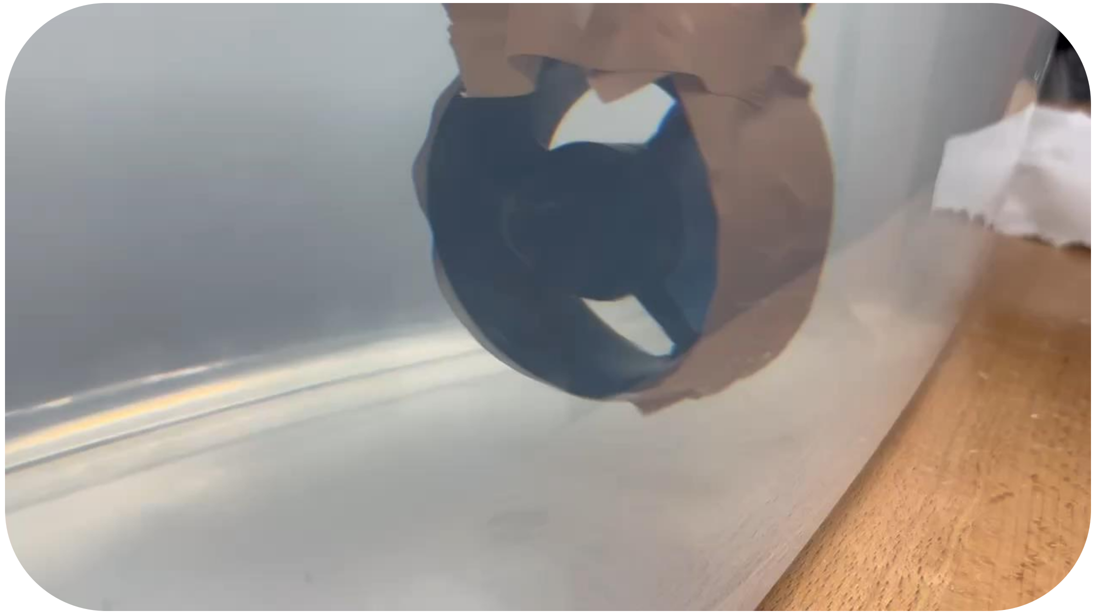
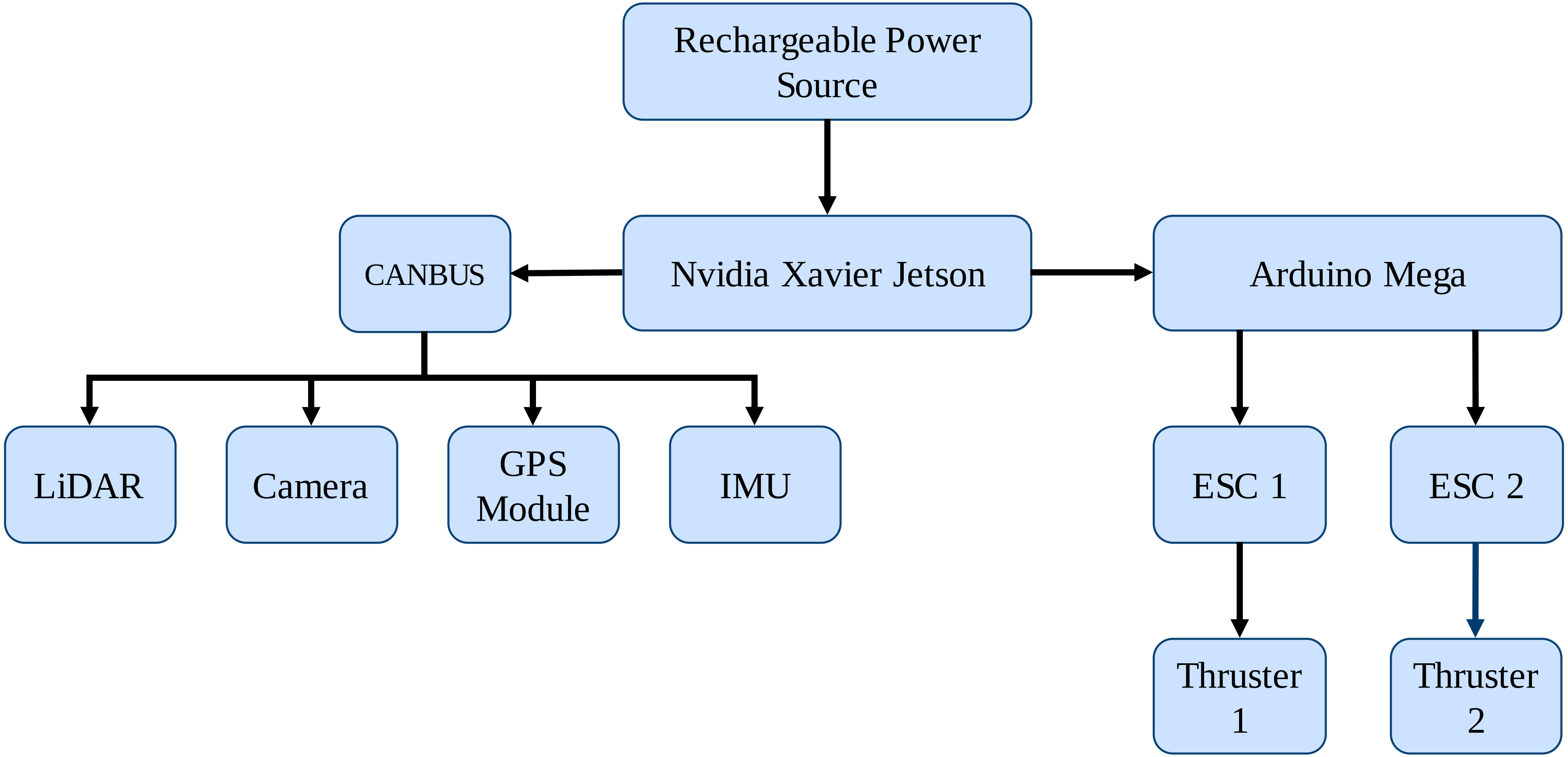
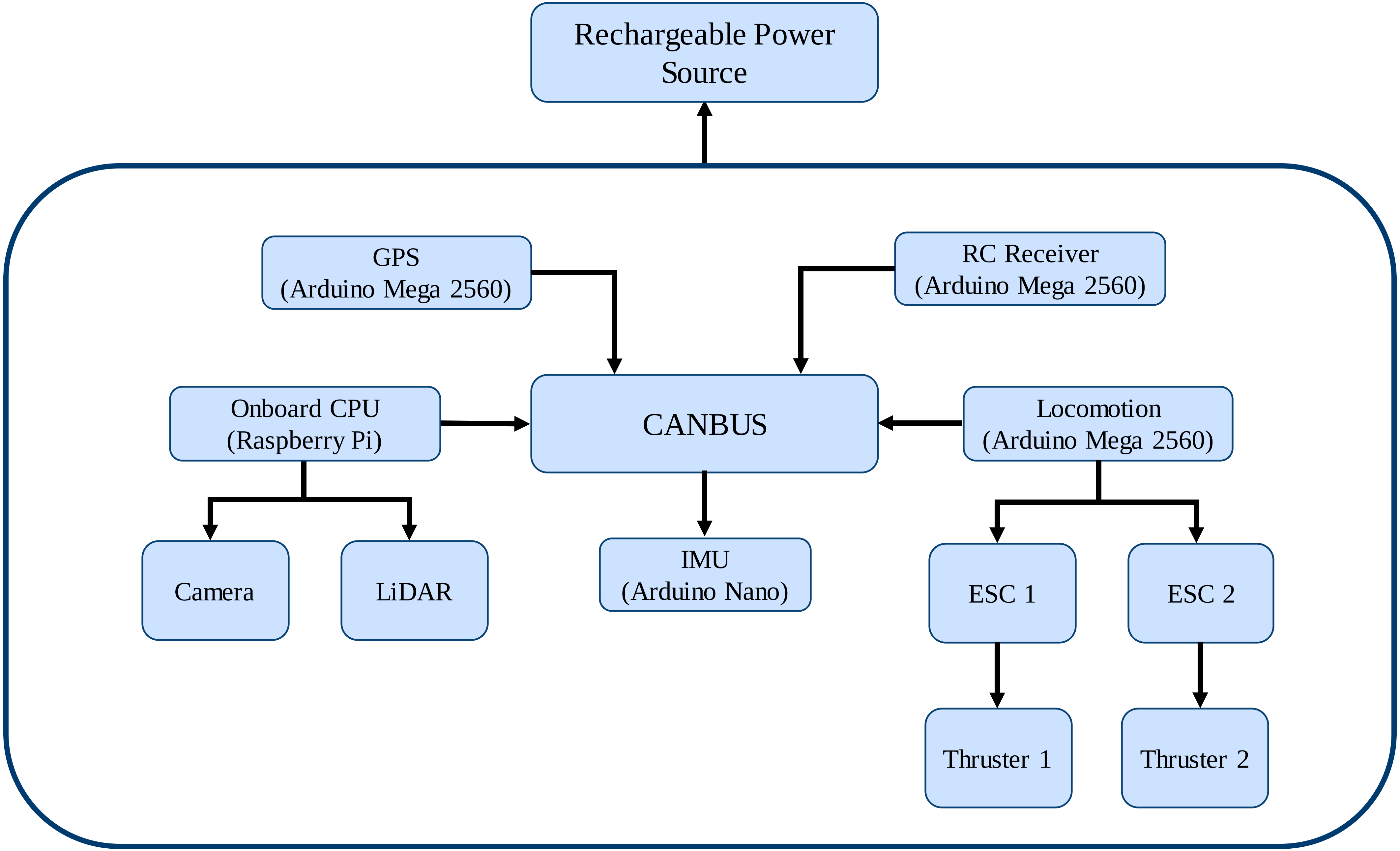
Current Work

Locomotion

- One fully functional thruster with ESC
  - Need new ESC (speed controller)
  - Thruster for rear of the boat




Rechargeable Power Source
Nvidia Xavier Jetson
CANBUS
Arduino Mega
LiDAR
Camera
GPS Module
IMU
ESC 1
ESC 2
Thruster 1
Thruster 2

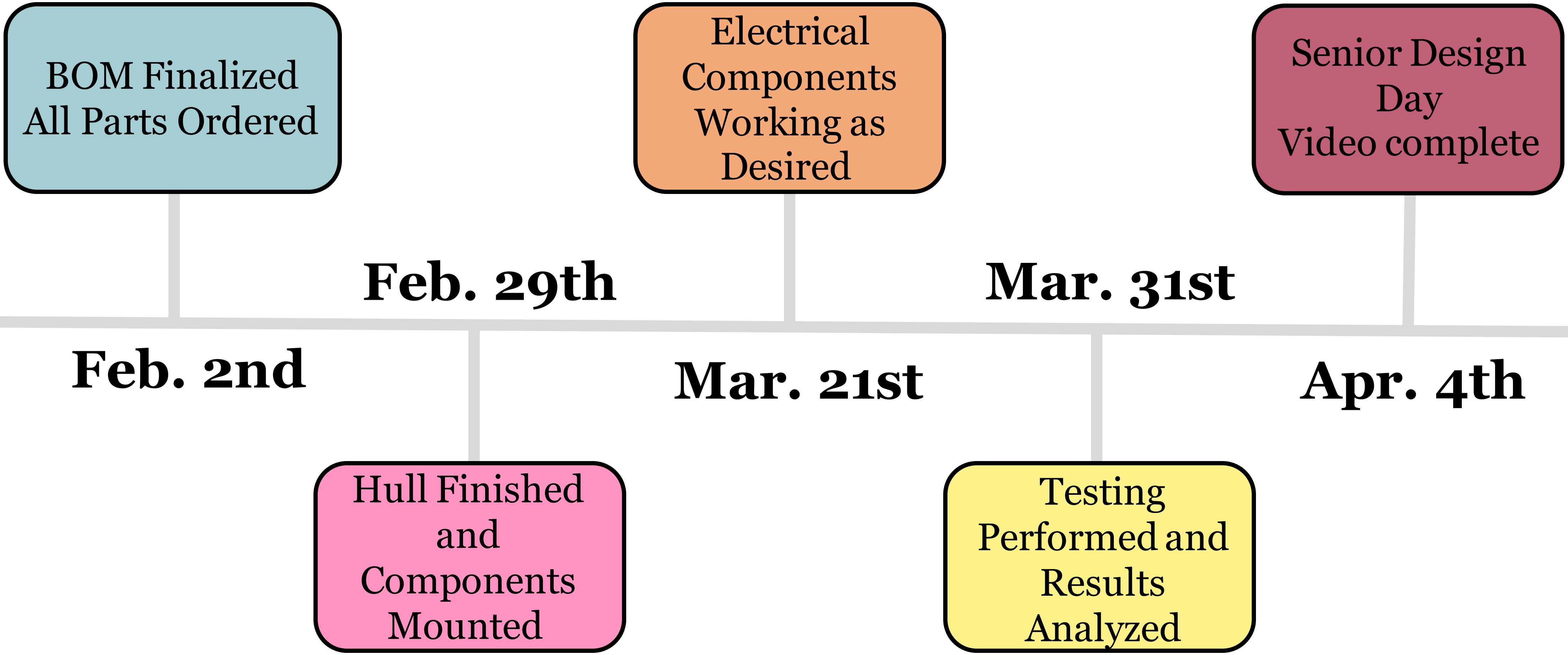

Rechargeable Power Source
GPS (Arduino Mega 2560)
RC Receiver (Arduino Mega 2560)
Onboard CPU (Raspberry Pi)
CANBUS
Locomotion (Arduino Mega 2560)
Camera
LiDAR
IMU (Arduino Nano)
ESC 1
ESC 2
Thruster 1
Thruster 2

Powering the System

- Nvidia Xavier Jetson required power supply voltage V_{in} = 14.8 V
  - Power supplied by 22 Ah, 14.8V lithium-ion battery
  - Depending on the power consumption of the system, V_{out} = 15 W
- CANBUS LINE
  - LiDAR requires V_{in} = 24V
    - Two 12 Ah, 12V lithium-ion batteries in series (12V+12V = 24V)
    - High voltage rated diode will prevent any power being used by other components
  - GPS requires V_{in} = 2.7V – 3.6V
  - IMU requires V_{in} = 5V
  - Camera requires V_{in} = 5V

Sophia Barron

Future Work and Timeline



Feb. 2nd

BOM Finalized
All Parts Ordered

Feb. 29th

Hull Finished and Components Mounted

Mar. 21st

Electrical Components Working as Desired

Mar. 31st

Testing Performed and Results Analyzed

Apr. 4th

Senior Design Day
Video complete

Thank You

Thank You

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References

About. RoboBoat. (2021, March 13). https://roboboat.org/about/

Past programs. RoboBoat. (2019, September 27). https://roboboat.org/past-programs/

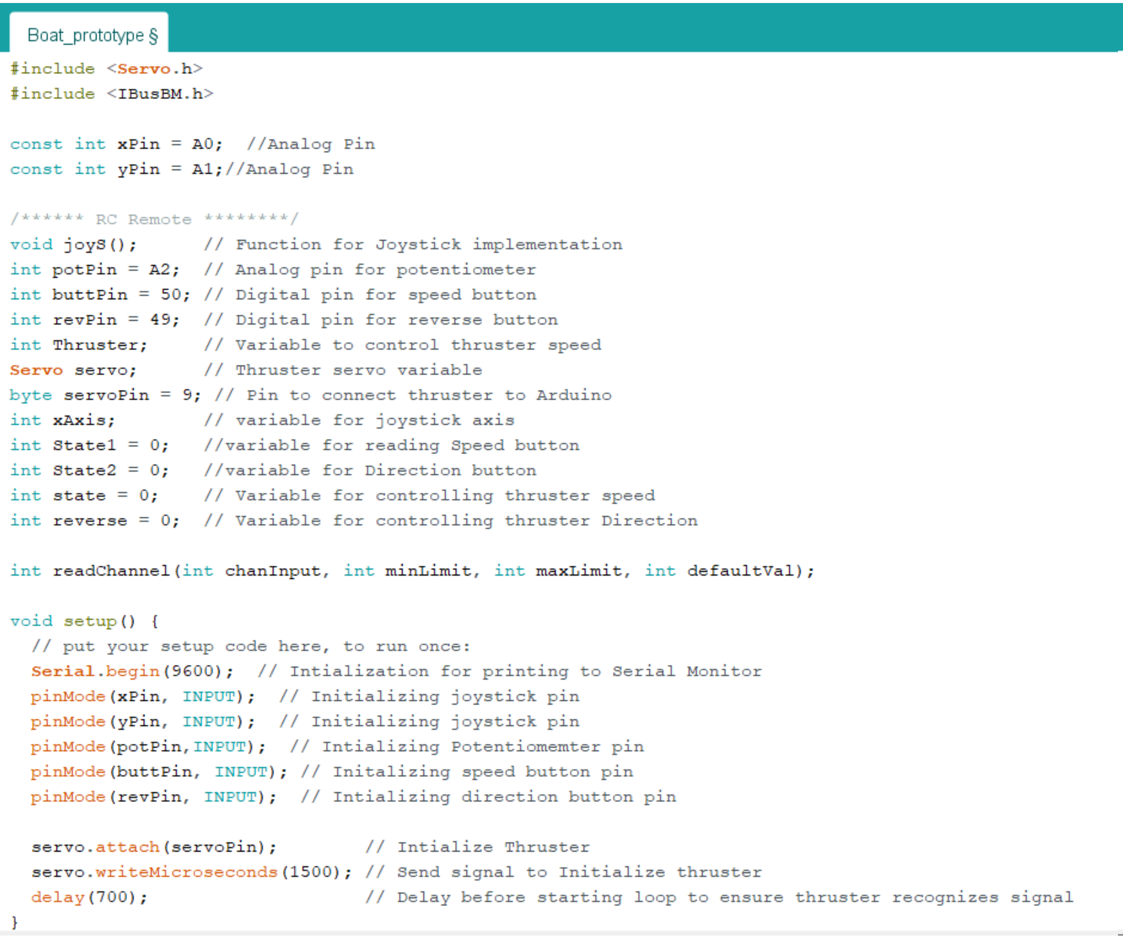
RoboBoat 2024. RoboBoat. (2023, October 13). https://roboboat.org/programs/2024/

Tel Aviv Competition Strategy Video. (2022, May 16). https://www.youtube.com/watch?v=qss0lyN3KJ8

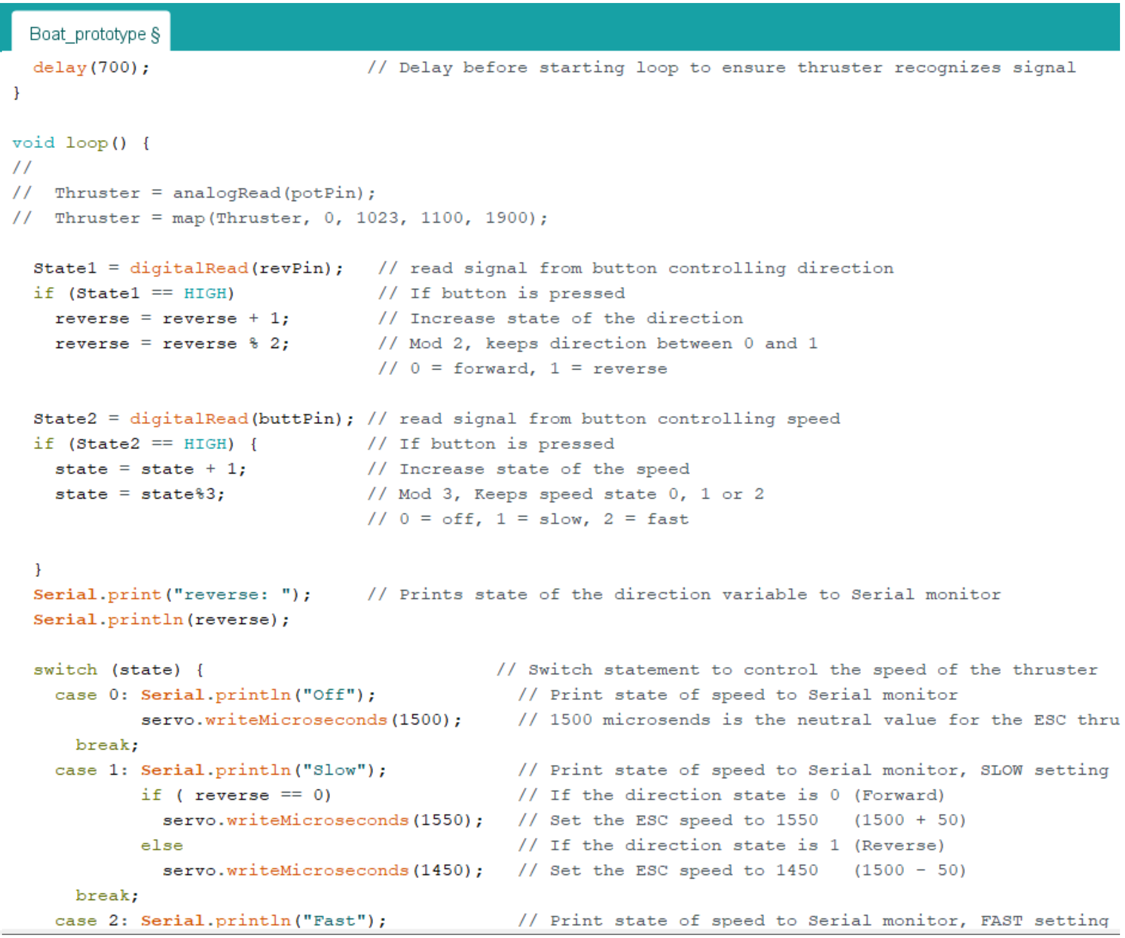
Backup Slides

Thruster Code

Michael Fitzsimmons



```
#include <Servo.h>
#include <IBusBM.h>

const int xPin = A0;  //Analog Pin
const int yPin = A1;//Analog Pin

/****** RC Remote ********/
void joyS();      // Function for Joystick implementation
int potPin = A2;  // Analog pin for potentiometer
int buttPin = 50; // Digital pin for speed button
int revPin = 49;  // Digital pin for reverse button
int Thruster;     // Variable to control thruster speed
Servo servo;      // Thruster servo variable
byte servoPin = 9; // Pin to connect thruster to Arduino
int xAxis;        // variable for joystick axis
int State1 = 0;   //variable for reading Speed button
int State2 = 0;   //variable for Direction button
int state = 0;    // Variable for controlling thruster speed
int reverse = 0;  // Variable for controlling thruster Direction

int readChannel(int chanInput, int minLimit, int maxLimit, int defaultVal);

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);  // Intialization for printing to Serial Monitor
  pinMode(xPin, INPUT);  // Initializing joystick pin
  pinMode(yPin, INPUT);  // Initializing joystick pin
  pinMode(potPin,INPUT);  // Intializing Potentiomemter pin
  pinMode(buttPin, INPUT); // Initalizing speed button pin
  pinMode(revPin, INPUT);  // Intializing direction button pin

  servo.attach(servoPin);         // Intialize Thruster
  servo.writeMicroseconds(1500); // Send signal to Initialize thruster
  delay(700);                     // Delay before starting loop to ensure thruster recognizes signal
}
```



```
  delay(700);                     // Delay before starting loop to ensure thruster recognizes signal
}

void loop() {
//
//  Thruster = analogRead(potPin);
//  Thruster = map(Thruster, 0, 1023, 1100, 1900);

  State1 = digitalRead(revPin);   // read signal from button controlling direction
  if (State1 == HIGH)             // If button is pressed
    reverse = reverse + 1;        // Increase state of the direction
    reverse = reverse % 2;        // Mod 2, keeps direction between 0 and 1
                                  // 0 = forward, 1 = reverse

  State2 = digitalRead(buttPin); // read signal from button controlling speed
  if (State2 == HIGH) {          // If button is pressed
    state = state + 1;           // Increase state of the speed
    state = state%3;             // Mod 3, Keeps speed state 0, 1 or 2
                                 // 0 = off, 1 = slow, 2 = fast

  }
  Serial.print("reverse: ");     // Prints state of the direction variable to Serial monitor
  Serial.println(reverse);

  switch (state) {                           // Switch statement to control the speed of the thruster
    case 0: Serial.println("Off");             // Print state of speed to Serial monitor
            servo.writeMicroseconds(1500);     // 1500 microsends is the neutral value for the ESC thru
      break;
    case 1: Serial.println("Slow");            // Print state of speed to Serial monitor, SLOW setting
            if ( reverse == 0)                 // If the direction state is 0 (Forward)
              servo.writeMicroseconds(1550);   // Set the ESC speed to 1550   (1500 + 50)
            else                               // If the direction state is 1 (Reverse)
              servo.writeMicroseconds(1450);   // Set the ESC speed to 1450   (1500 - 50)
      break;
    case 2: Serial.println("Fast");            // Print state of speed to Serial monitor, FAST setting
```

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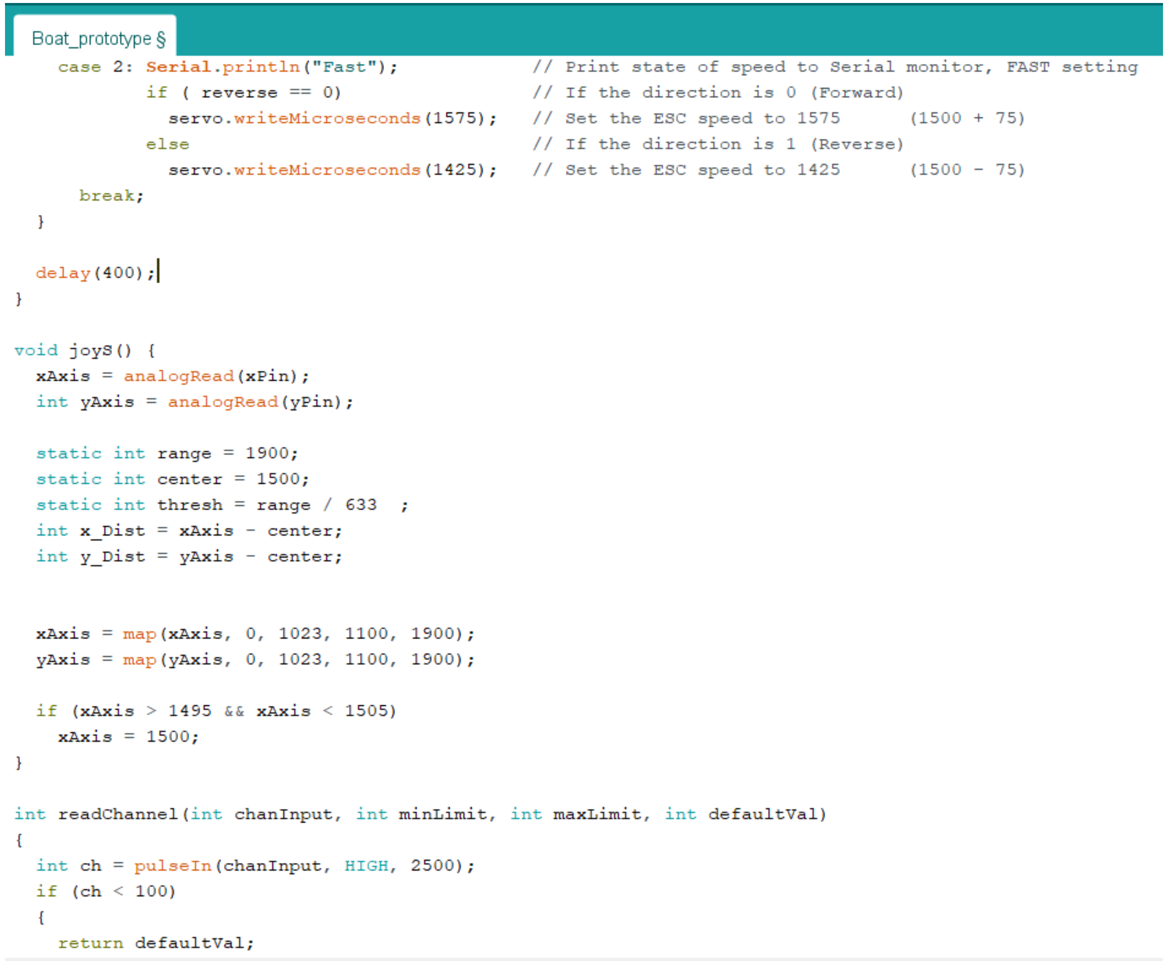
Thruster Code



```
    case 2: Serial.println("Fast");            // Print state of speed to Serial monitor, FAST setting
            if ( reverse == 0)                 // If the direction is 0 (Forward)
              servo.writeMicroseconds(1575);   // Set the ESC speed to 1575      (1500 + 75)
            else                               // If the direction is 1 (Reverse)
              servo.writeMicroseconds(1425);   // Set the ESC speed to 1425      (1500 - 75)
      break;
  }

  delay(400);
}

void joyS() {
  xAxis = analogRead(xPin);
  int yAxis = analogRead(yPin);

  static int range = 1900;
  static int center = 1500;
  static int thresh = range / 633  ;
  int x_Dist = xAxis - center;
  int y_Dist = yAxis - center;


  xAxis = map(xAxis, 0, 1023, 1100, 1900);
  yAxis = map(yAxis, 0, 1023, 1100, 1900);

  if (xAxis > 1495 && xAxis < 1505)
    xAxis = 1500;
}

int readChannel(int chanInput, int minLimit, int maxLimit, int defaultVal)
{
  int ch = pulseIn(chanInput, HIGH, 2500);
  if (ch < 100)
  {
    return defaultVal;
```

Michael Fitzsimmons

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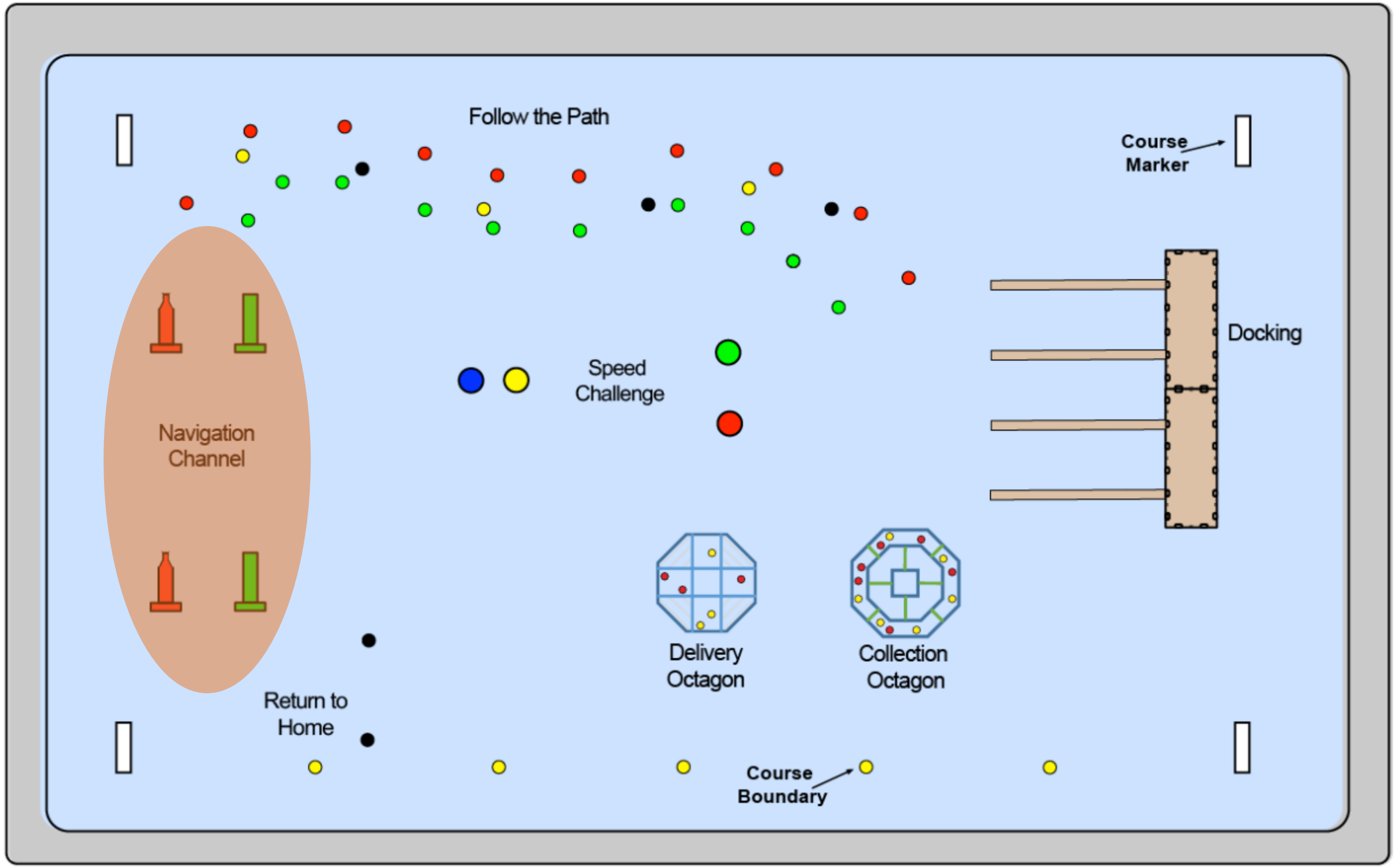

Task 1:
Navigation Channel

Task 2:
Follow the Path

Task 3:
Docking

Task 4:
Duck Wash

Task 5:
Speed Challenge

Task 6:
Collection Octagon

Task 7:
Delivery Octagon

Task 8:
Return to Home

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Makenzie
Wiggins

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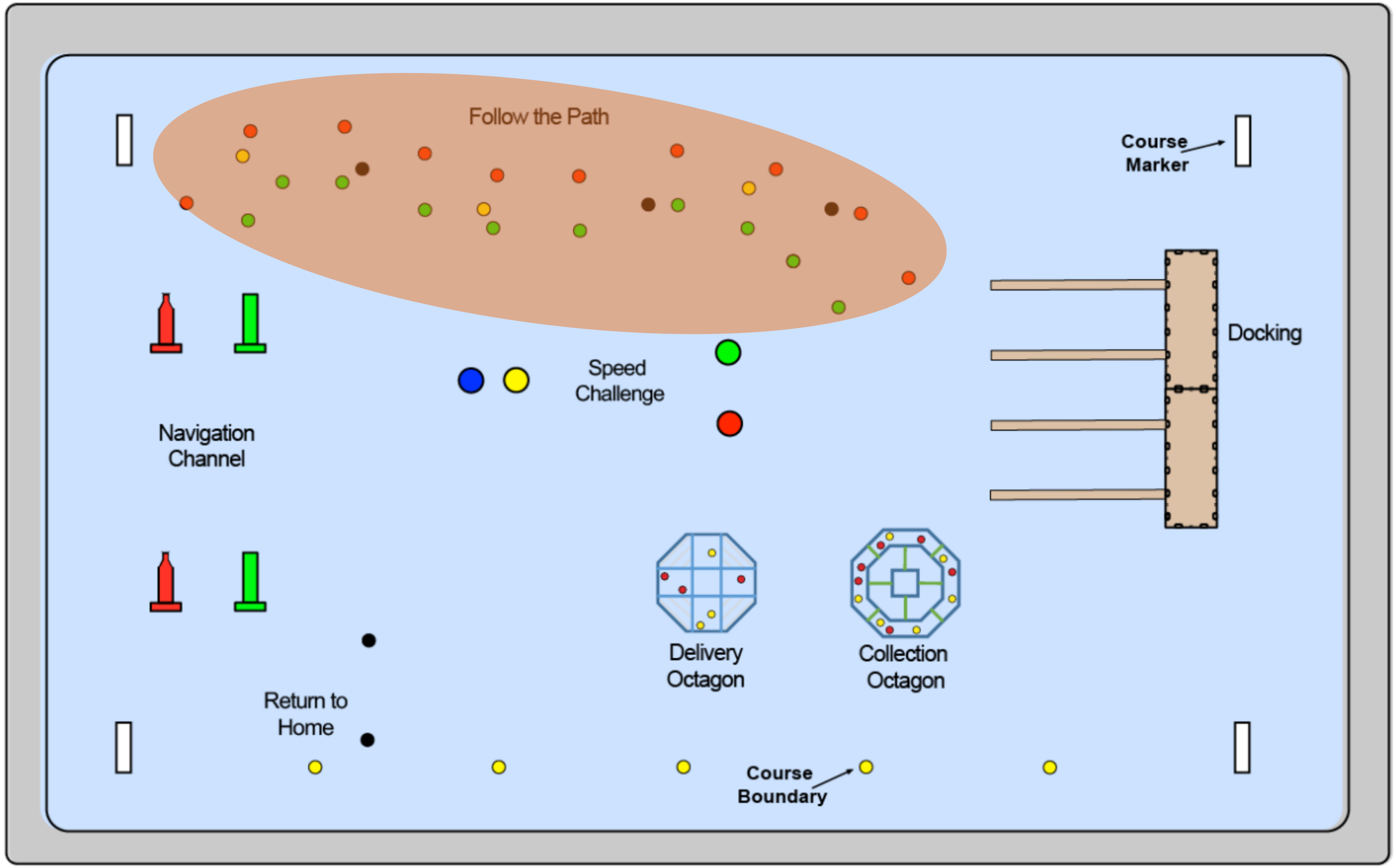

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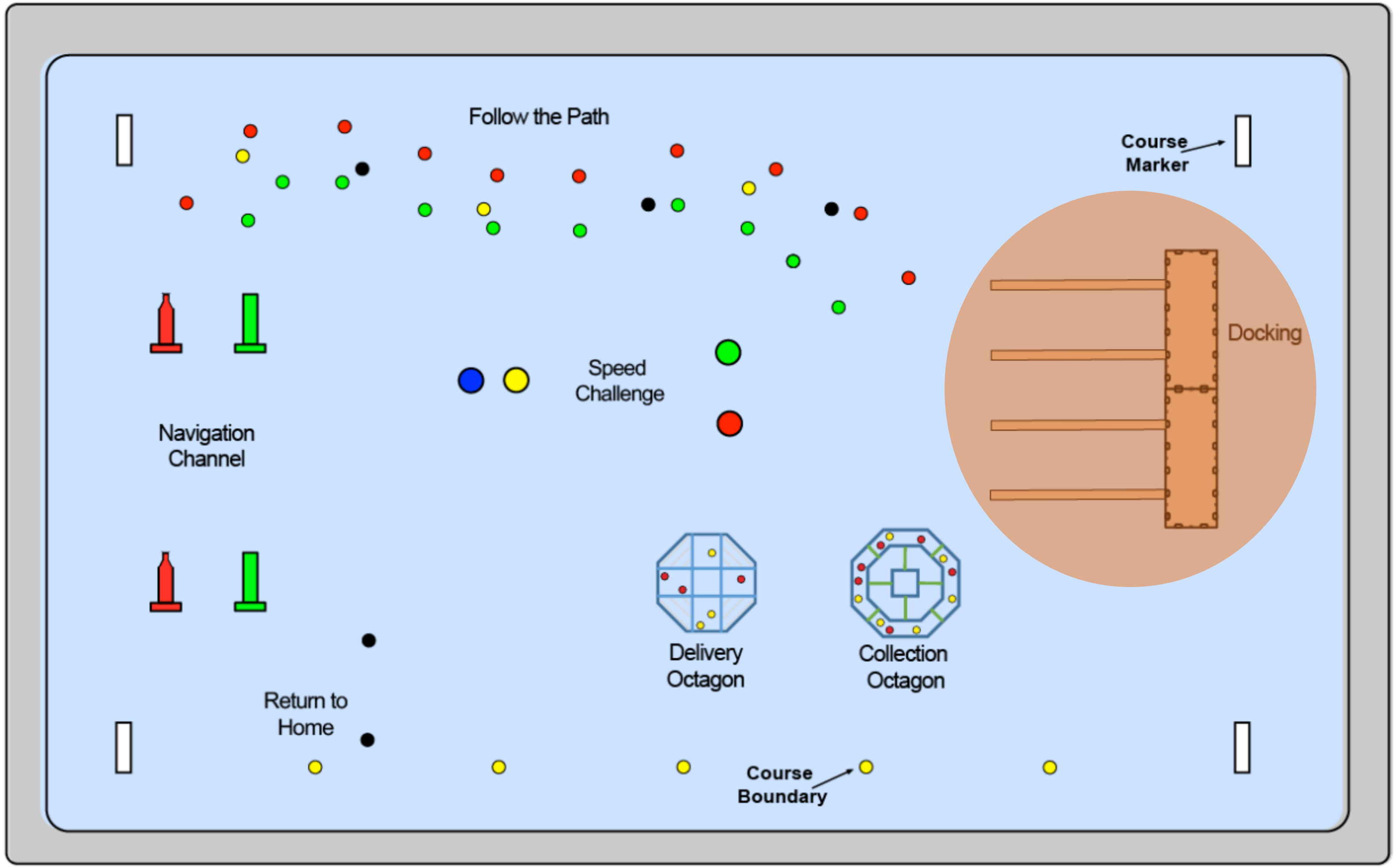

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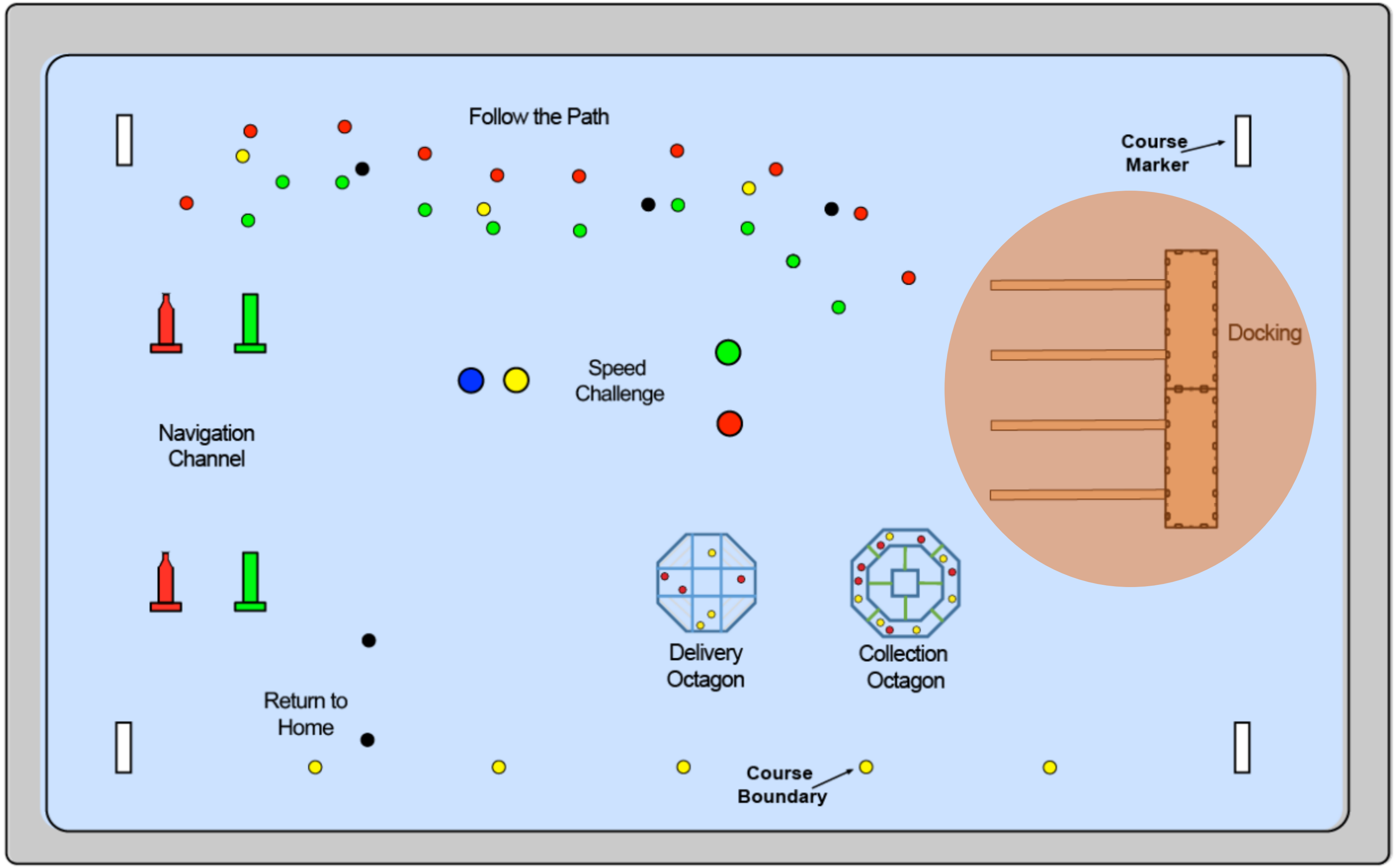

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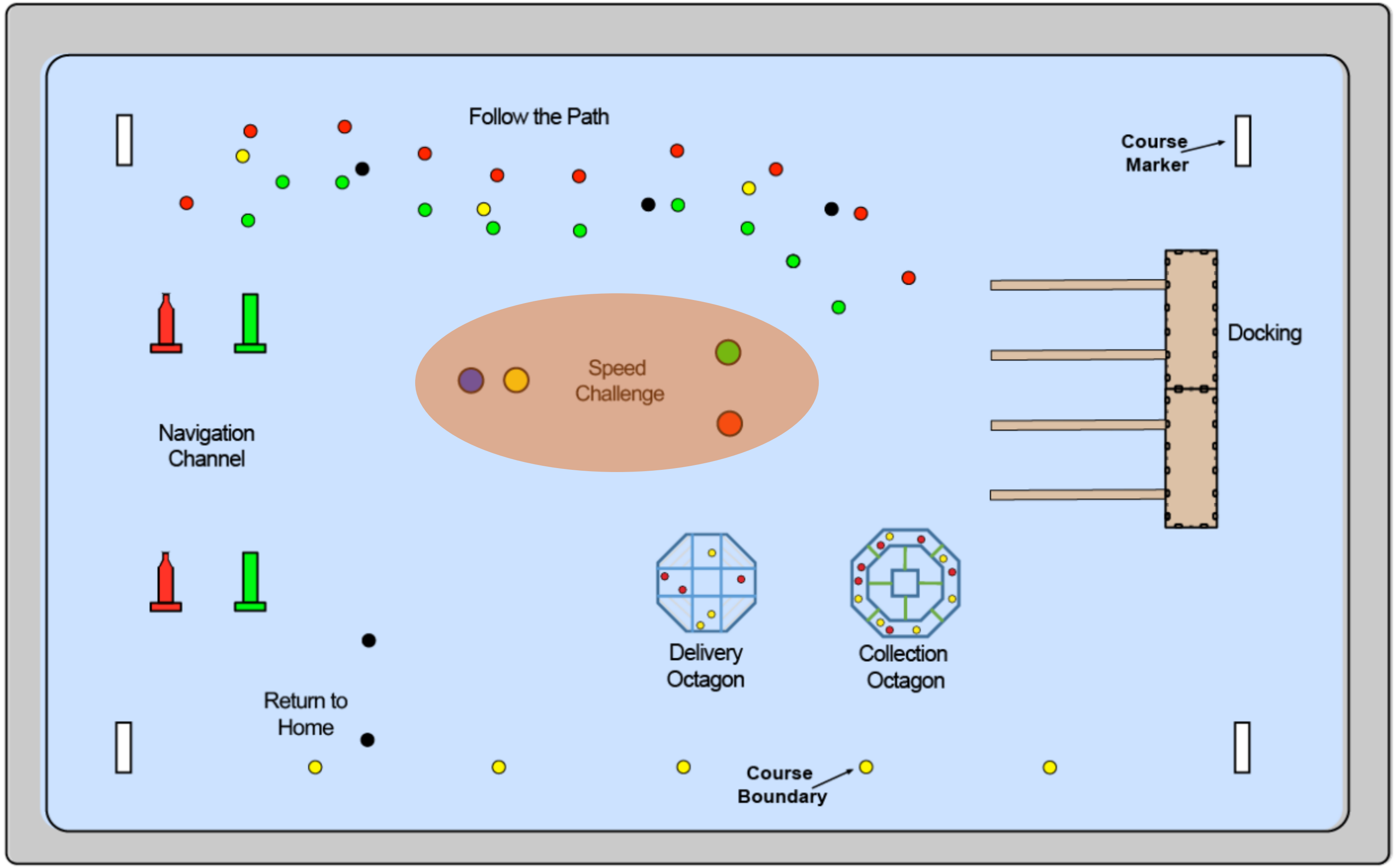

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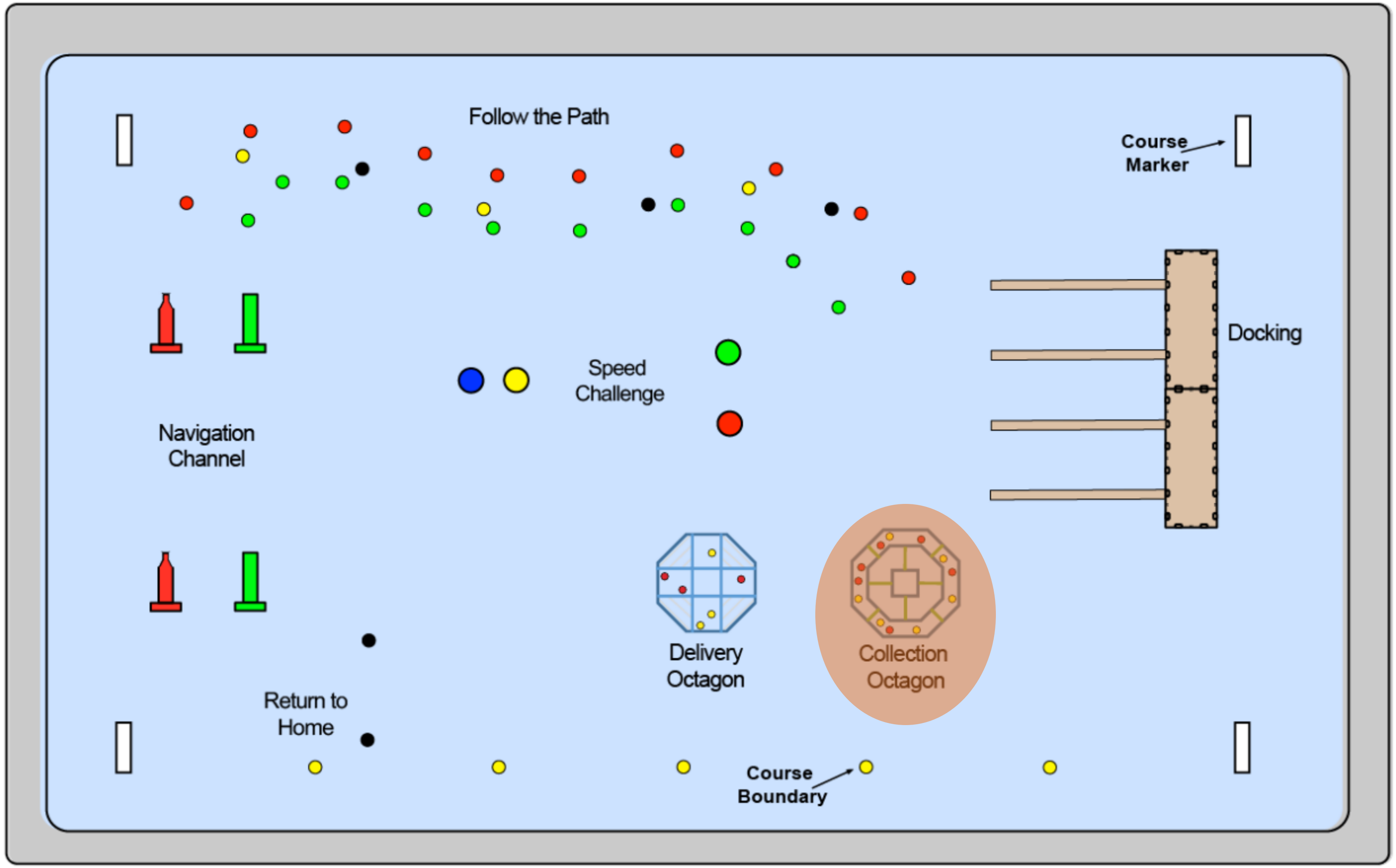

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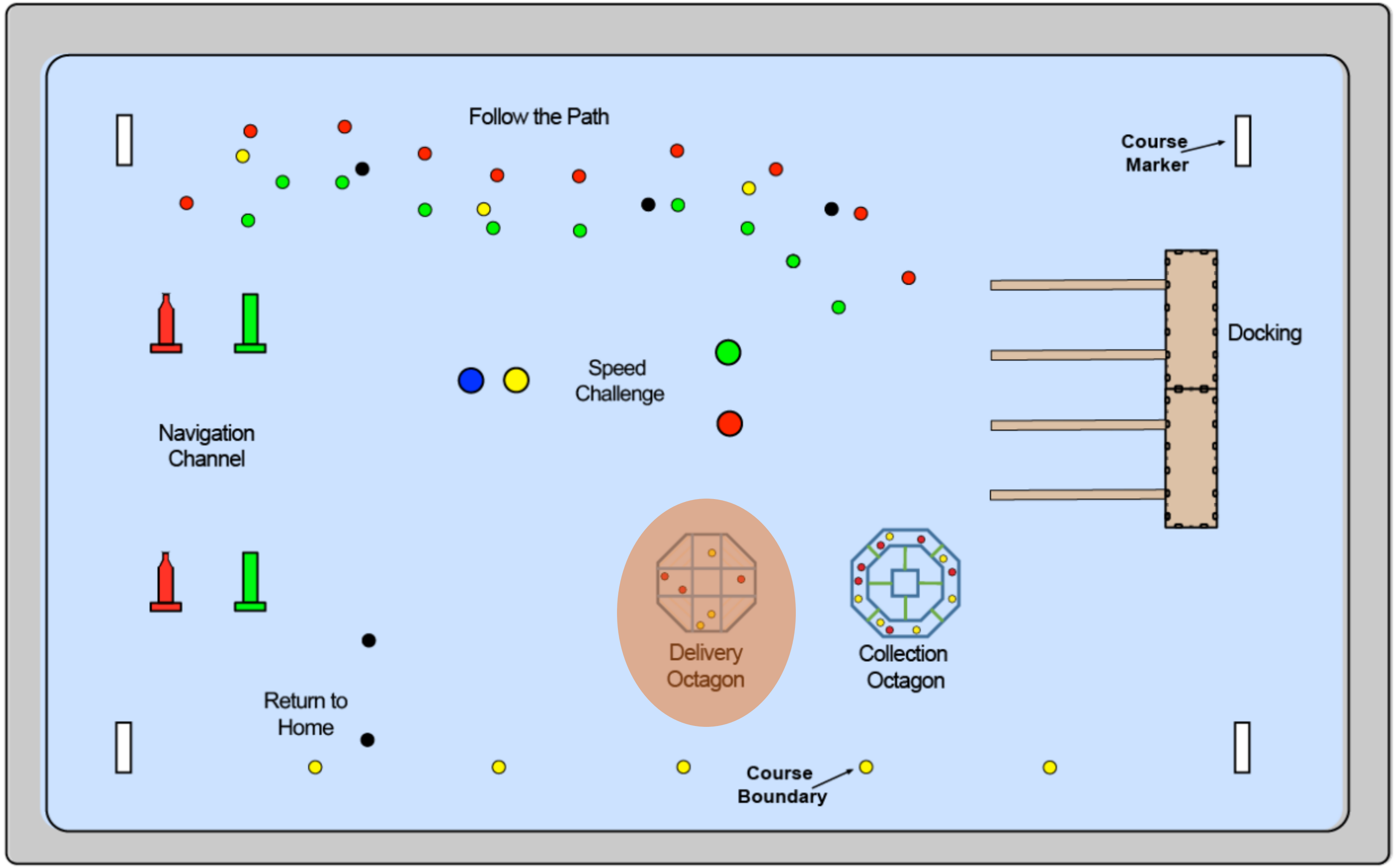

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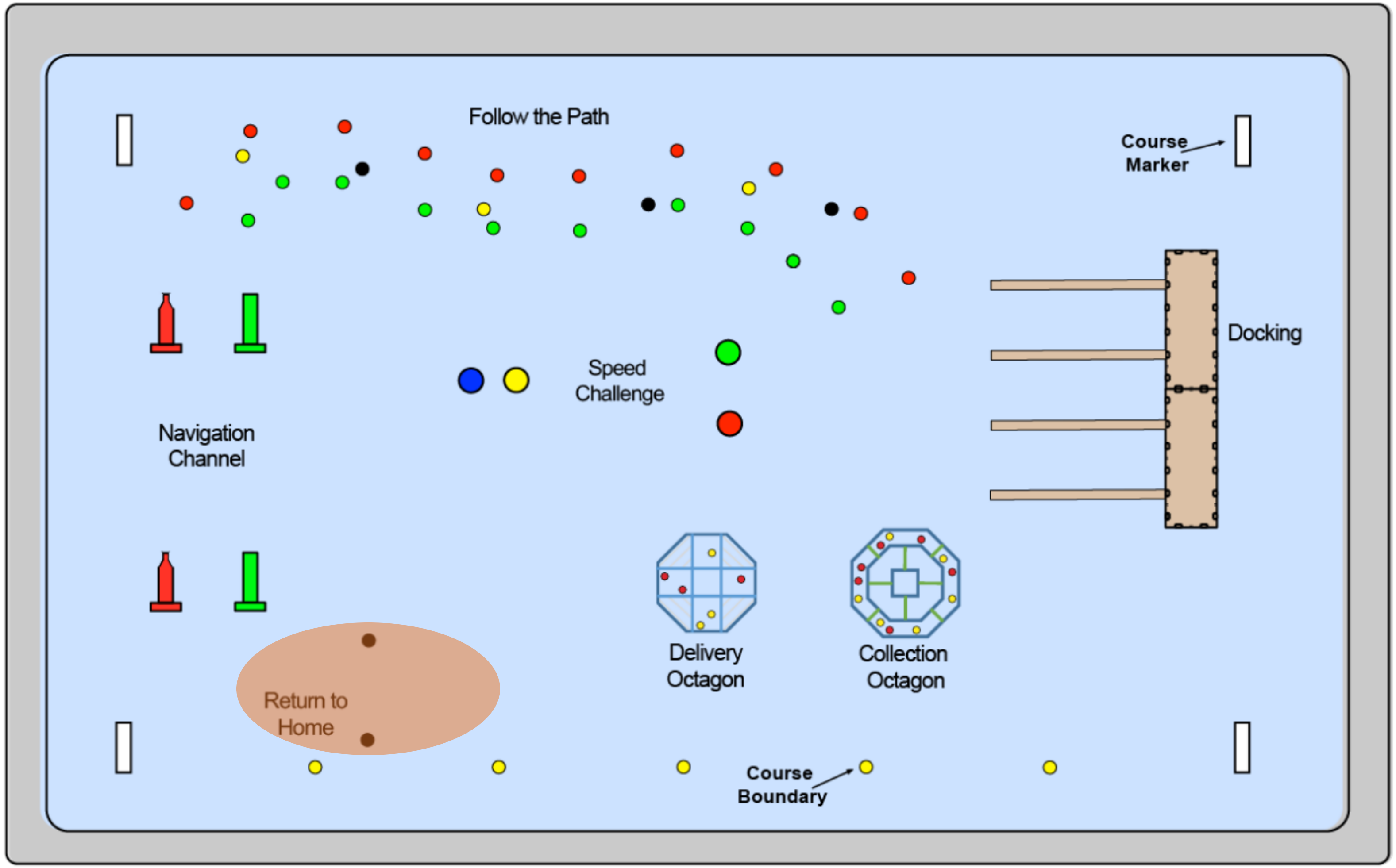

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System: Structure

Function	Target	Metric
Length	3.94(ft)	size
Width	2.58(ft)	size
Height	2.445(ft)	size
Weight	63.25(lbs)	weight
Buoyancy	300N	force
Deflection Angle	15 degrees	angle

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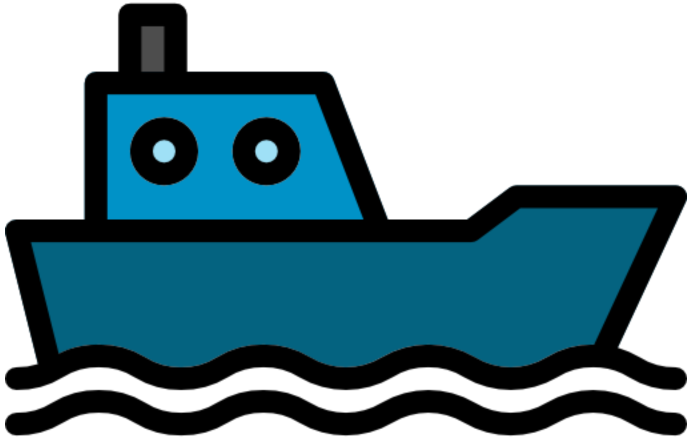
System: Locomotion

Function	Target	Metric
Speed	>=1.515 (m/s)	velocity
Acceleration	0.25 (m/s)	acceleration
Thrust	14.6 (lbs)	force



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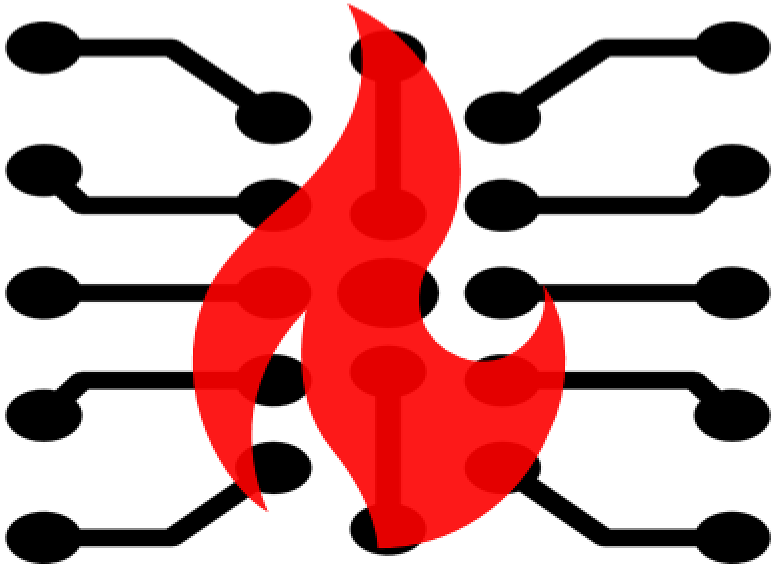
System: Safety

Function	Target	Metric
Kill switch response time	0.25(s)	time
Manual-Remote kill switch integration	True	Boolean



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System: Navigation

Function	Target	Metric
Cross-track error of navigating to a destination	2(m)	length
Boat localization error	< 5(m)	length

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System: Power Systems

Function	Target	Metric
Battery size	22000(mAh)	Charge capacity
Battery life	1 (hr)	Time
Capability of tracking battery life	True	Boolean

System: Object Detection

Function	Target	Metric
Camera Resolution	1920x1080 (pixels)	Number of Pixels
Range of object detection	25(m)	Length
Accuracy of detecting color	95%	Percent Error
Capability of identifying different objects	Min. Of 6 objects	Number of objects

Ivanna Caballero

System: Object Detection

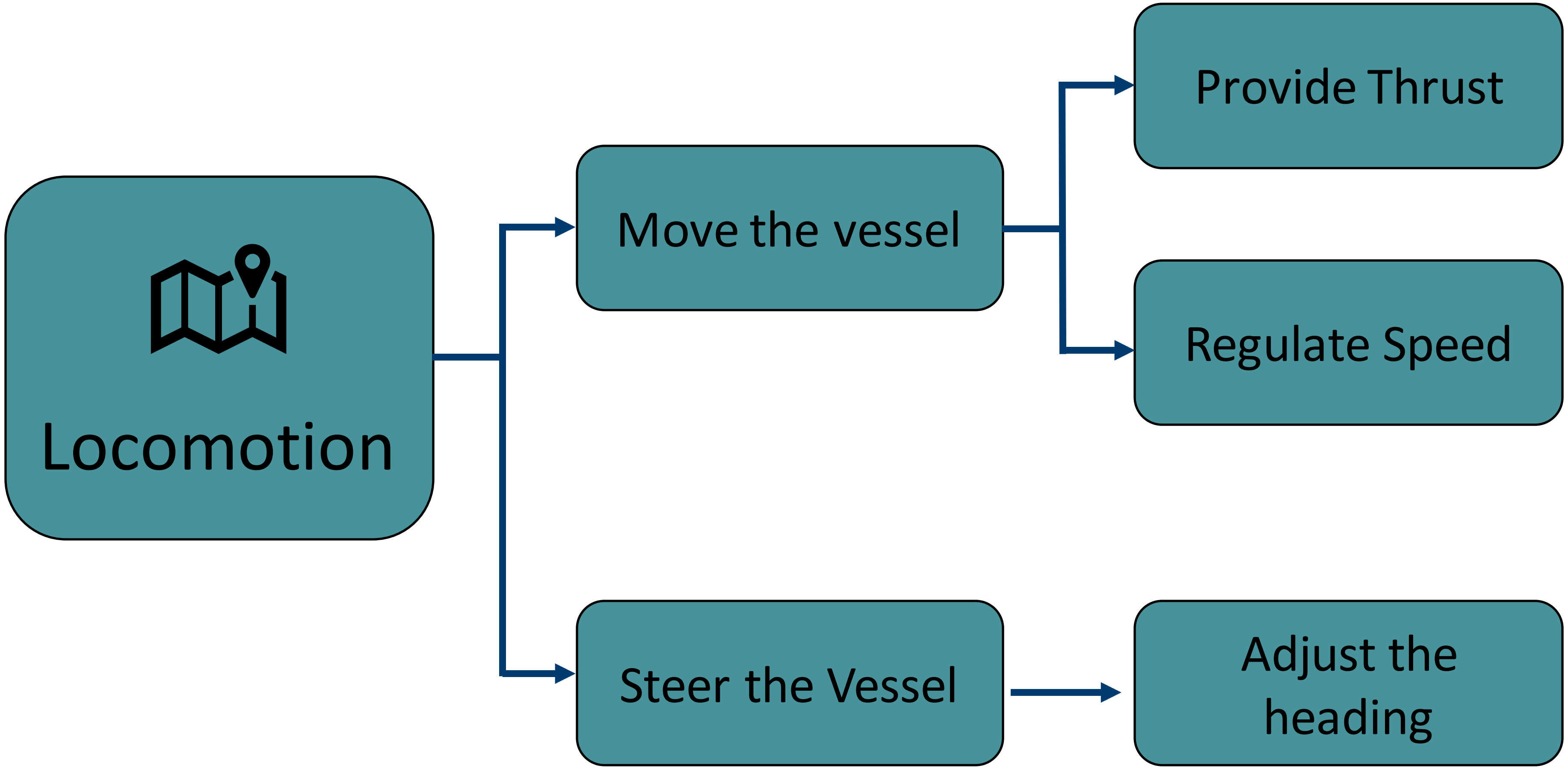
Function	Target	Metric
Camera Resolution	1920x1080 (pixels)	Number of Pixels
Range of object detection	25(m)	Length
Accuracy of detecting color	95%	Percent Error
Capability of identifying different objects	Min. Of 6 objects	Number of objects

Sophia Barron

Functional Decomposition

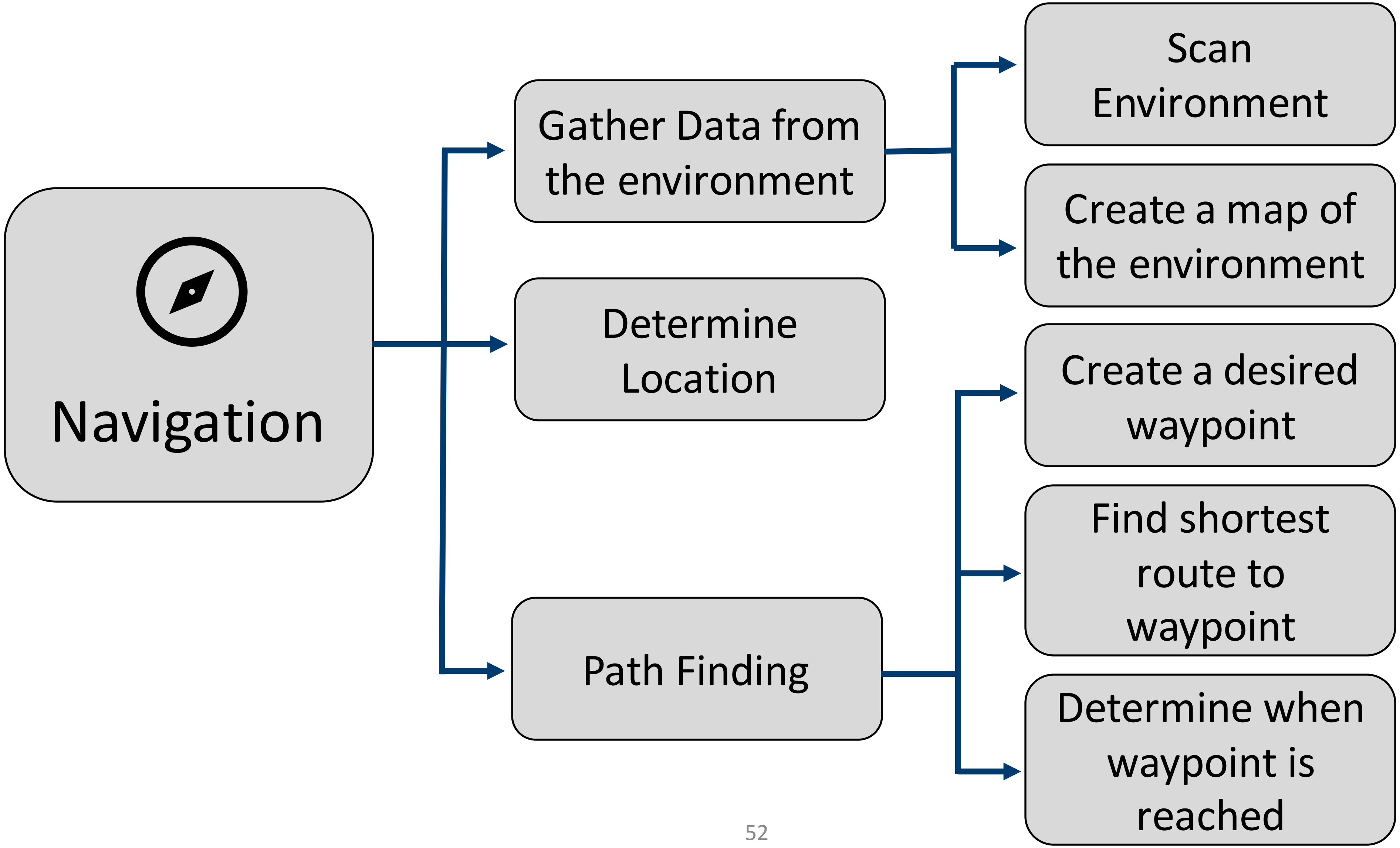
- Locomotion
- Navigation
- Structure
- Power Systems
- Safety
- Object Retrieval
- Water Spraying
- Object Detection

Functional Decomposition



Sophia Barron

Functional Decomposition



Navigation

Gather Data from the environment

Scan Environment

Create a map of the environment

Determine Location

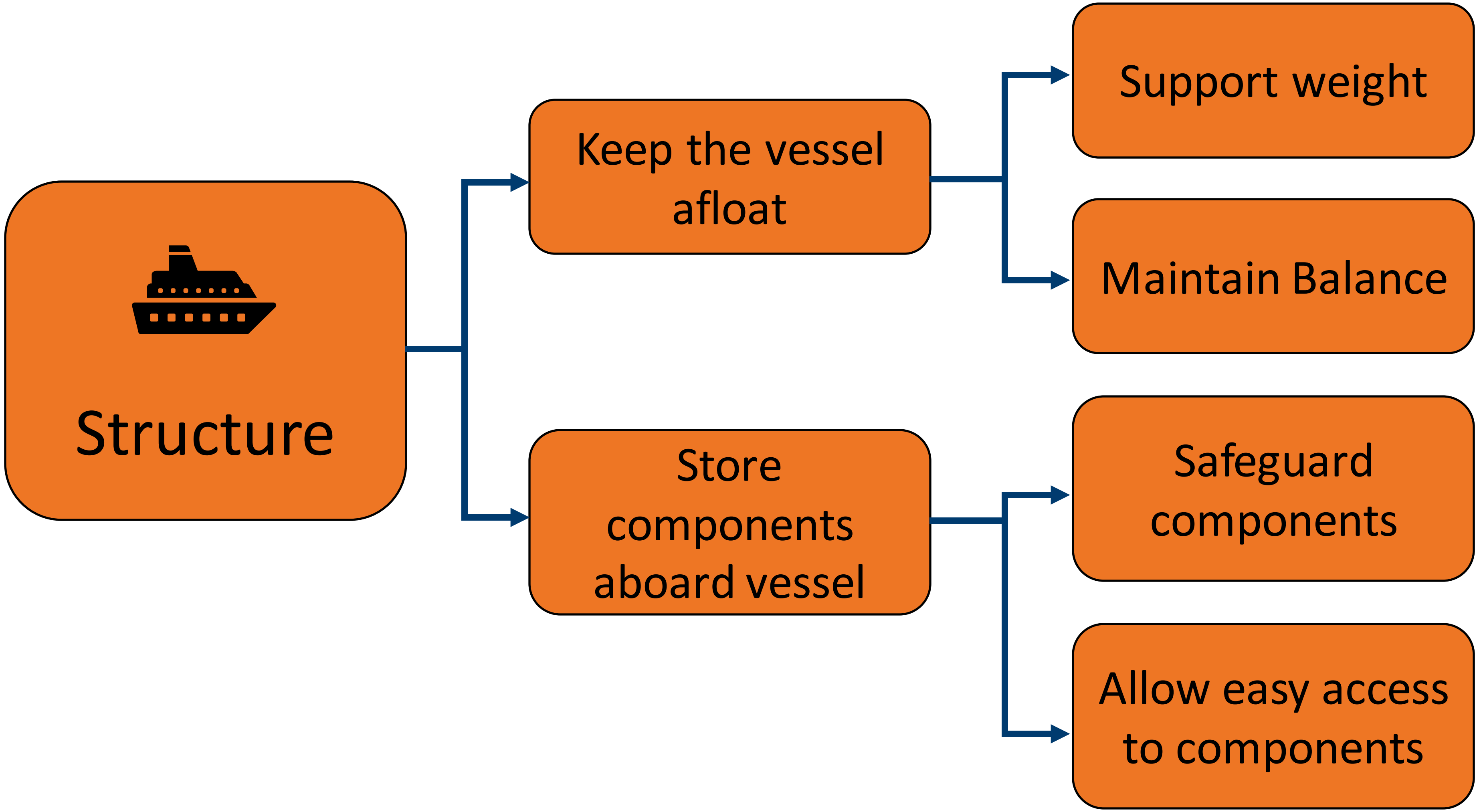
Path Finding

Create a desired waypoint

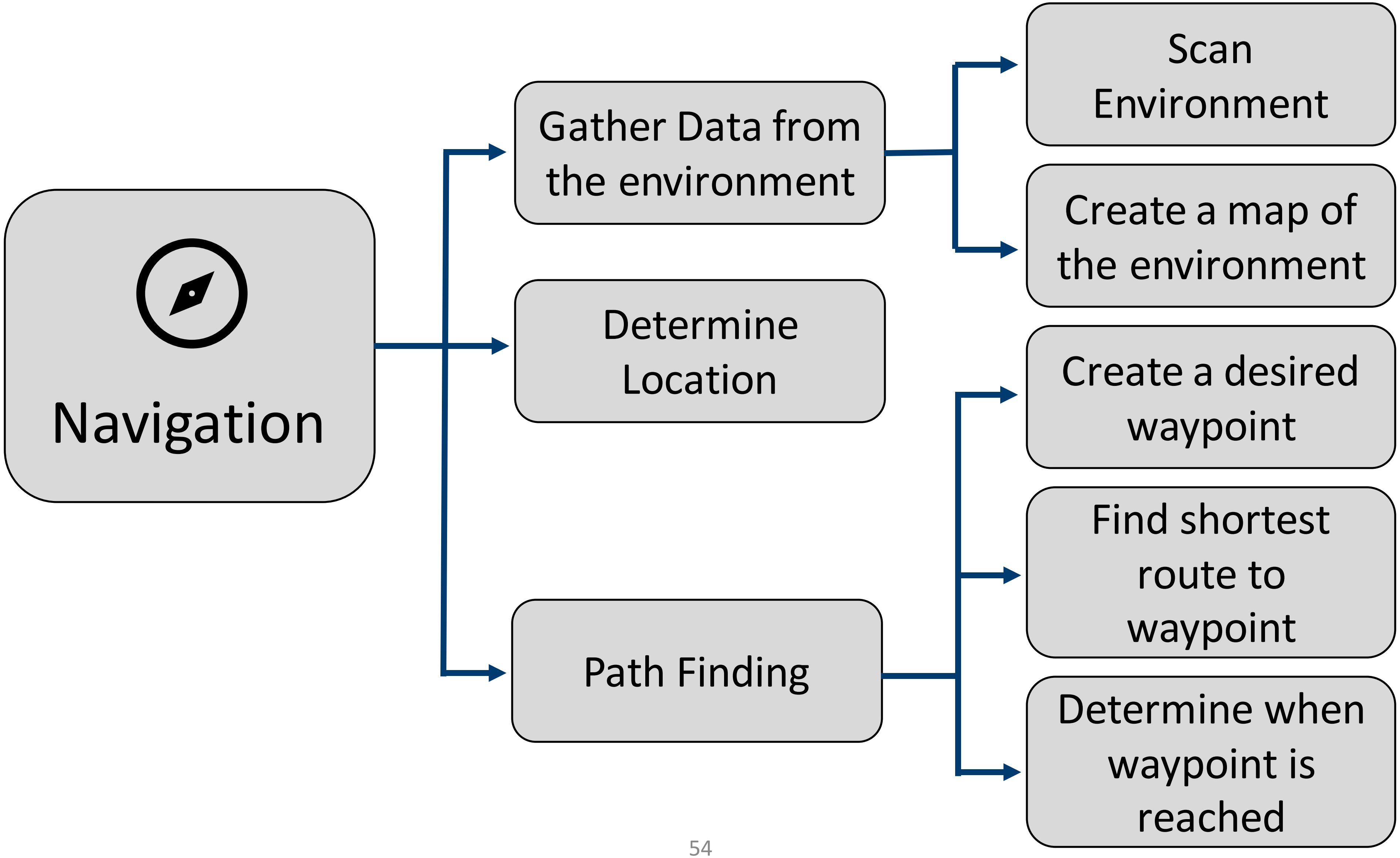
Find shortest route to waypoint

Determine when waypoint is reached

Functional Decomposition



Functional Decomposition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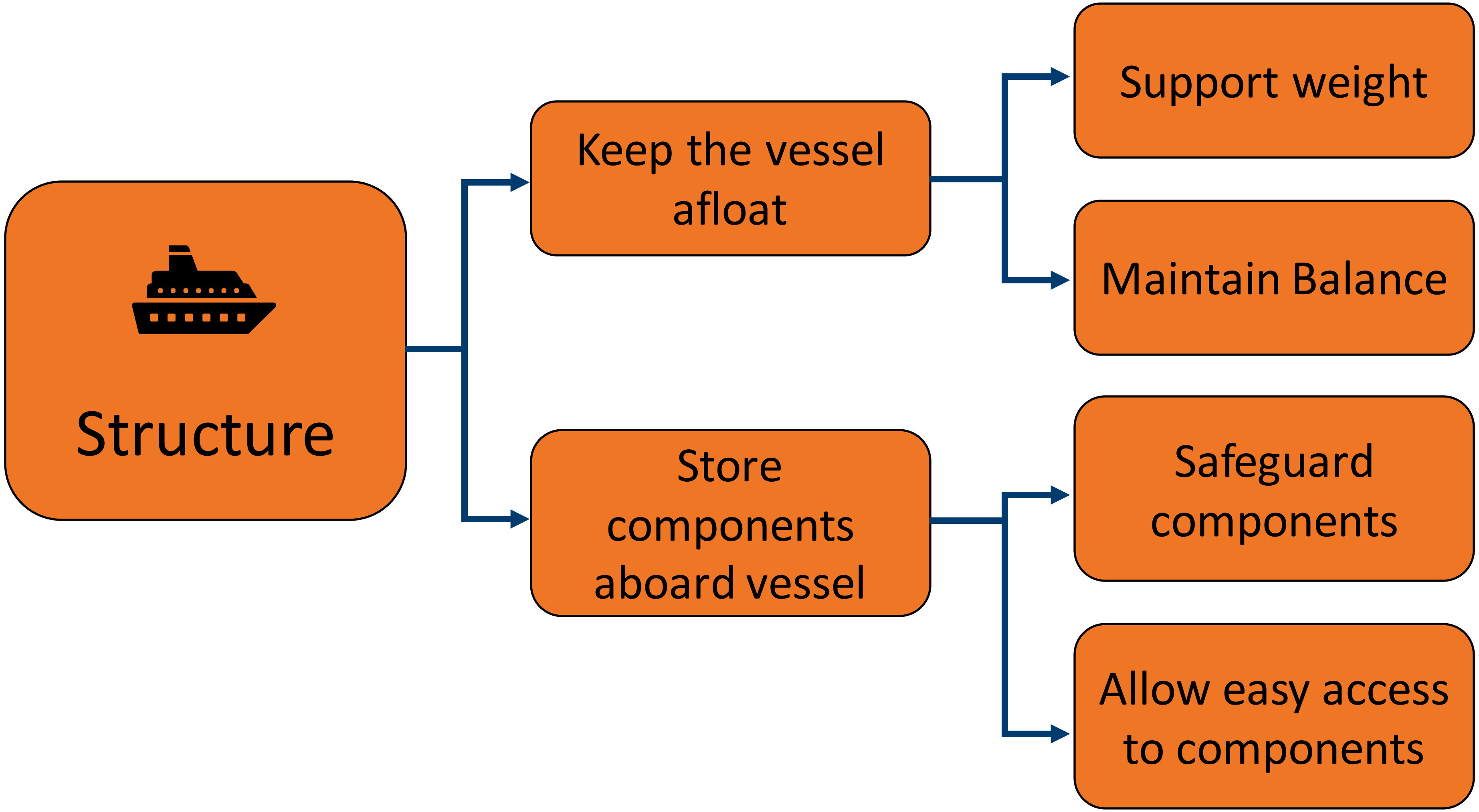

Structure

Keep the vessel afloat

Store components aboard vessel

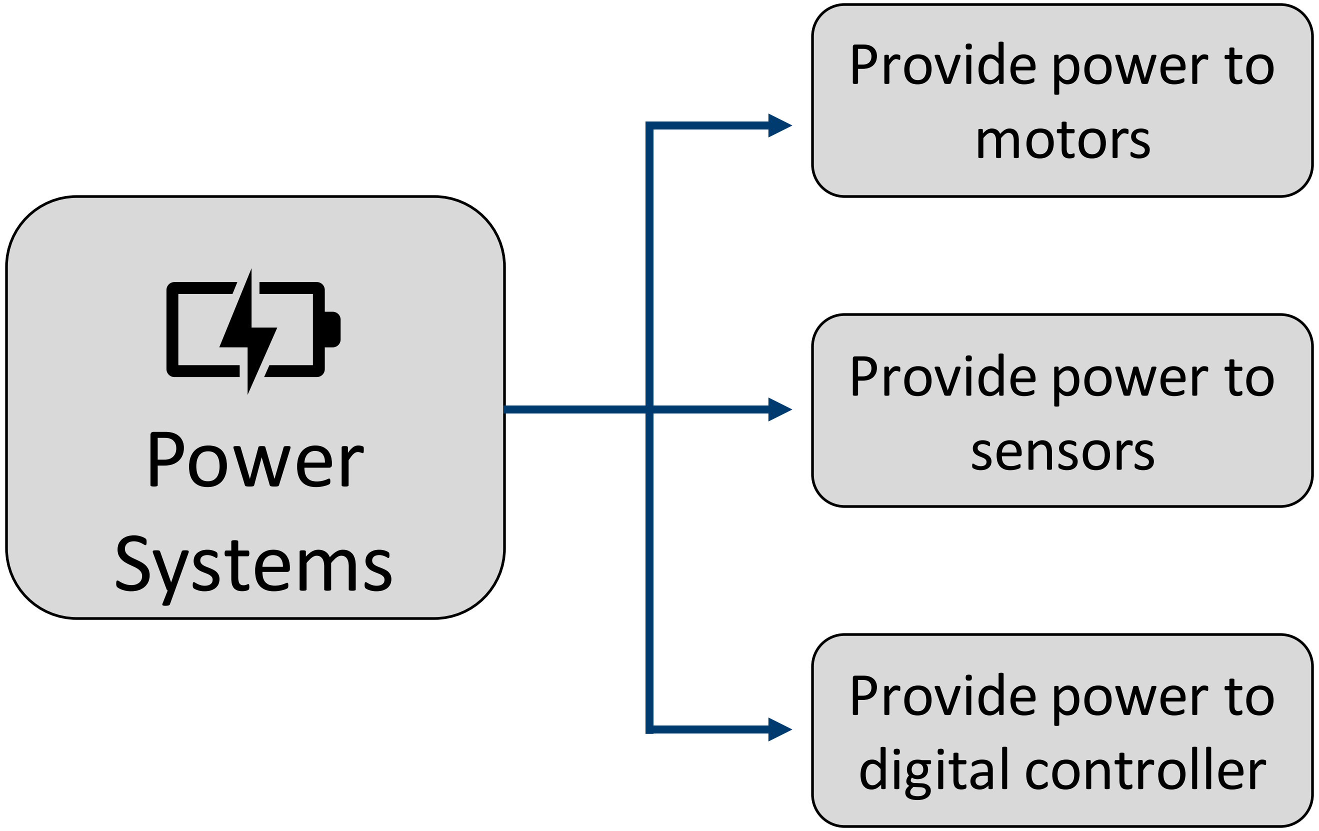
Support weight

Maintain Balance

Safeguard components

Allow easy access to components

Functional Decomposition



Power Systems

Provide power to motors

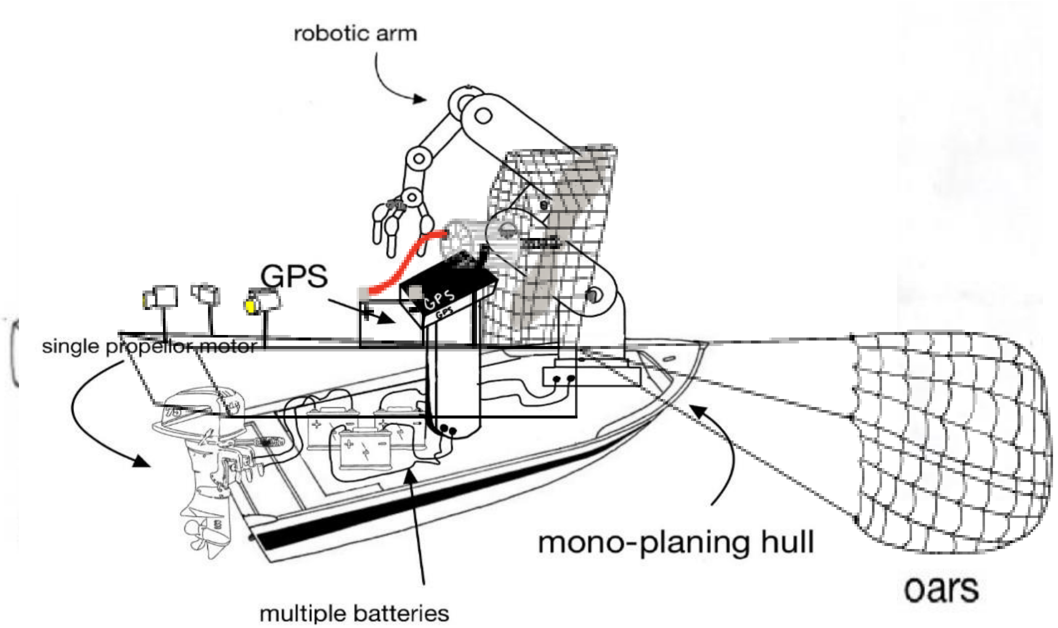
Provide power to sensors

Provide power to digital controller

Medium Fidelity Concepts

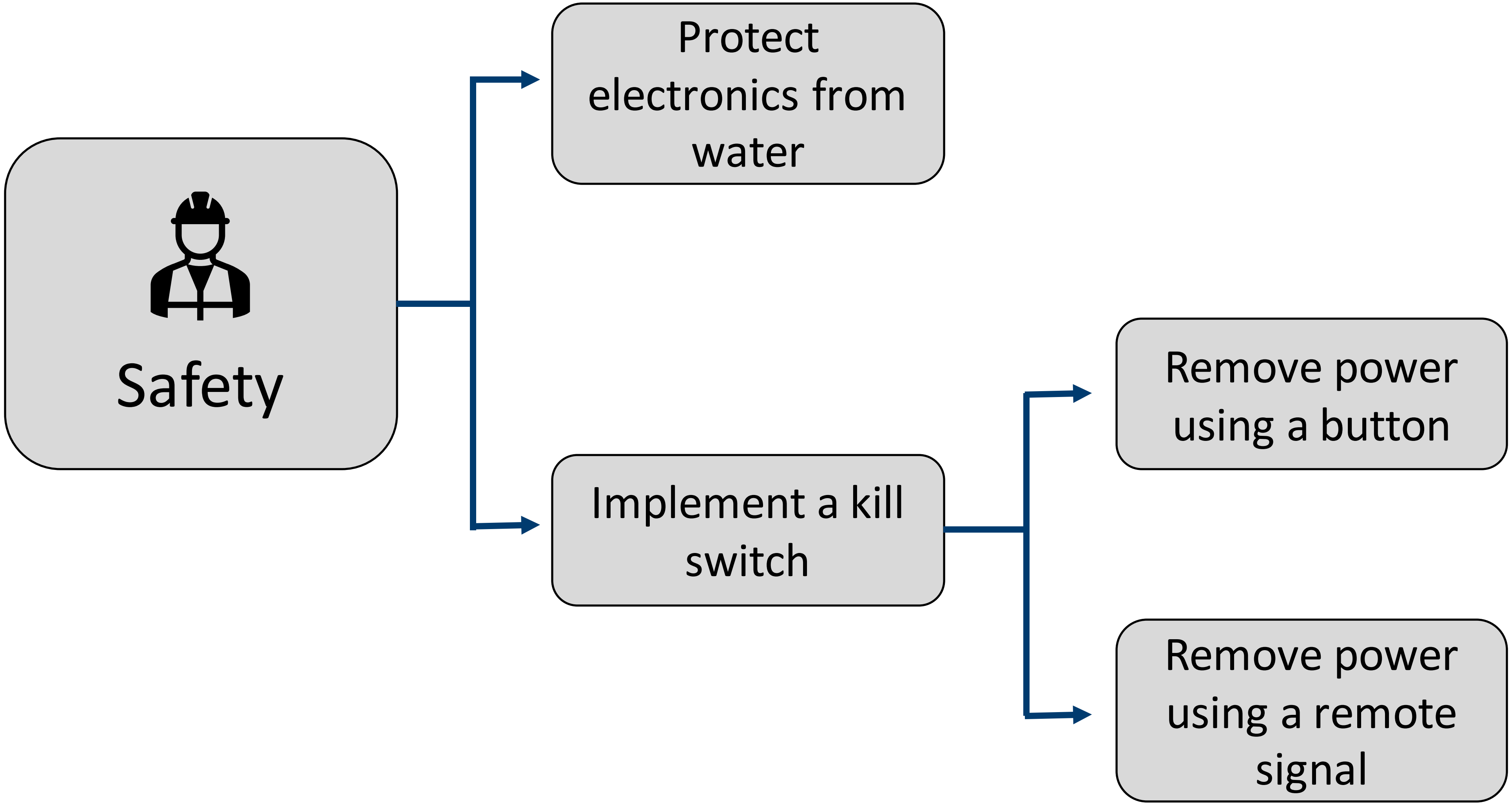
- S.S. Galley
- S.S. Ordonomy
- S.S. Hooker V1
- S.S. Air Goose
- S.S. Ol’ John

S.S. OL’ JOHN



Sophia Barron

Functional Decomposition



Safety

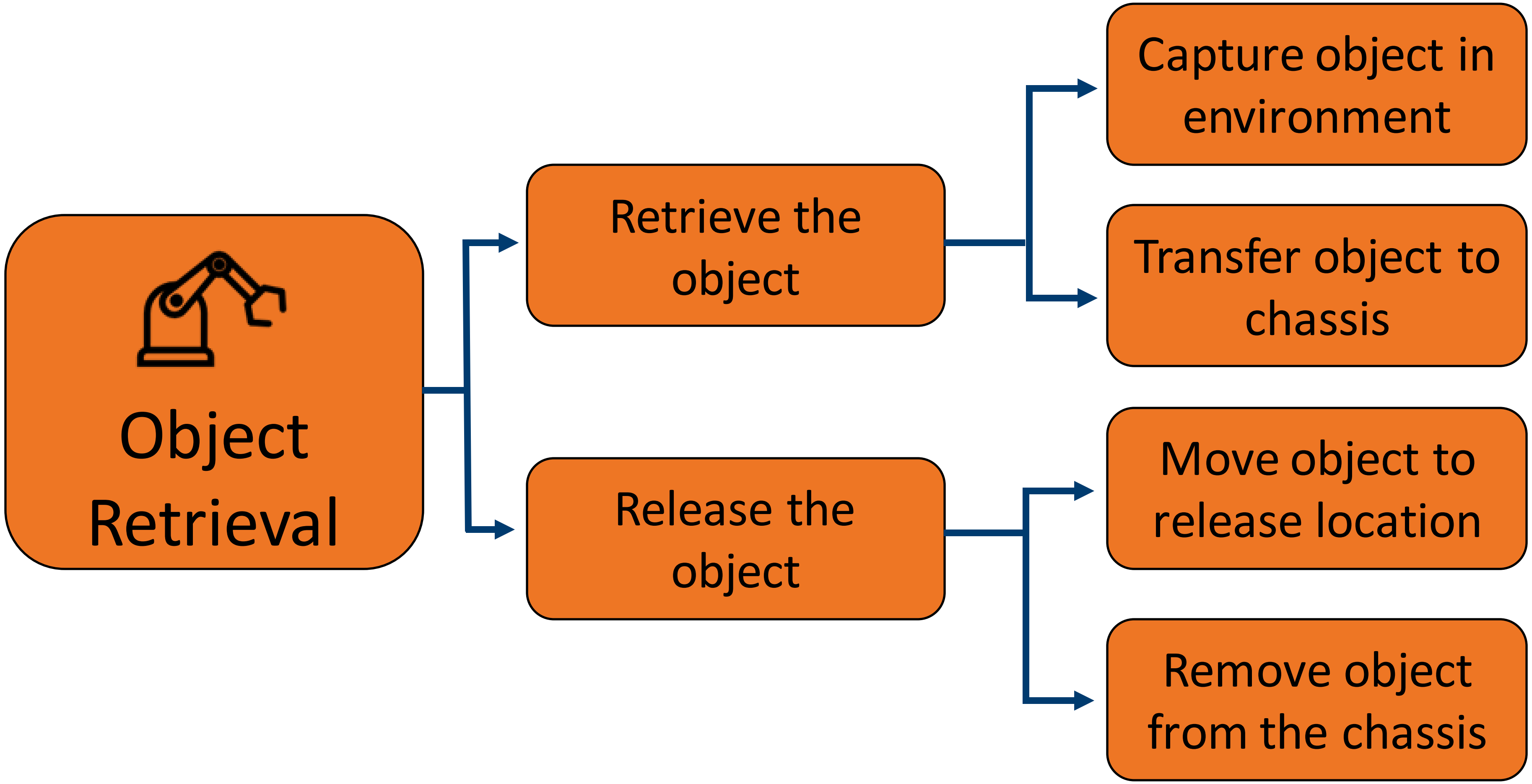
Protect electronics from water

Implement a kill switch

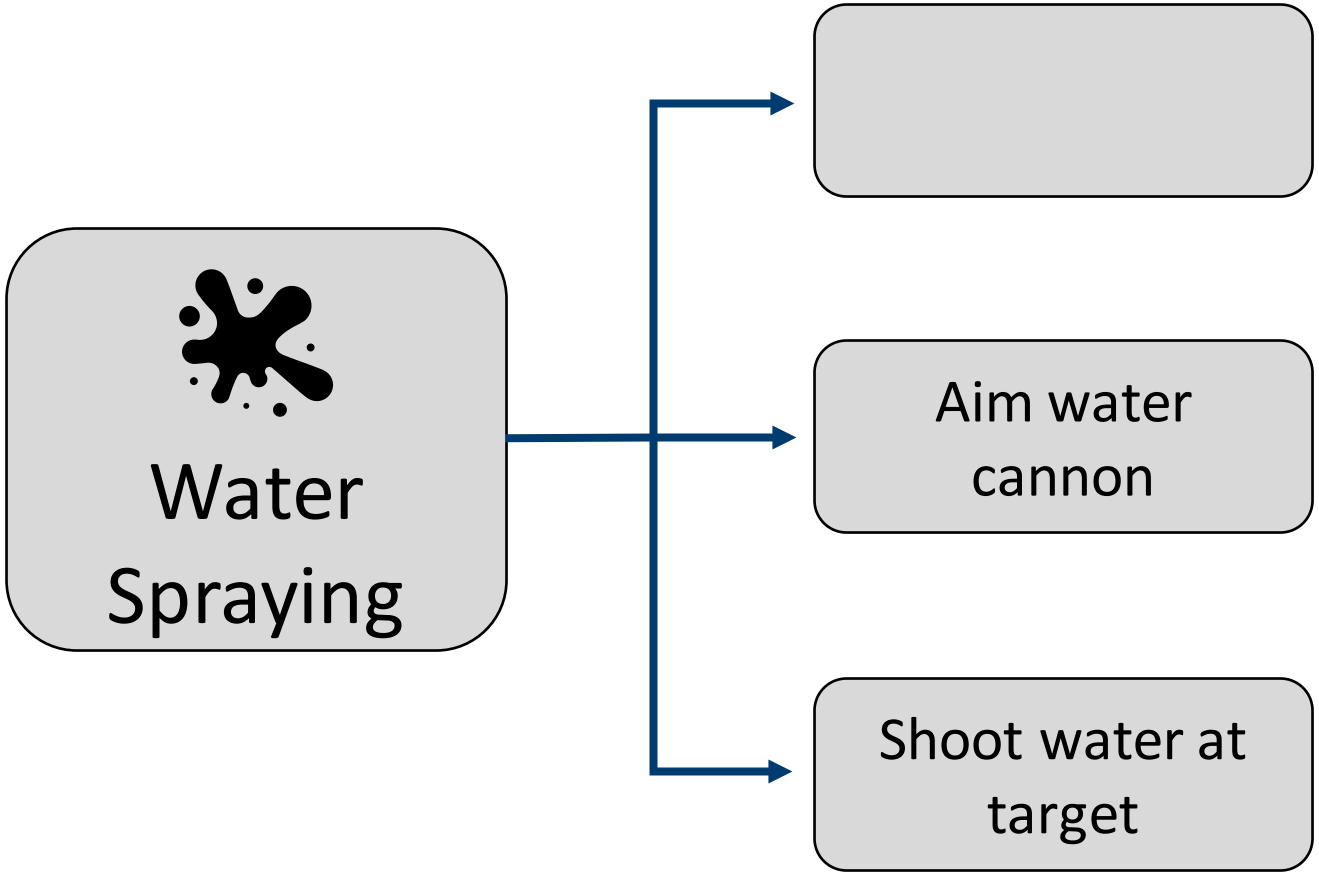
Remove power using a button

Remove power using a remote signal

Functional Decomposition


Object Retrieval
Retrieve the object
Release the object
Capture object in environment
Transfer object to chassis
Move object to release location
Remove object from the chassis

Functional Decomposition



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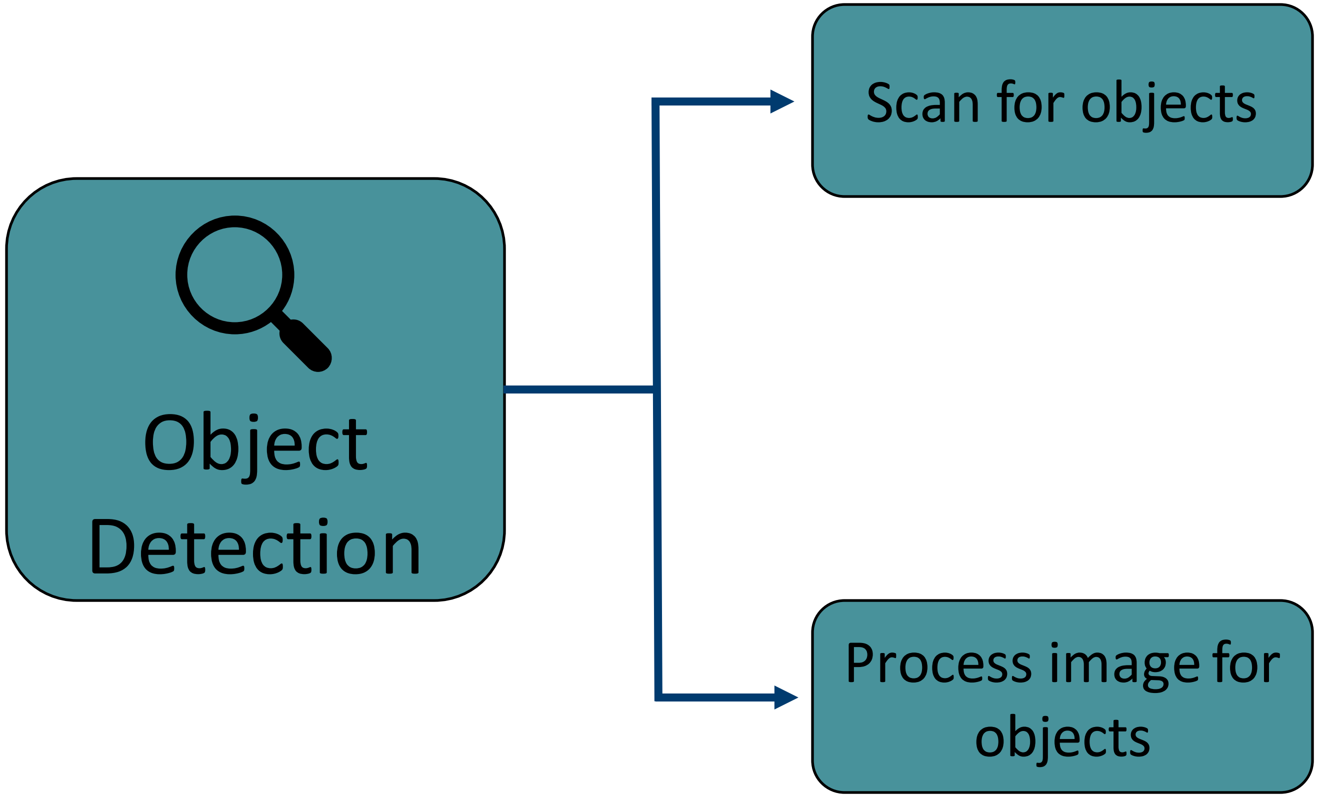
Functional Decomposition



Object Detection

Scan for objects

Process image for objects

Near Future Work

- Start working on robot localization
  - Test different GPS module (found in Senior design room)
  - Draft navigation code diagram
  - Test different obstacle aversion methods on prototype
- Test given thrusters (PCB Campus)
- Start drafting and testing kill switches
  - Remote with RC transmitter
  - Physical with push button

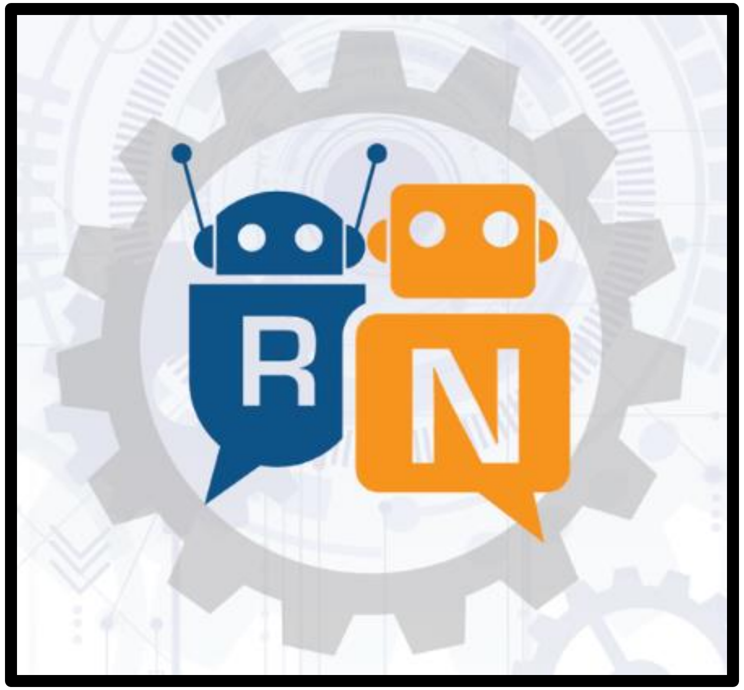
Future Work

- Start working on materializing chosen structural design
- Start working on camera object detection
  - Geometric segmentation: Recognizing shapes
  - Semantic segmentation: Object class (Ducks, buoy, etc)
- Integrate different functional systems
  - I.e navigation w/ locomotion and object detection
- Preliminary electrical calculations/schematics
  - Power supply calculations
  - Overall block diagrams
- Finalize first draft of test code for the Autonomous navigation portion of ASV

Ivanna Caballero

Primary Markets

NAVSEA
NAVAL SEA SYSTEMS COMMAND



Ivanna Caballero

Secondary Markets

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Ivanna Caballero

Stakeholders

NAVSEA
NAVAL SEA SYSTEMS COMMAND

FAMU-FSU College of Engineering

Markets

NAVSEA
NAVAL SEA SYSTEMS COMMAND

R
N

RoyalCaribbean

INSANE
BOATS

BOSTON
WHALER
®

UNITED STATES COAST GUARD
1790

Michael Fitzsimmons

Medium Fidelity Concepts

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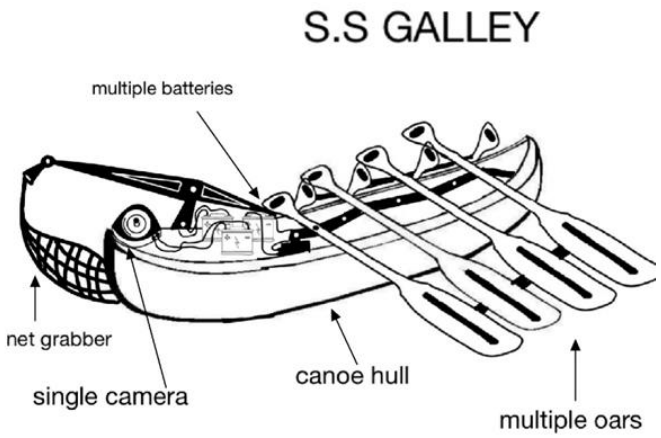
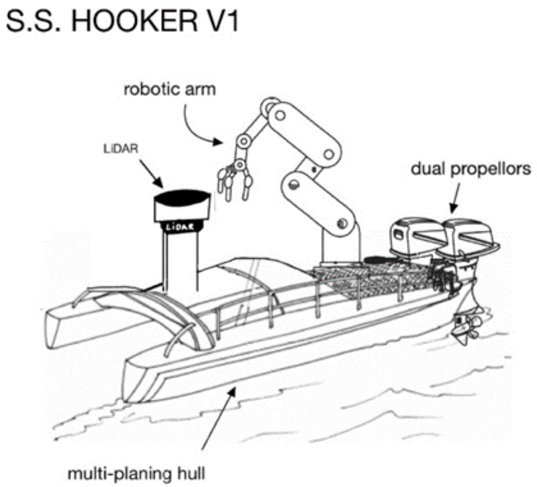
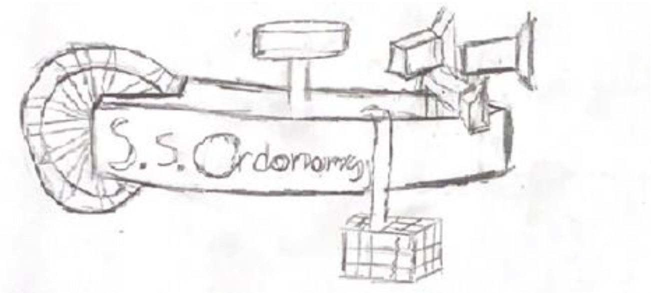
S.S Galley



S.S Hooker V1



S.S Ordonomy



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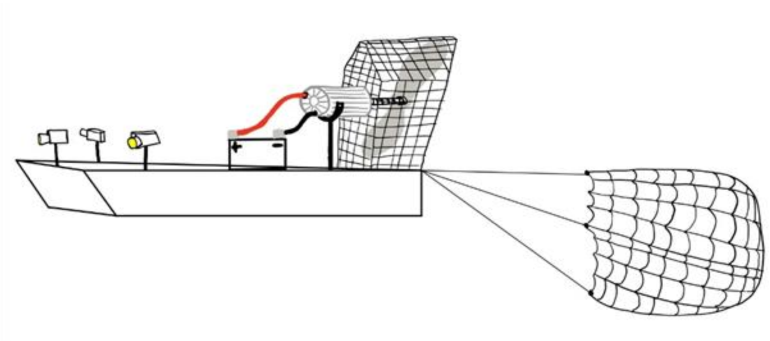
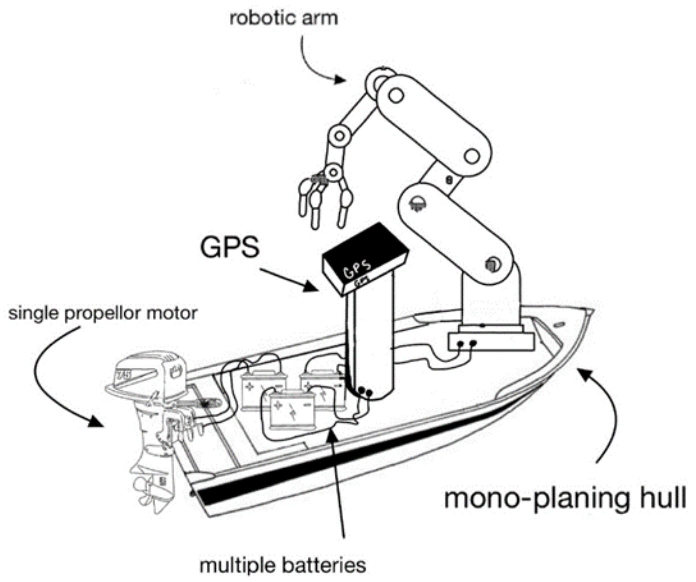
S.S Air Goose



S.S Ol’ John



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High Fidelity Concepts

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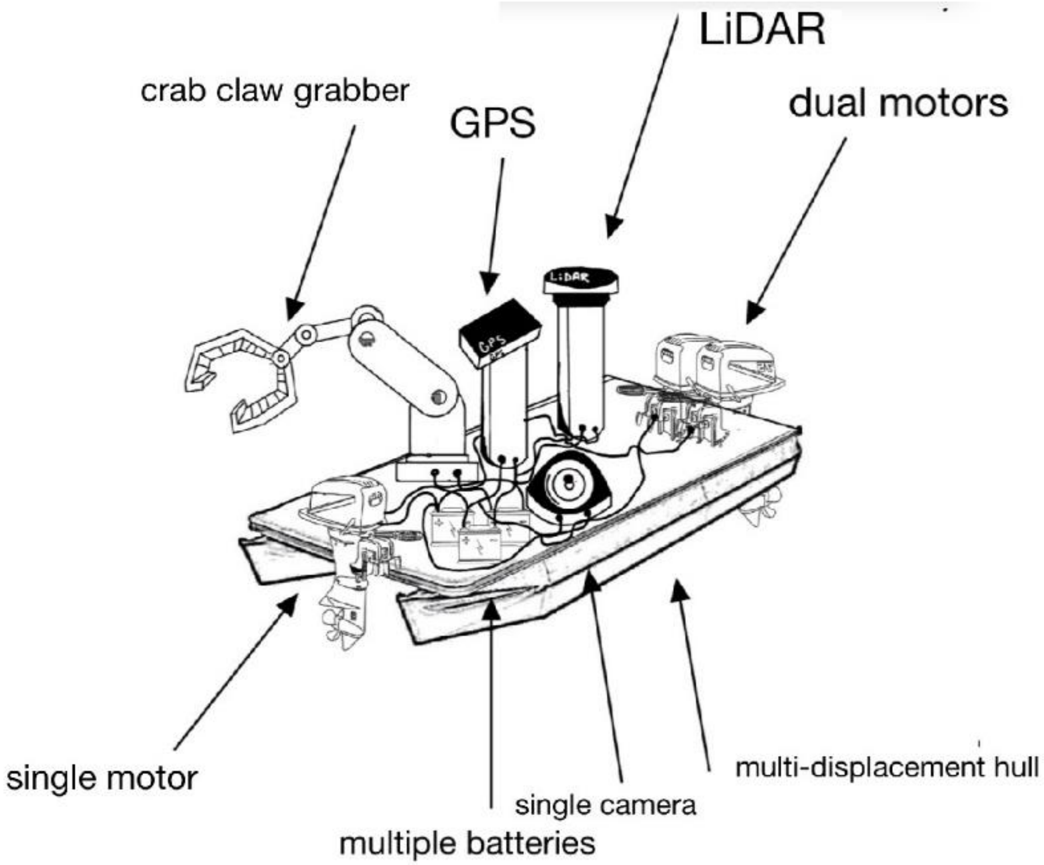
S.S. Shayne 1.0

- Multi-displacement hull
- Dual rear propellers
- Single front propeller
- GPS, camera, and Lidar
- Crab claw grabber
- Multiple batteries



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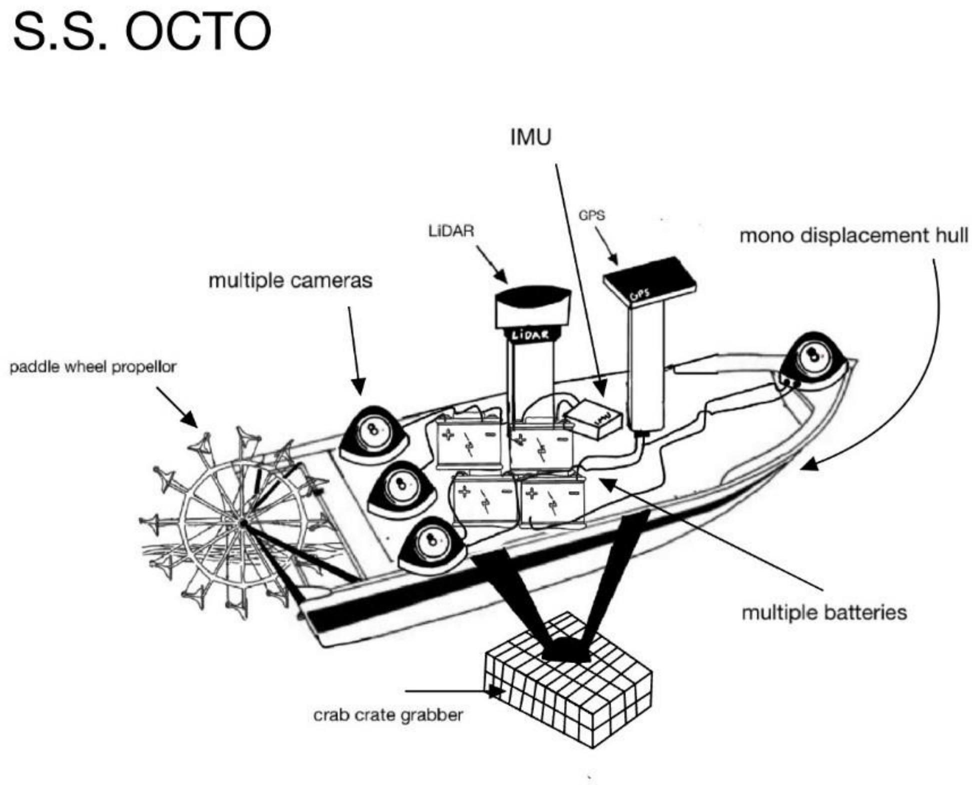
S.S. Octo

- Mono-displacement Hull
- Paddle wheel propeller
- Multiple cameras
- GPS, Lidar, IMU
- Crab crate
- Multiple batteries



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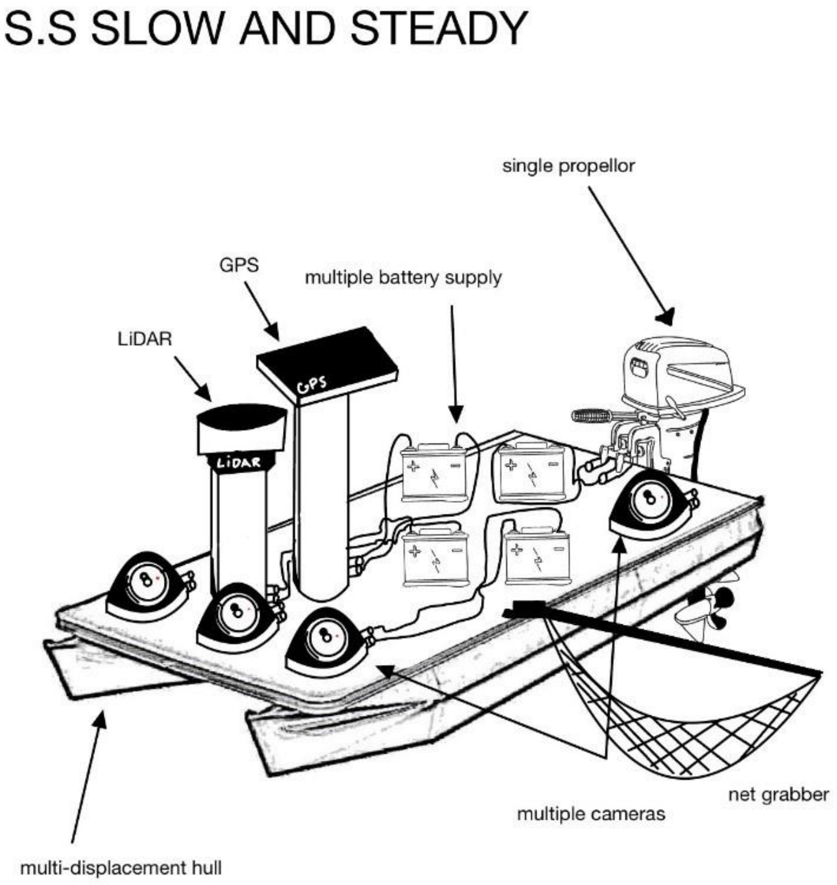
S.S. Slow N' Steady

- Multi-displacement hull
- Single propeller
- GPS & Lidar
- Multiple batteries
- Multiple Cameras
- Net Grabber



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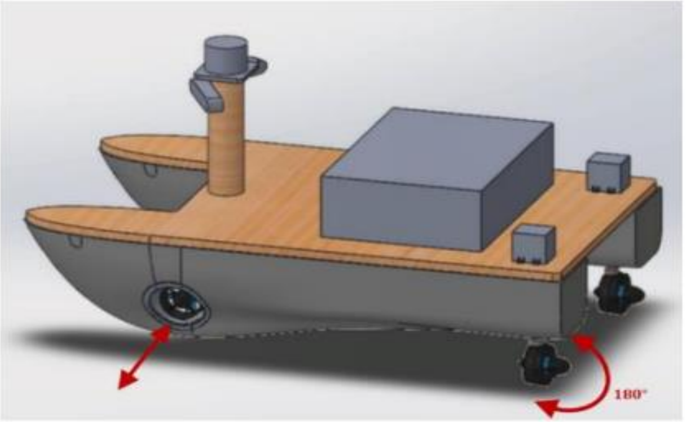
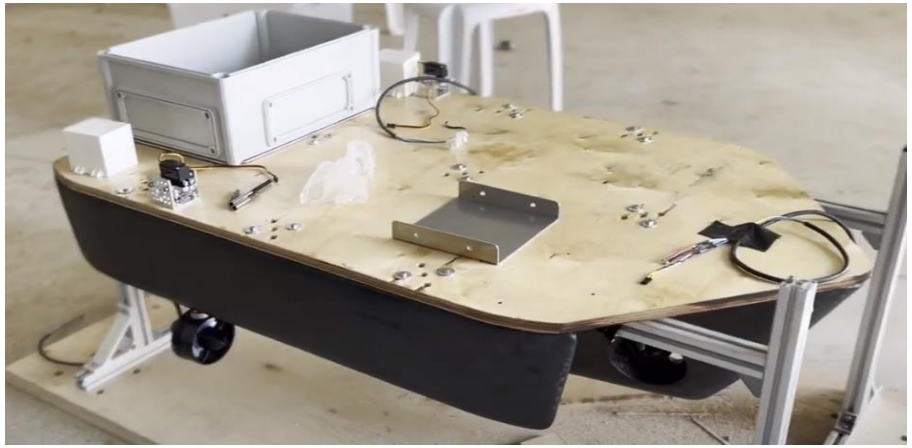
Pugh Charts – Tel Aviv

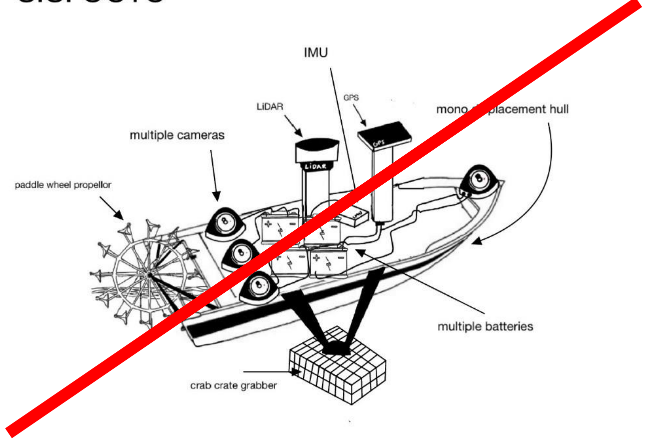




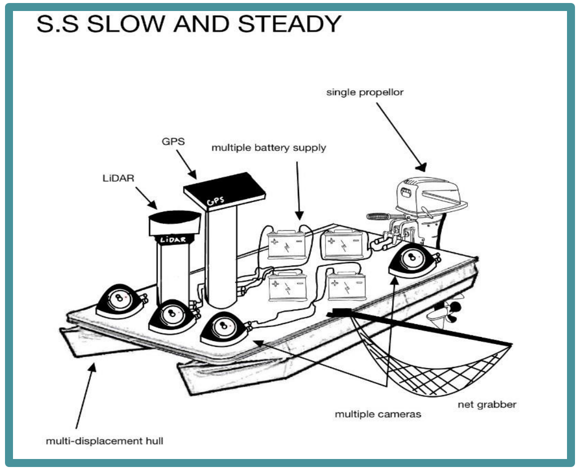
Nicholas Norwood

Pugh Charts – 1st Iteration

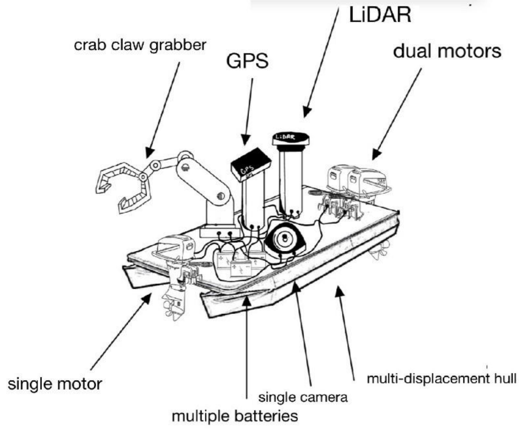
S.S. OCTO



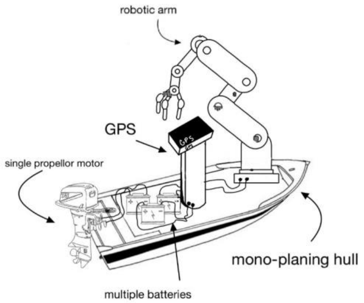
S.S SLOW AND STEADY



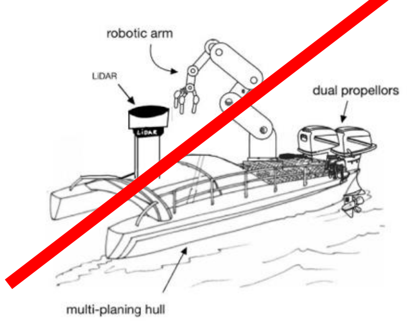
S.S. SHAYNE 1.0



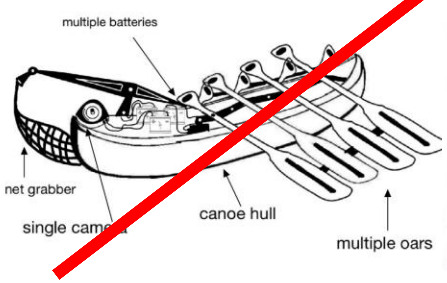
S.S. OL' JOHN



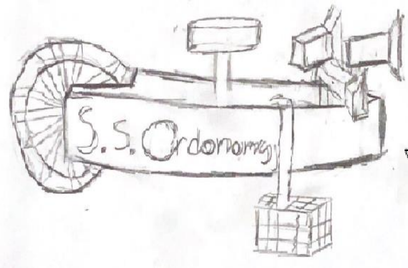
S.S. HOOKER V1



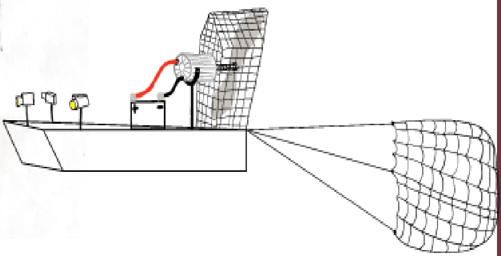
S.S GALLEY



S.S. Ordonomy



S.S. Air Goose



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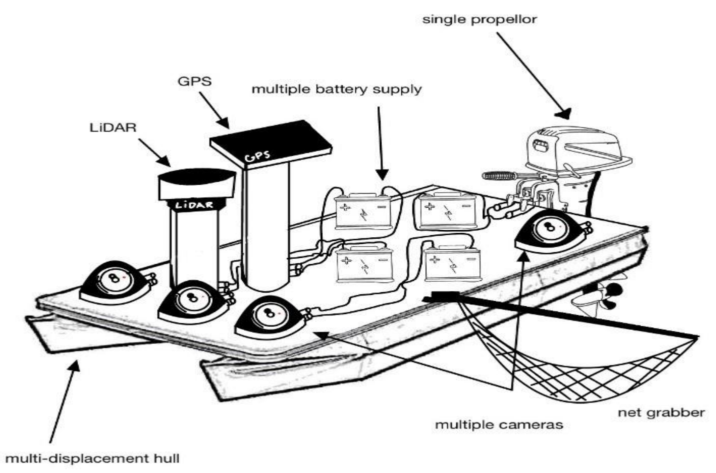
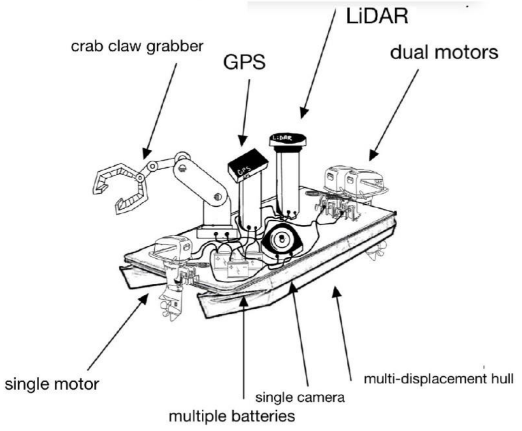
Pugh Charts – 2nd Iteration

New Datum

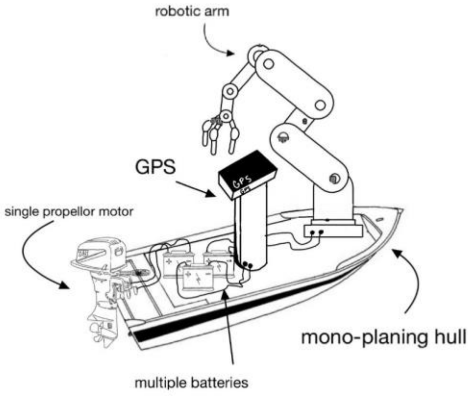
S.S SLOW AND STEADY



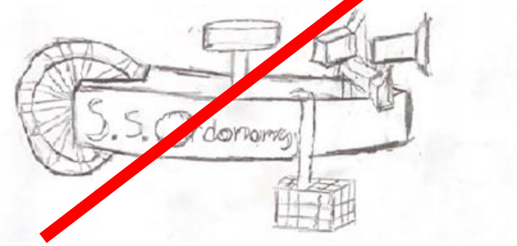
S.S. SHAYNE 1.0



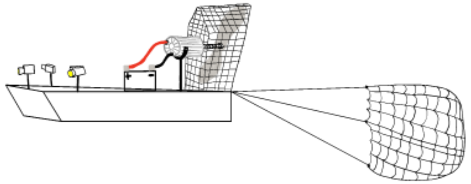
S.S. OL' JOHN



~~S.S. Ordonomy~~



S.S. Air Goose



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Engineering

Andly Jean

Functional Decomposition

- Locomotion
- Navigation
- Structure
- Power Systems
- Safety
- Object Retrieval
- Water Spraying
- Object Detection

Functional Decomposition

- Locomotion
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Andly Jean

Functional Decomposition

Locomotion	Navigation	Structure	Power Systems
Safety	Object Retrieval	Water Spraying	Object Detection

Functional Decomposition

- Locomotion
- Navigation
- Structure
- Power Systems
- Safety
- Object Retrieval
- Water Spraying
- Object Detection

Michael Fitzsimmons

Concept Generation

100 Concepts

5 Medium Fidelity

3 High Fidelity

Critical Targets and Metrics

Why Critical Targets Matter:

Foundation for Success

Enhanced Efficiency

Enhanced Safety

Michael Fitzsimmons

Methods used

Biomimicry

Anti-Problem

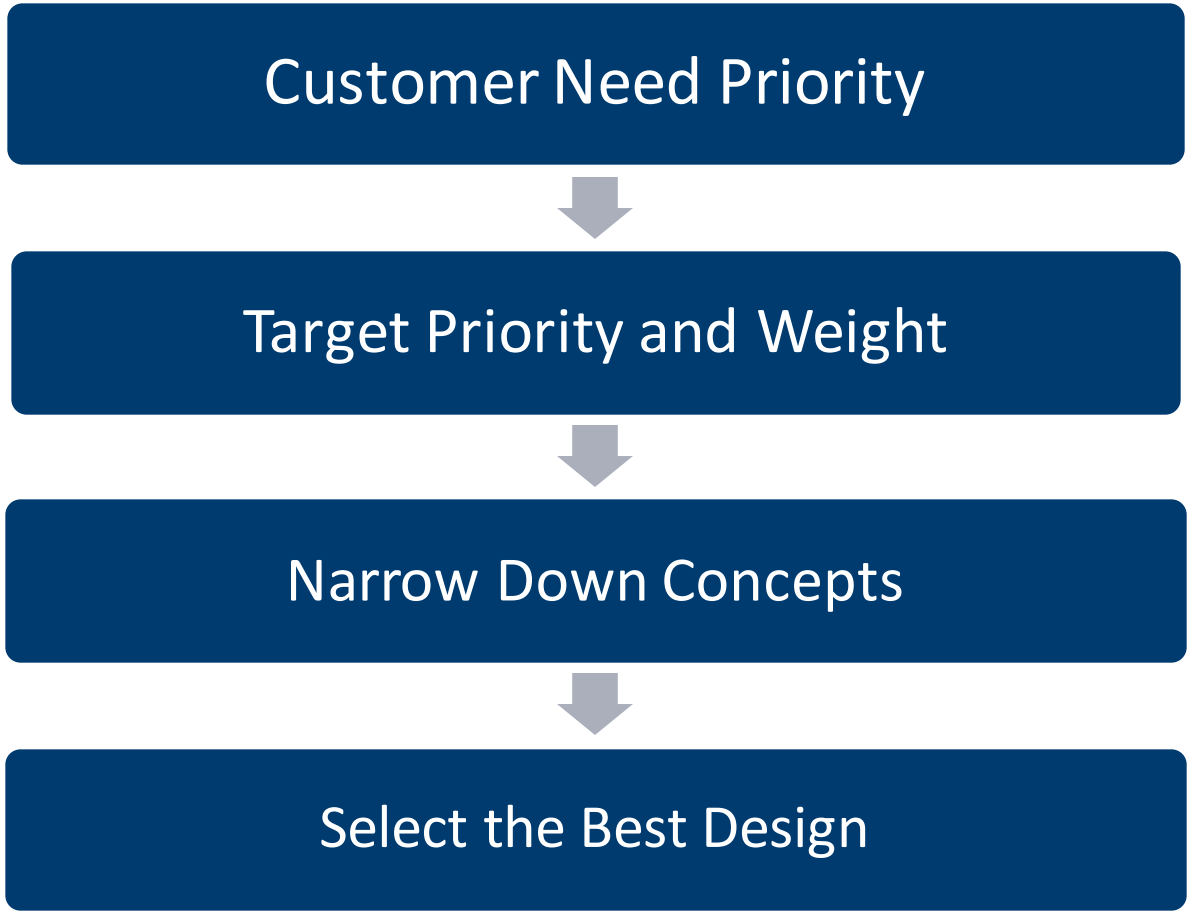
Crap Shoot

Forced Analogy

Morphological Charts

Nicholas Norwood

Concept Selection



Customer Need Priority

Target Priority and Weight

Narrow Down Concepts

Select the Best Design

Nicholas Norwood

Concept Selection

Customer Needs	Weight
Stability	9
Cost Stays Within Budget	8
Modular Components	6
Weight	6
Size Within Competition Rules	5
Navigation	5
Run Time	3
Object Detection	2
Autonomy	1
Object Retrieval	0

Target	Priority
Battery Power	1
Buoyancy	2
Sensor Resolution	3
Size	4
Weight	5
Navigation	6
Deflection Angle	7

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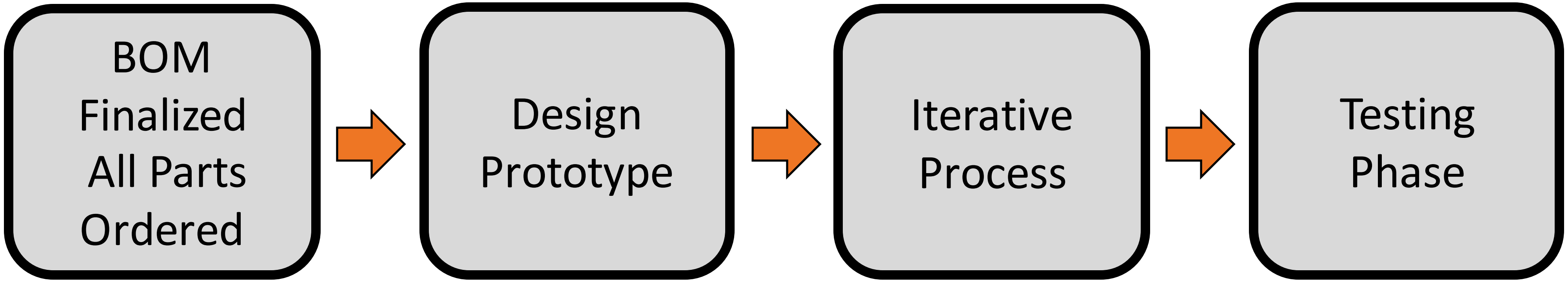
Future Work and Timeline



BOM Finalized All Parts Ordered → Design Prototype → Iterative Process → Testing Phase

- This is 10-point
- This is 15–point Times
- This is 20–point
- This is 25–point
- This is 30–point
- This is 35–point
- This is 40–point
- This is 50–point
- This is 60–point