presented by

ECHO TECHNOLOGIES

Systems Performance Specifications

15 November 2018

WHAT IS ECHO?

ABOUT US

- Year-long engineering senior capstone class and team
- 34 students per team that research, design, construct, and test a solution to an open-ended engineering problem
- Entirely student-led

This program is designed to...

- combine research, academic study, collaboration and discovery-based learning in an interdisciplinary environment
- inspire each student to develop the confidence and ability to embrace the challenges of the future and to work toward the betterment of the human condition

Design of a product,

development of a person.

VISION STATEMENT

To create **ideas worth hearing** that inspire the communities we serve, through the products we develop, and the leaders we cultivate.

MISSION STATEMENT

ECHO Technologies seeks to **surpass industry standards** and **achieve excellence** as an engineering business by **promoting student-led discovery** in the development of technical solutions, education of communities, and the growth of individual persons.

ECHO TECHNOLOGIES

TEAM BREAKDOWN

53%

47%

Project Manager

Deputy Project Managers

Chief Scientist

Chief Financial Officer

Director of Mechanical Engineering

Director of Electrical Engineering

Director of Systems Engineering

Director of Manufacturing

Director of Programming

Director of Outreach

Director of Media

Director of Interns

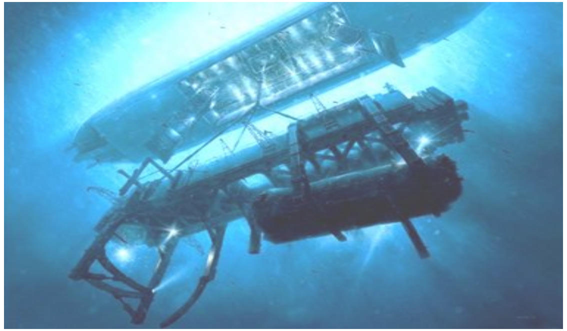
Members of the Technical Staff

MISSION OVERVIEW

EXECUTIVE SUMMARY
(PROBLEM STATEMENT)

The CIA failed to completely recover a valuable Soviet submarine with nuclear capabilities from the ocean floor. As a ship was raising the K-129 from the ocean floor, it broke apart and part of the submarine was lost, including its cargo.

ECHO Technologies is tasked to design, model and test a **UAV/UUV vehicle (Megalodon)** that can **recover the items of interest** from the K-129 after pinpointing a signal from an **ROV vehicle (Remora)** that **locates those items of interest.**



MISSION THEATRE

- Search of Wreckage
- Recovery of items of interest
- Return of Megalodon and Remora

MEGALODON DELIVERABLES

Must...

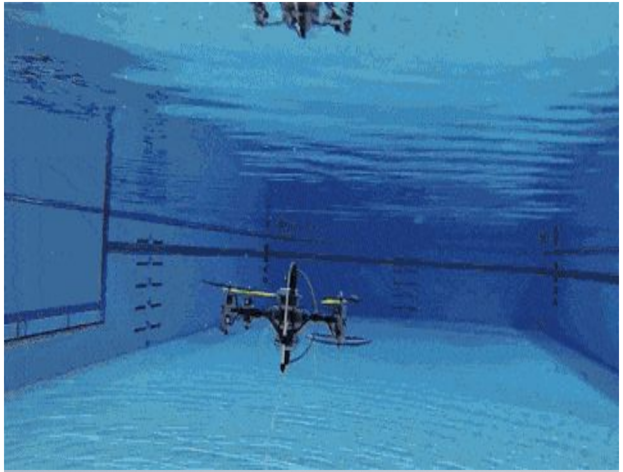
- be completely waterproof.
- be capable of flight, in dual fluid mediums.
- fly 201.9 feet in the air to the pool, locate the pool, and dive into the pool, swimming to the wreckage.
- manipulate recovery articulation.
- be able to detect the beacon of the Remora, and retrieve it, once the salvage operation is complete.
- NOT be tethered

AERIAL SUBSYSTEM

CRITERIA & CONSTRAINTS

Specific System Problems:

- Autonomous flight (with Vision)
  - Automatic Vision Targeting
- Flying a linear distance of 201.9 feet
- Watertight enclosures for diving
- Flight testing and FAA Legalities
- Physical obstructions when flying to body of water

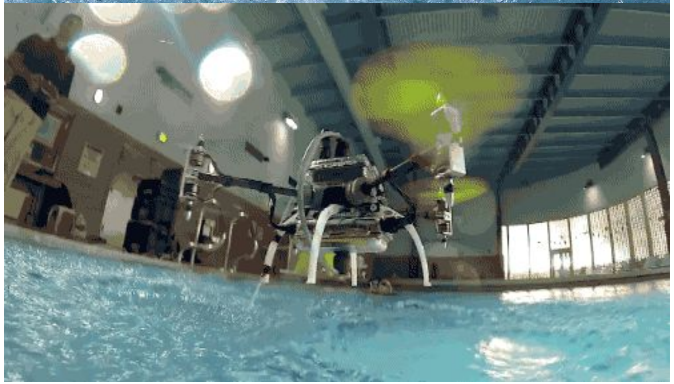


AQUATIC SUBSYSTEM

CRITERIA & CONSTRAINTS

Specific System Problems:

- Autonomous underwater flight
  - Automatic Vision Targeting
- Watertight enclosures for underwater movement
- Ability to autonomously maneuver in and out of water
- Waterproof testing
- Underwater communication



EDD INTERNSHIP PROGRAM

- EDD Internship Program
  - Origins
  - Who are the interns?
  - What do interns do?

- This year's interns
  - What is their task?

REMORA DELIVERABLES

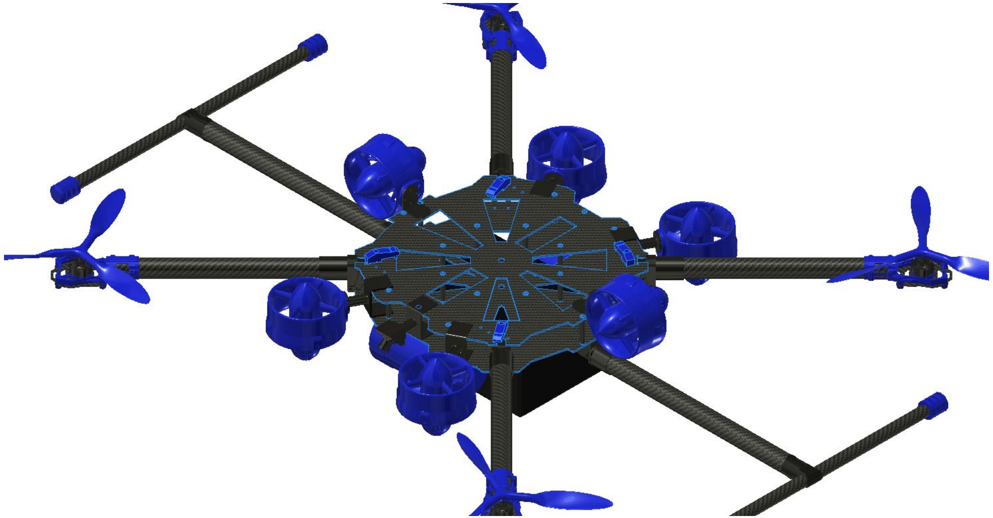
Must....

- be completely waterproof
- be lightweight (carried by Megalodon twice)
- locate wreckage site
- provide beacon
- identify and retrieve any nuclear items through radioactive detection sensors

OUR APPROACH

DESIGN OVERVIEW
MEGALODON

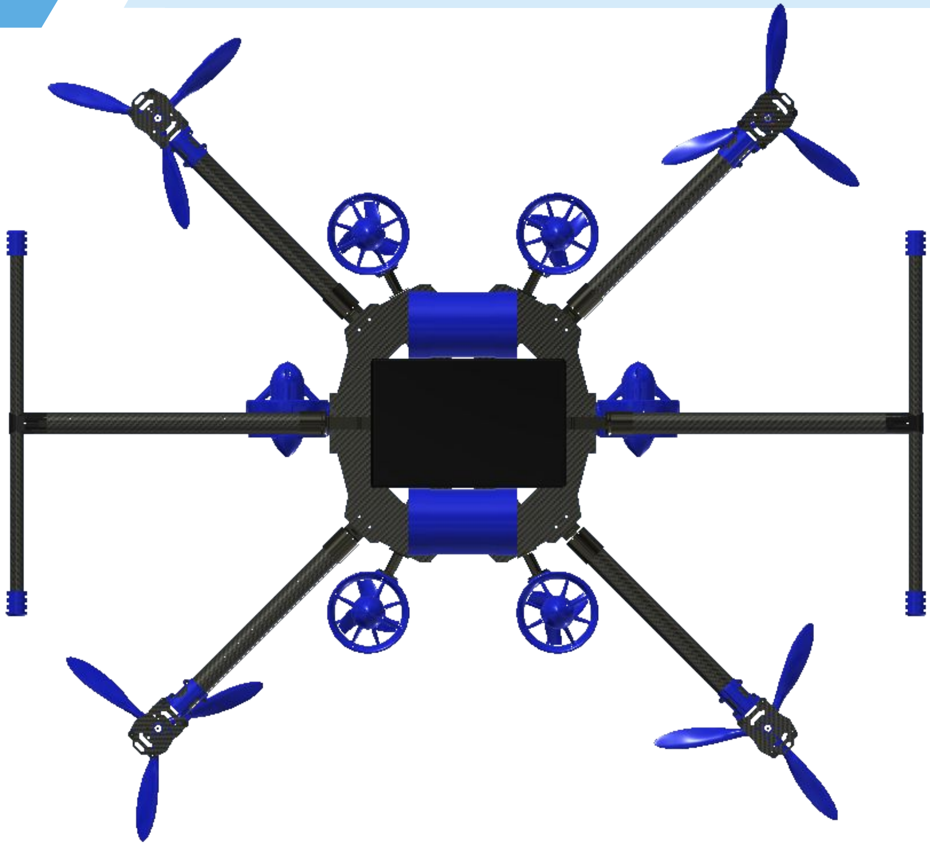
- Carbon Fiber Frame
- 4 aerial motors
- 6 underwater motors
- Object Recovery Mechanism



DESIGN OVERVIEW

MEGALODON CONT.

- Watertight Electronics Enclosure
- Ballast System
- Programmable flight controller and vision
- Current Design Limitations



DESIGN OVERVIEW

REMORA

- ABS plastic
- 6 underwater motors
- Vision
- Radioactive detection
- Ballast System
- Watertight Electronics Enclosure
- Object Recovery System
- Software

MISSION STRATEGY

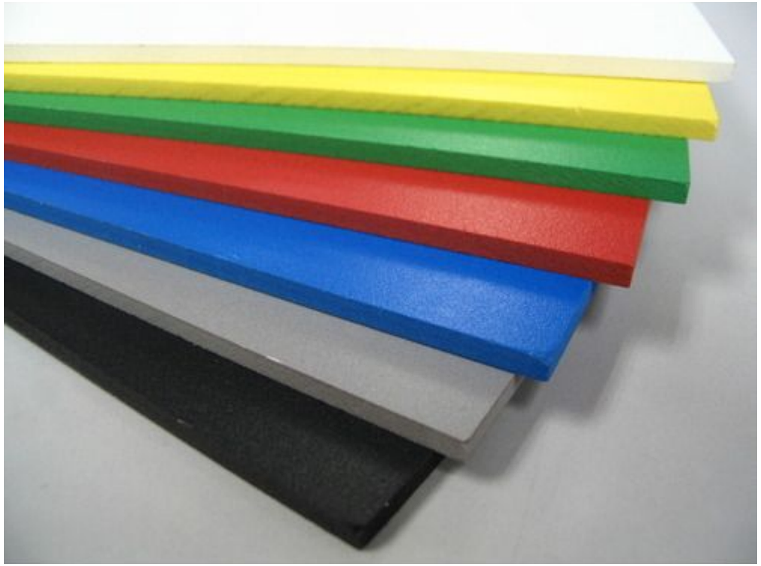
- Search of Wreckage
    - Remora Tracking System
- Recovery of items of interest
    - Trip Efficiency
    - Remora Camera
- Return of Megalodon and Remora

MECHANICAL DESIGN

UNDERWATER CONSTRAINTS

To ensure maximum maneuverability of the Megalodon in the air and water, our material used must have the following criteria:

- Impact Resistant
- Water Resistant
- Lightweight
- Durable

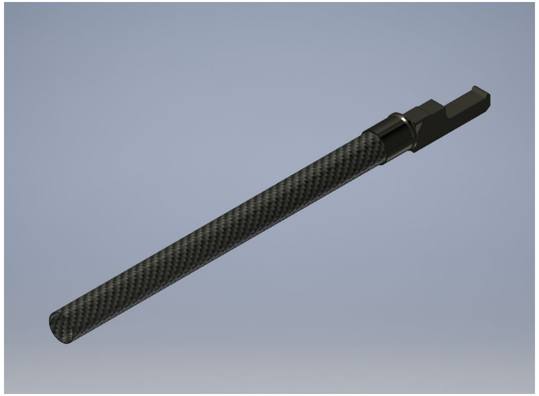


FRAME STRUCTURE DESIGN

To determine what material to build our drone out of, we brainstormed different materials and compared them in a decision matrix.

Ultimately, we chose carbon fiber because of its strength, weight, and high melting point.

Material/Criteria	Cost	Weight	Durability	Water Resistance	Melting Point	Machinability	Total
Carbon Fiber	0	2	2	0	1	-1	4
HDPE	1	1	0	1	-1	0	2
PVCs	1	1	0	1	-1	-1	1
Acrylic	1	-1	-1	1	-1	-1	-2
Wood	1	-1	-1	-1	-2	0	-4



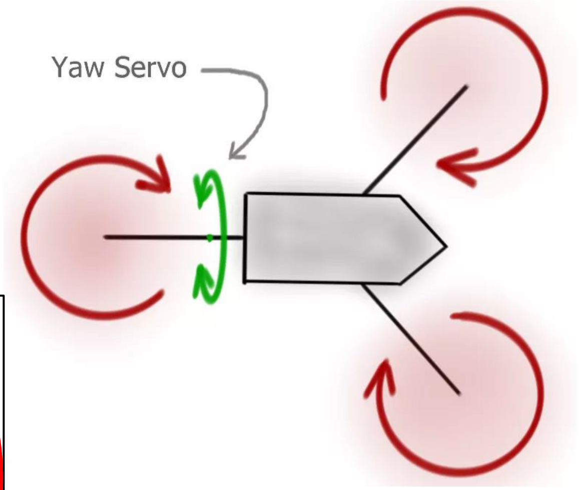
FLIGHT

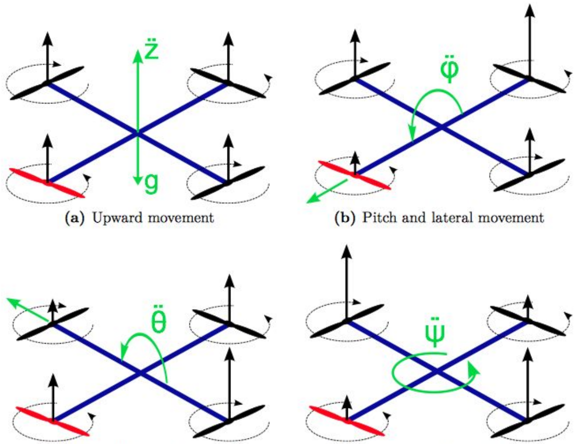
Number of Motors?

Three Motors	Four Motors
- Cheaper - Lighter - Limited mobility options - Difficult maneuvering	- More costly - Heavier - Simpler manufacturing - Wide mobility options - Easy to maneuver

Number of Blades per Propeller?

Three Blades	Four Blades
- More Efficient - Less thrust	- Less efficient - More thrust





(a) Upward movement (b) Pitch and lateral movement

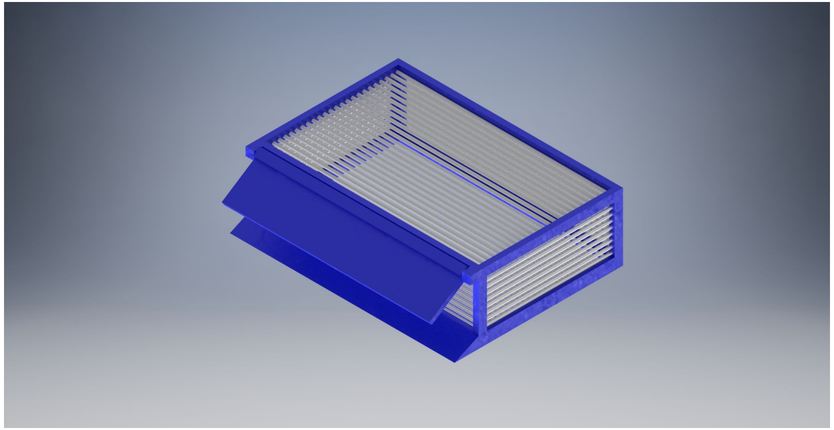
(c) Roll and lateral movement (d) Yaw and rotational movement

CAMERAS

- Megalodon will include two cameras for broader range of view
- Camera 1
  - Placed at the bottom of the vehicle in the center
  - Gives straight down view to align with Remora
- Camera 2
  - Placed at front of drone for automatic target object retrieval
  - Angled 45 degrees downward

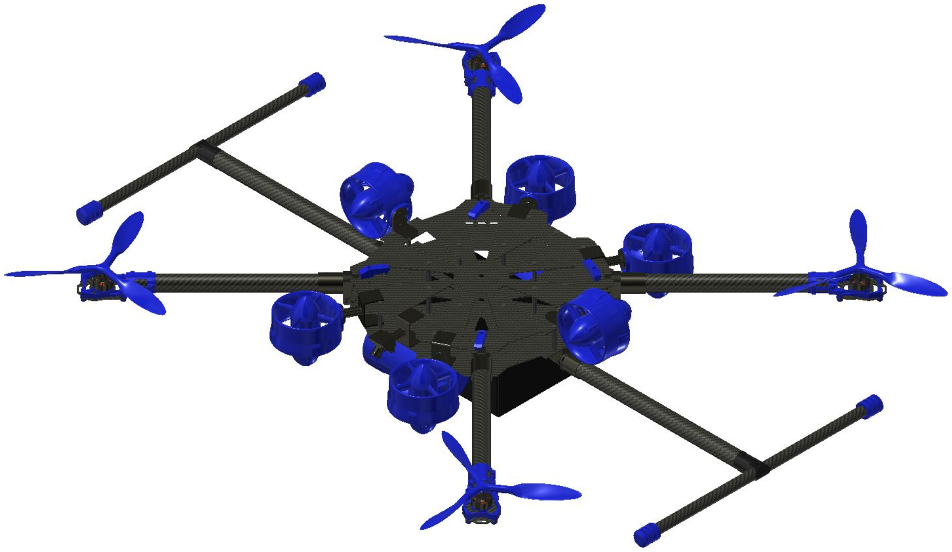
RECOVERY MECHANISM

- Our recovery mechanism is similar to a broom and dustpan.
- Having this system as opposed to a claw allows us to pick up multiple objects, both large and small.



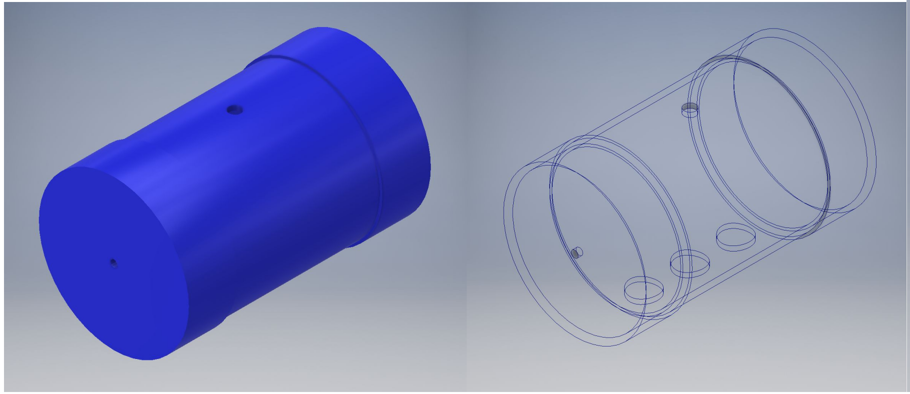
UNDERWATER FLIGHT

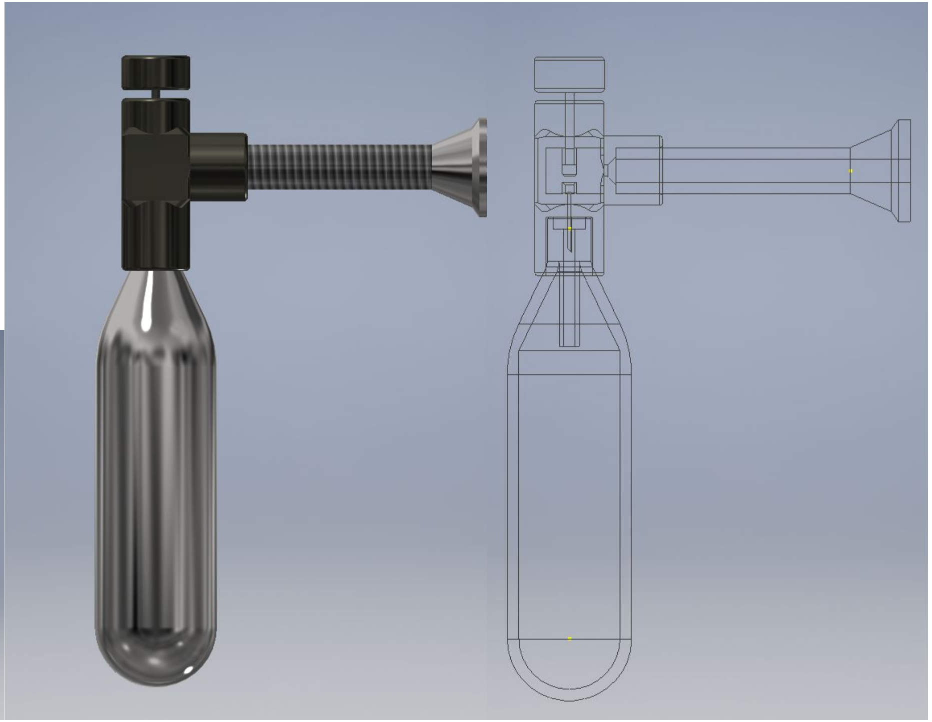
- Our proposed system is composed of **4 aerial motors** and **6 underwater thrusters.**
- Although we're planning on using 6 thrusters, if our testing shows that it is more efficient to use 4, then we will adapt and use 4.



BALLAST SYSTEM

- Our ballast system consists of two ballast tanks.
- Two 16g CO_2 cartridges.
- This system saves:
  - Battery power
  - Time





BUILD VS. BUY
ADVANTAGES & DISADVANTAGES

BUILD

- We only have to pay for materials and tools
- More customization options
- More time required to machine and design
- Requires more testing to everything is functioning properly

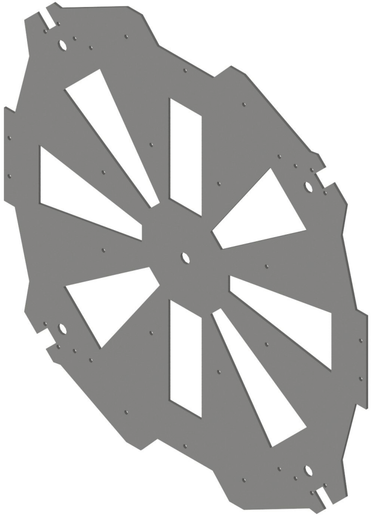
BUY

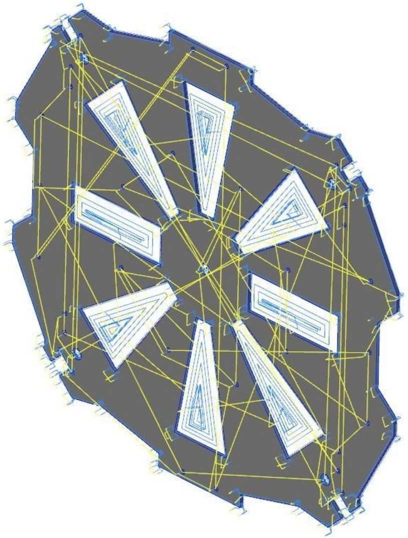
- Quality assurance guarantee
- Requires less time to incorporate with our design
- No advanced machining tools or machines required

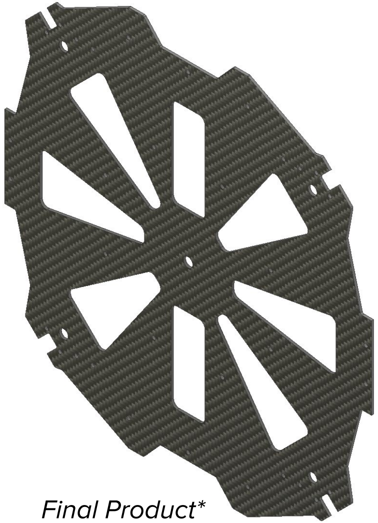
MANUFACTURING PROCEDURES

FABRICATION PROCESSES

CAD → **CAM** → **PRODUCT**







*Final Product**

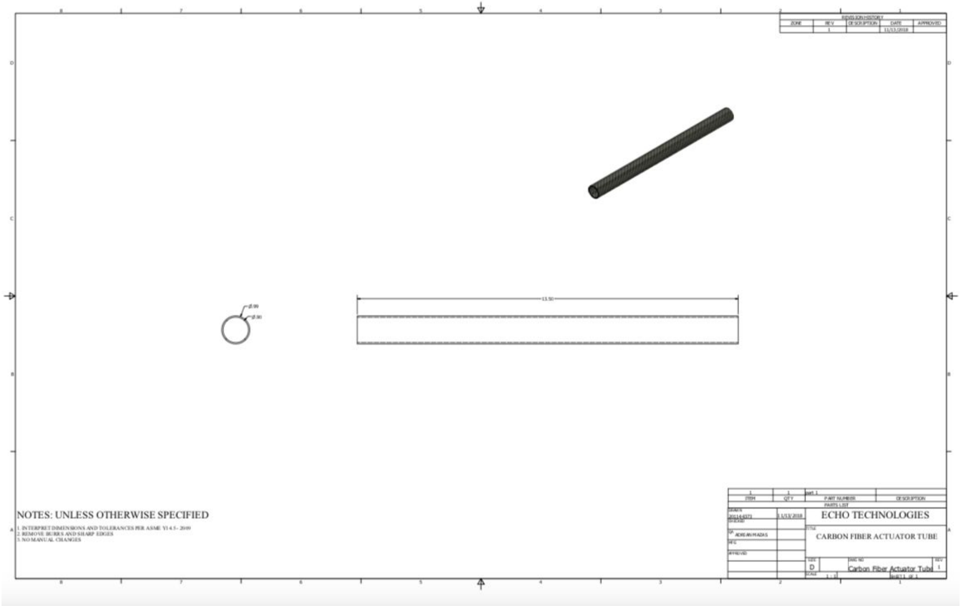
TYPES OF FABRICATION

- **Subtractive Manufacturing**
  - Milling
  - Turning
  - Laser Cutting

- **Additive Manufacturing**
  - Welding
  - 3D Printing

TECHNICAL DRAWINGS

PARTS FOR THE AERIAL SUBSYSTEM

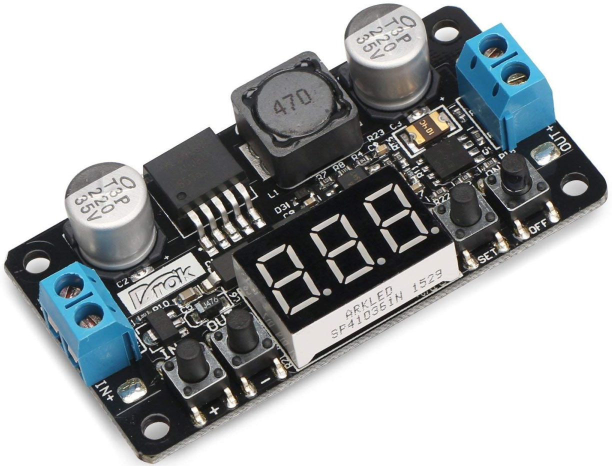


ELECTRICAL COMPONENTS

BATTERY

- Multistar High Capacity Lithium-Polymer (LiPo) Battery
  - 10000mAh 6S 22.2V
  - Can provide up to 120 amps continuously
- Will provide power directly to the underwater and aerial motors

VOLTAGE REGULATION MODULE (VRM)



- DC Voltage Step Down Circuit (Buck Converter)
- Lowers 22.2V battery output voltage to 5V operating voltage
- Used when providing power to low-voltage components (Raspberry Pi, IMU, Flight Controller, Servo)

MOTORS

UNDERWATER MOTORS

Blue Robotics M200 Brushless Motor

- Purpose built waterproof ROV motor
- Up to .5 Nm (4.5 in-lb) of torque per motor
- 6-20 V operating voltage / 22 amp max current

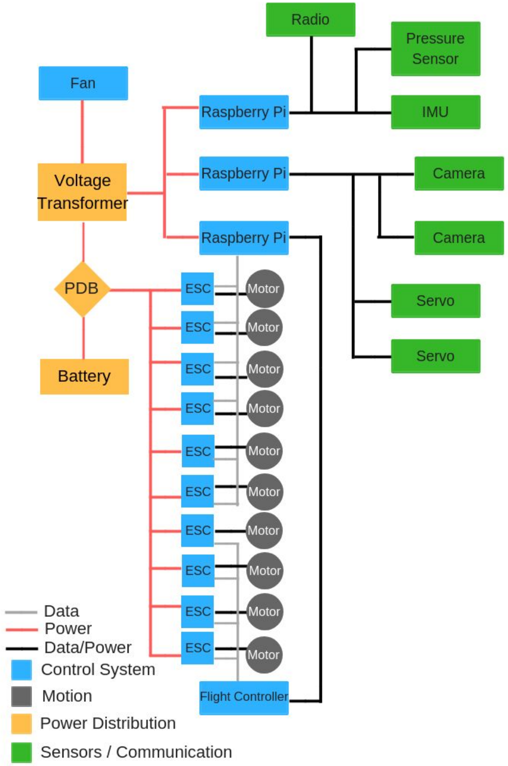
AERIAL MOTORS

Tarot 6115 kv320 Brushless Drone Motor

- Recommended motor for drone frame
- Up to 11 lbs of thrust per motor when paired with 26 in propellers at 24 V
- More than doubles the estimated thrust needed to lift the finished Megalodon

POWER

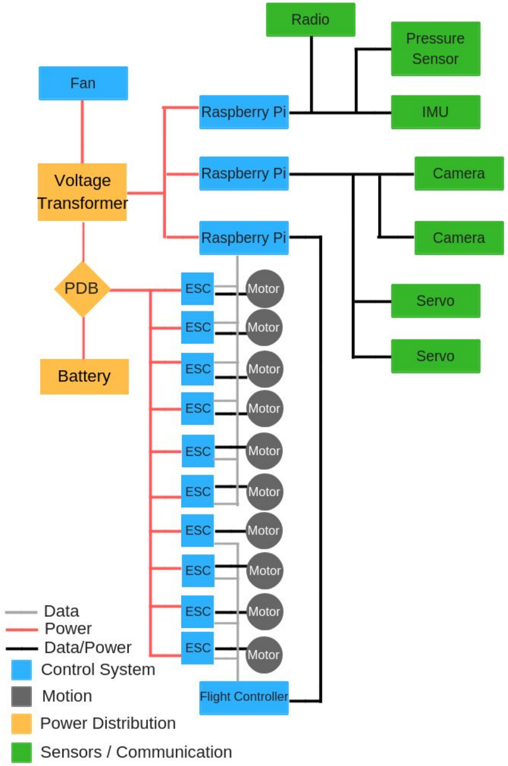
POWER DISTRIBUTION



- One LiPo Battery
- Brushless motors
  - Electronic speed controllers
- Raspberry Pi 3 Model B boards
  - Sensors
  - Flight Controller
  - Servos + Cameras

CONTROL SYSTEM

CONTROL SYSTEM



- 3 Raspberry Pi Model 3 Programming Boards
- Raspberry Pi #1
  - Flight controller with integrated Inertial Measuring Unit (IMU)
  - Four aerial motors attached to flight controller through electronic speed controller (ESC)
- Raspberry Pi #2
  - Six underwater BlueRobotics M200 ROV Motors connected through ESC’s
  - Additional IMU to monitor robot orientation and locomotion
  - Two waterproof servos to actuate claw
  - Pressure Sensor
- Raspberry Pi #3
  - Two high pixel density waterproof cameras and vision processing

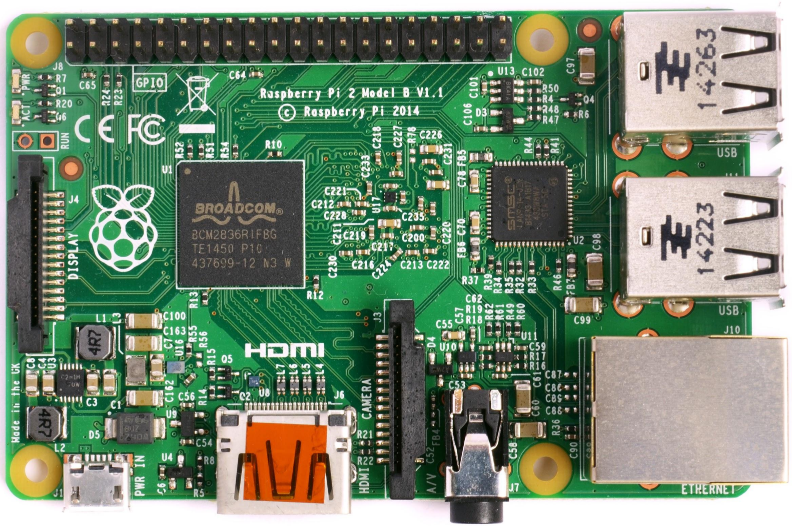
SOFTWARE

PROCESSING
SOFTWARE

Raspberry Pi 3 Model B

- Processing speed: 1.2GHz with 32kB Level 1 and 512kB Level 2 cache memory

- Compatibility / Adaptability



PROCESSING

SOFTWARE

- Raspberry Pi 1
  - Interface with sensors
- Raspberry Pi 2
  - Commands the Megalodon to move
- Raspberry Pi 3
  - Image processing

PROCESSING
SOFTWARE

Pi to Pi Communication

- USB to TTL converter
- Python Serial Connection
- Pi Serial Packet
- Nano Directory
- Serial Monitoring Software

```python
import time
import serial

print "Starting program"

ser = serial.Serial('/dev/ttyAMA0', baudrate=9600,
                    parity=serial.PARITY_NONE,
                    stopbits=serial.STOPBITS_ONE,
                    bytesize=serial.EIGHTBITS
                    )
time.sleep(1)
try:
    ser.write('Hello World\r\n')
    ser.write('Serial Communication Using Raspberry Pi\r\n')
    ser.write('By: Embedded Laboratory\r\n')
    print 'Data Echo Mode Enabled'
    while True:
        if ser.inWaiting() > 0:
            data = ser.read()
            print data

except KeyboardInterrupt:
    print "Exiting Program"

except:
    print "Error Occurs, Exiting Program"

finally:
    ser.close()
    pass
```

FRAMEWORK
SOFTWARE

Program:

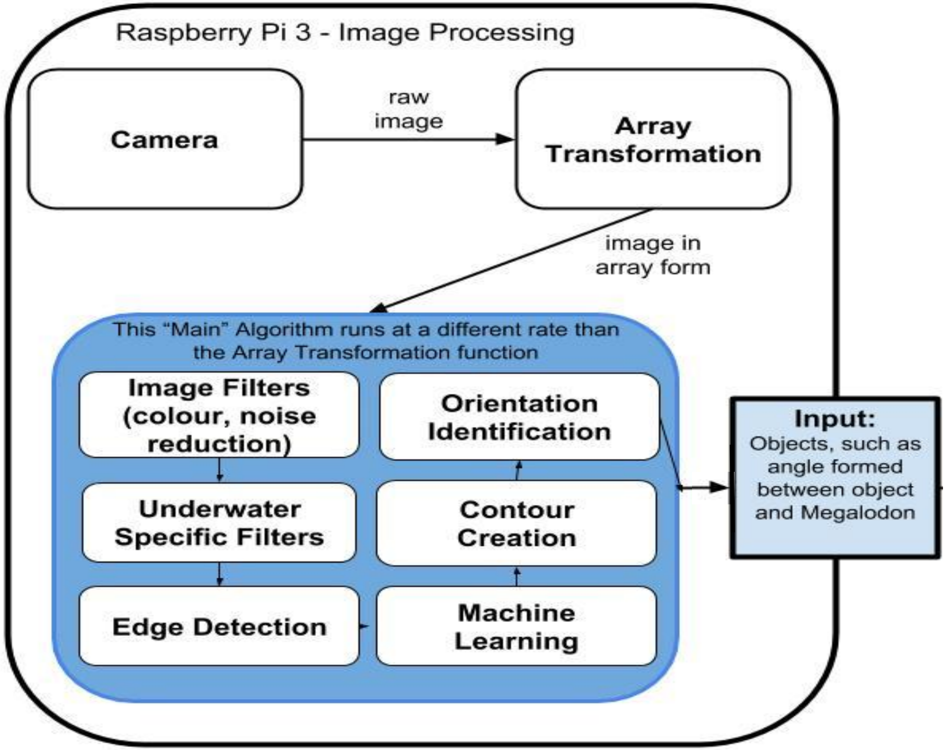
- Processes high amount of input/output (I/O)
- High-level code handling low-level components

What we want:

- **Concurrency (parallel processing)**
- Control over our subprocesses

IMAGE PROCESSING

SOFTWARE



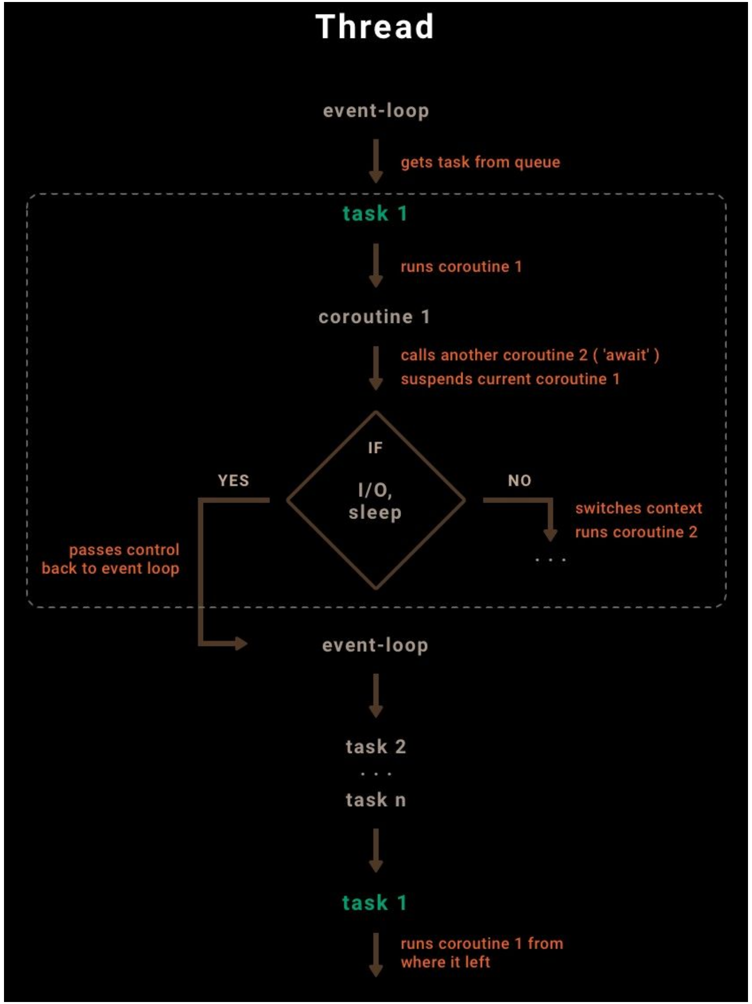
FRAMEWORK
SOFTWARE

Solution:

- Use asynchronous I/O
  - Python module: **asyncio**
    - Utilizes async/await syntax

How does **asyncio** work?

- Coroutines
- Tasks
- Event loop



FRAMEWORK
SOFTWARE

main.py saved

```python
import asyncio
from time import gmtime, strftime

# prints phrase and UTC timestamp after specified delay
async def say(phrase, delay):
    await asyncio.sleep(delay)
    print(phrase, '@', strftime('%H:%M:%S', gmtime()))

# stops event loop after specified delay
async def stop(delay):
    await asyncio.sleep(delay)
    print('stopping loop @', strftime('%H:%M:%S', gmtime()))
    loop.stop()

print('starting loop @', strftime('%H:%M:%S', gmtime()))
loop = asyncio.get_event_loop() # create event loop

# create tasks
loop.create_task(say('hello 1', 4))
loop.create_task(say('hello 2', 1))
loop.create_task(say('hello 3', 6))
loop.create_task(stop(5))

loop.run_forever() # run until loop stops
loop.close() # close loop, end program
```

```
Python 3.6.1 (default, Dec 2015, 13:05:11)
[GCC 4.8.2] on linux
›
starting loop @ 19:17:18
hello 2 @ 19:17:19
hello 1 @ 19:17:22
stopping loop @ 19:17:23
›
```

FRAMEWORK

SOFTWARE

Goals:

- Optimize response time
- Minimize latency & interference

Component speeds:

- Position controller/estimator (low)
    - 20 Hz
- Attitude controller/estimator (medium)
    - 200 Hz
- Motor controllers (high)
    - 500 Hz

UNDERWATER CONTROL

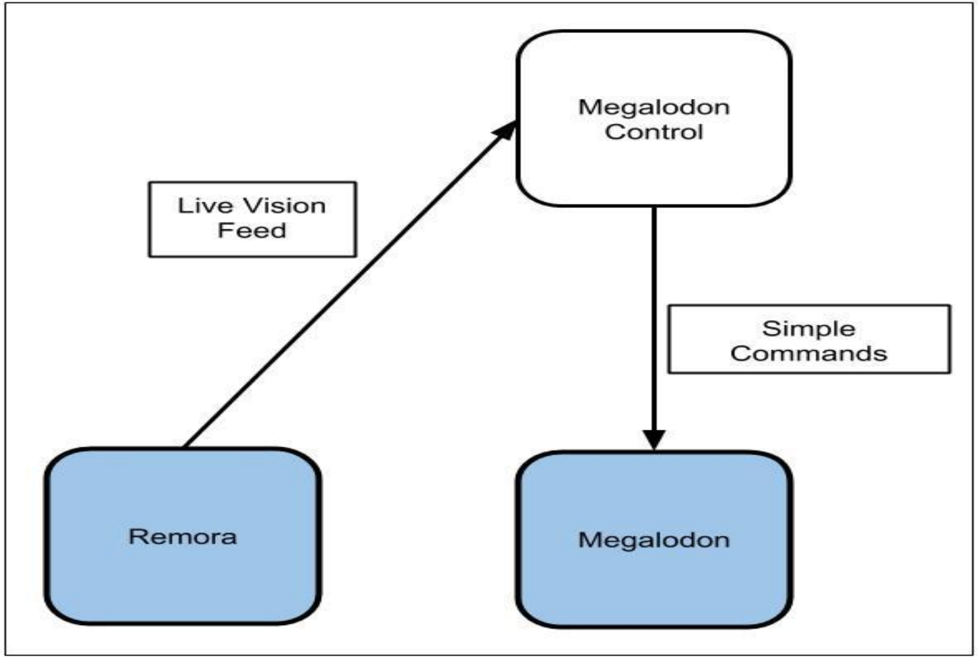
SOFTWARE

General Strategy:

Remora sends visual input to human control.

Human control sends simple commands to move Megalodon to the vicinity of the object.

Automatic vision optimise Megalodon orientation and command itself to adjust accordingly.



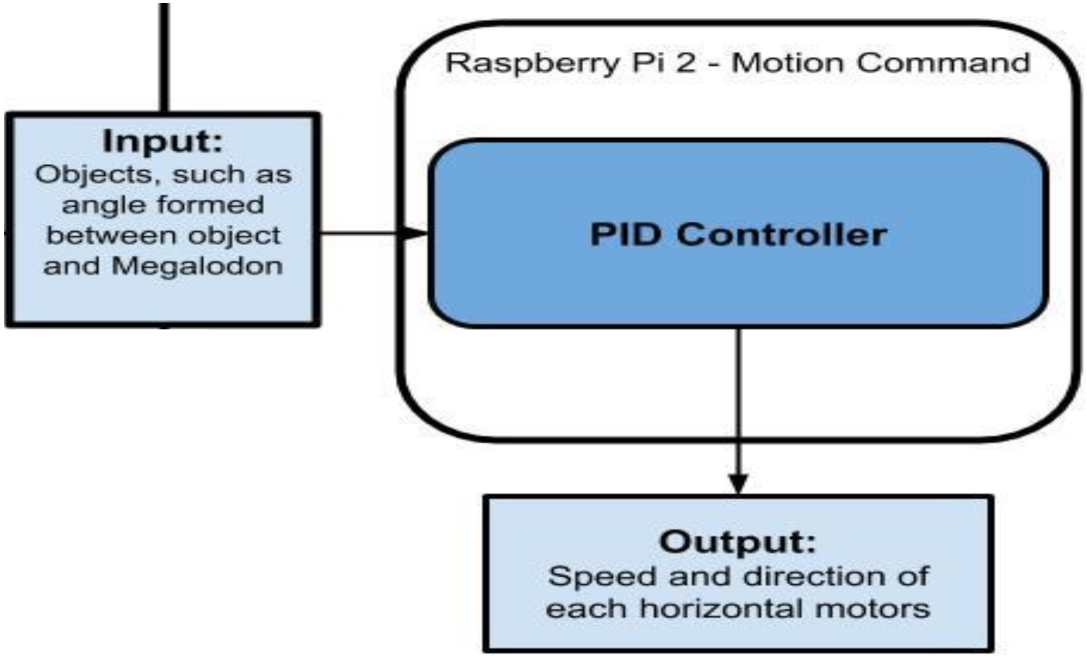
CAMERA SELECTION

SOFTWARE

- USB 2.0 (compatible with Raspberry Pi 3 Model B)
- 3.9 x 1.6 x 1.2 (in.) and 0.8 oz
- 640 x 480 resolution
- Adjustable focus, moderate framerate (~20 fps)

UNDERWATER MOTION

SOFTWARE



UNDERWATER CONTROL

SOFTWARE

Attitude Control

- A PID Controller will be used to maintain the speed and direction of the motors which will maintain the Megalodon's underwater angle and motion.

PID CONTROL

SOFTWARE

Output = Proportional + Integral + Derivative

$$u(t) = K_c e(t) + \frac{K_c}{\tau_i}\int_0^t e(t)dt + K_c\tau_d\frac{de(t)}{dt}$$

$$u(t) = K_p e(t) + K_i\int_0^t e(t)dt + K_d\frac{de(t)}{dt}$$

Proportional → takes error

Integral → takes sum of error over time

Derivative → takes rate of (how fast / how slowly) change in error over time

Proportional → this value is needed to gauge necessary input for reaching certain output

Integral → speeds up the process of reaching output relative to how much error is left

Derivative → predicts behavior of process relative to how much error is left

UNDERWATER CONTROL

SOFTWARE

How PID will be used for automatic vision tracking:

Input:

- Objects, such as location relative to Megalodon, from image processing (this also serves as the error for the PID algorithm)

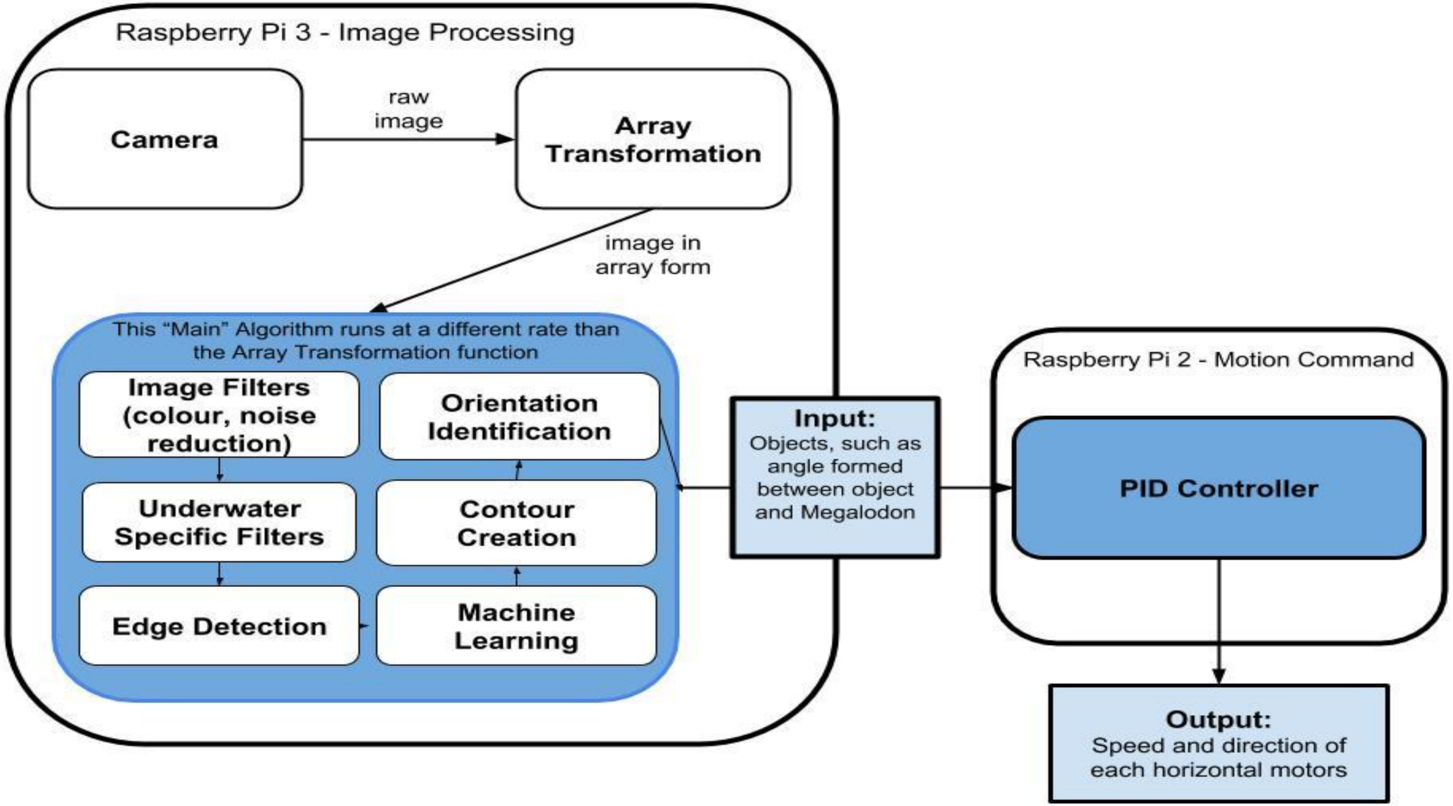
Output:

- Speed/power sent to each underwater subsystem motor

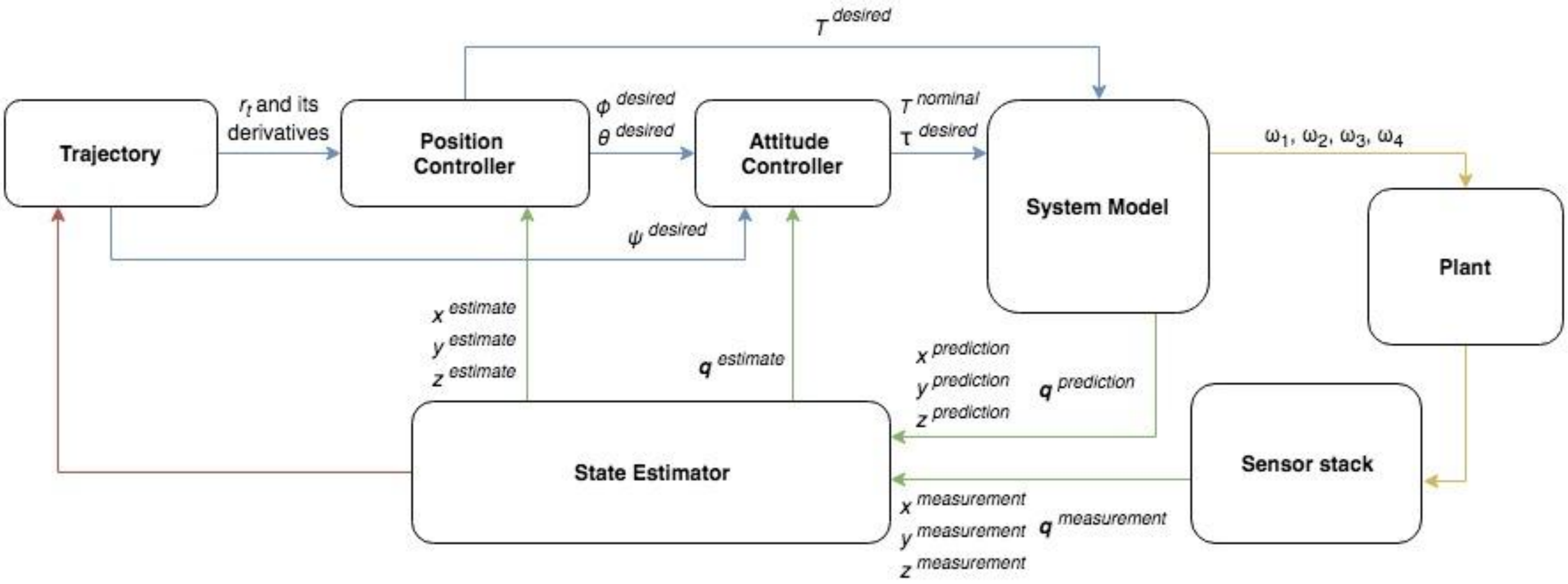
Goal:

- Megalodon turns / maneuvers underwater

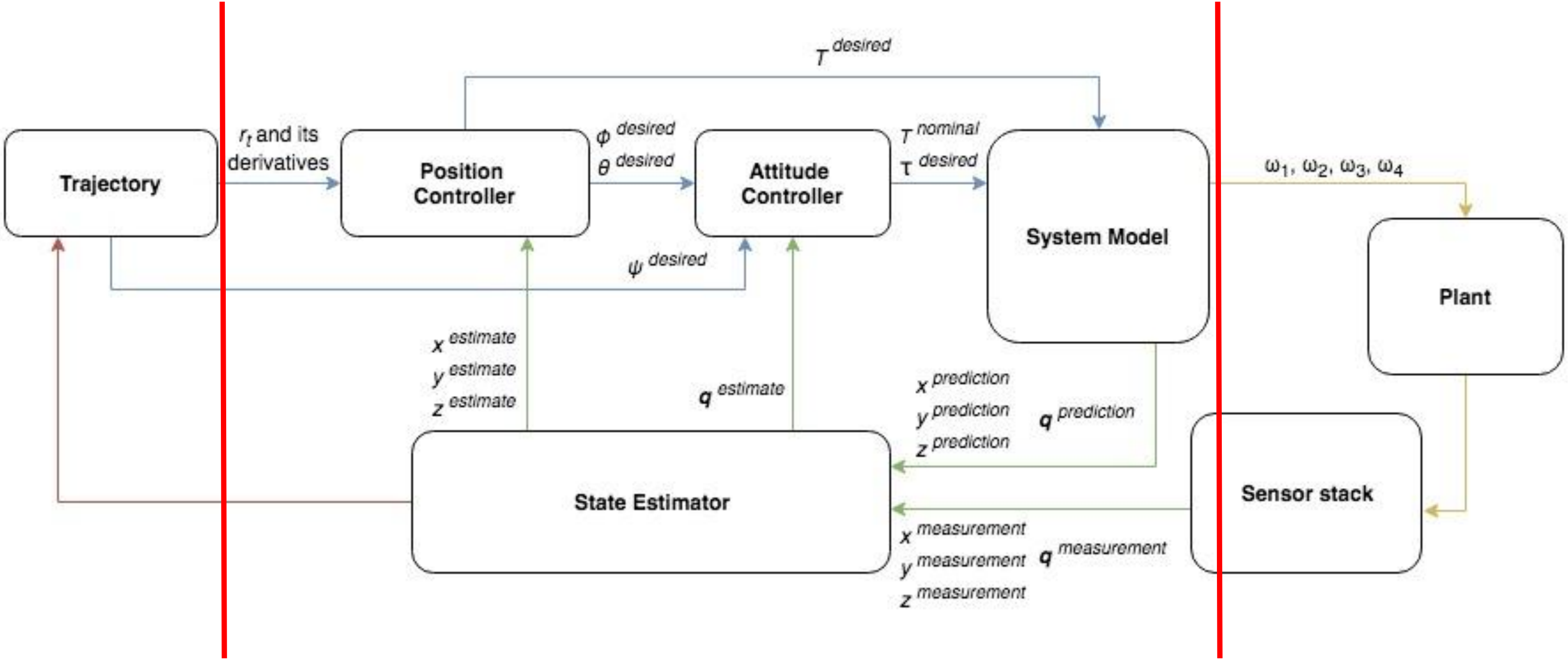
IMAGE PROCESSING
SOFTWARE



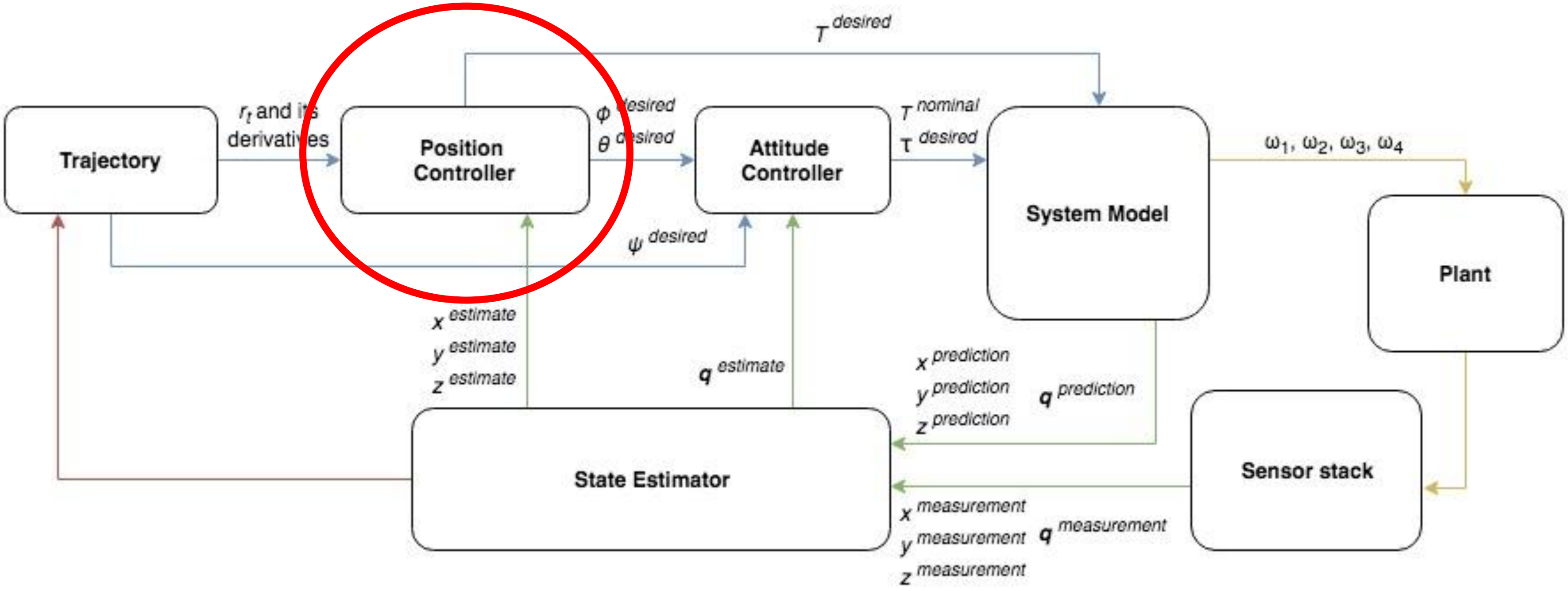
FLIGHT CONTROL
SOFTWARE

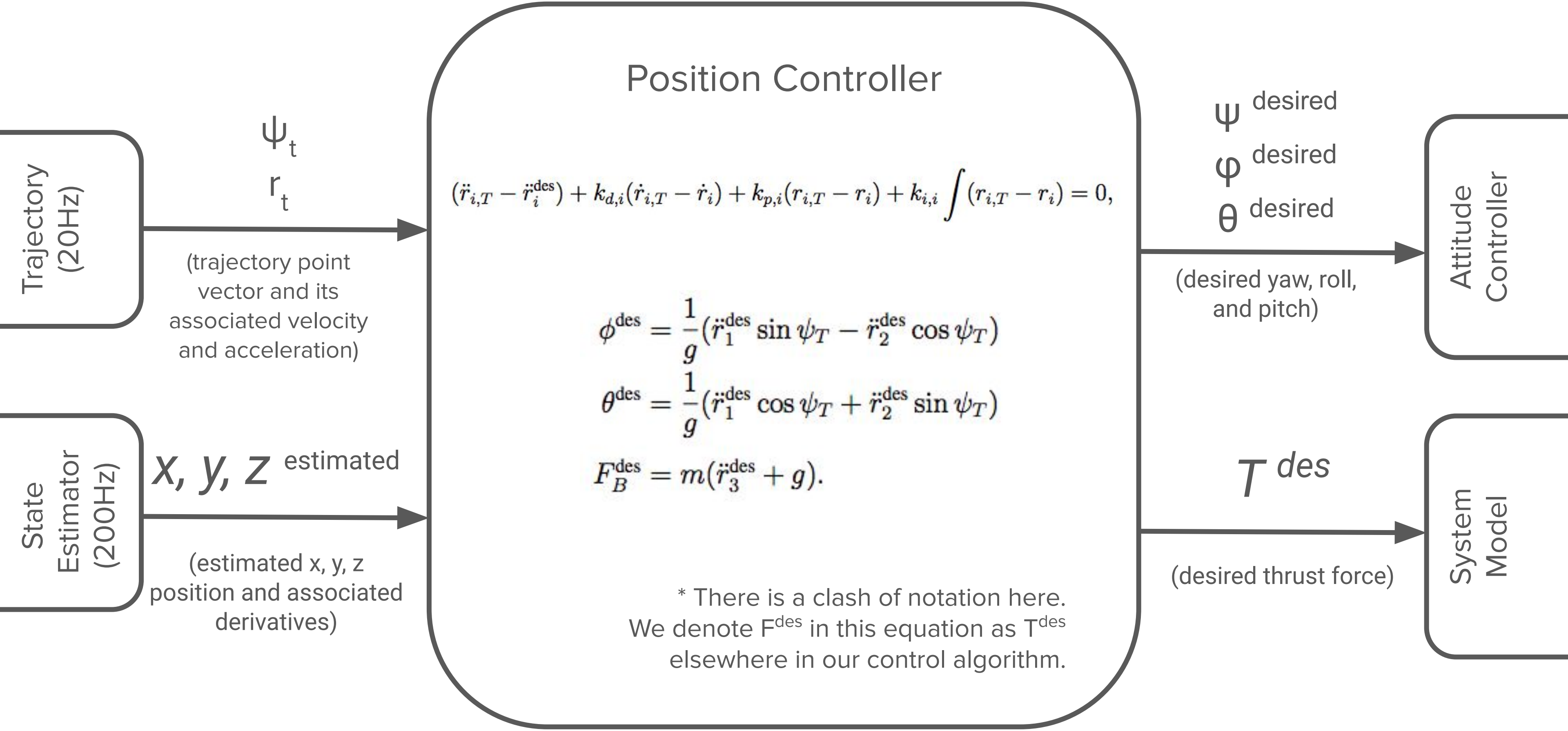


FLIGHT CONTROL
SOFTWARE

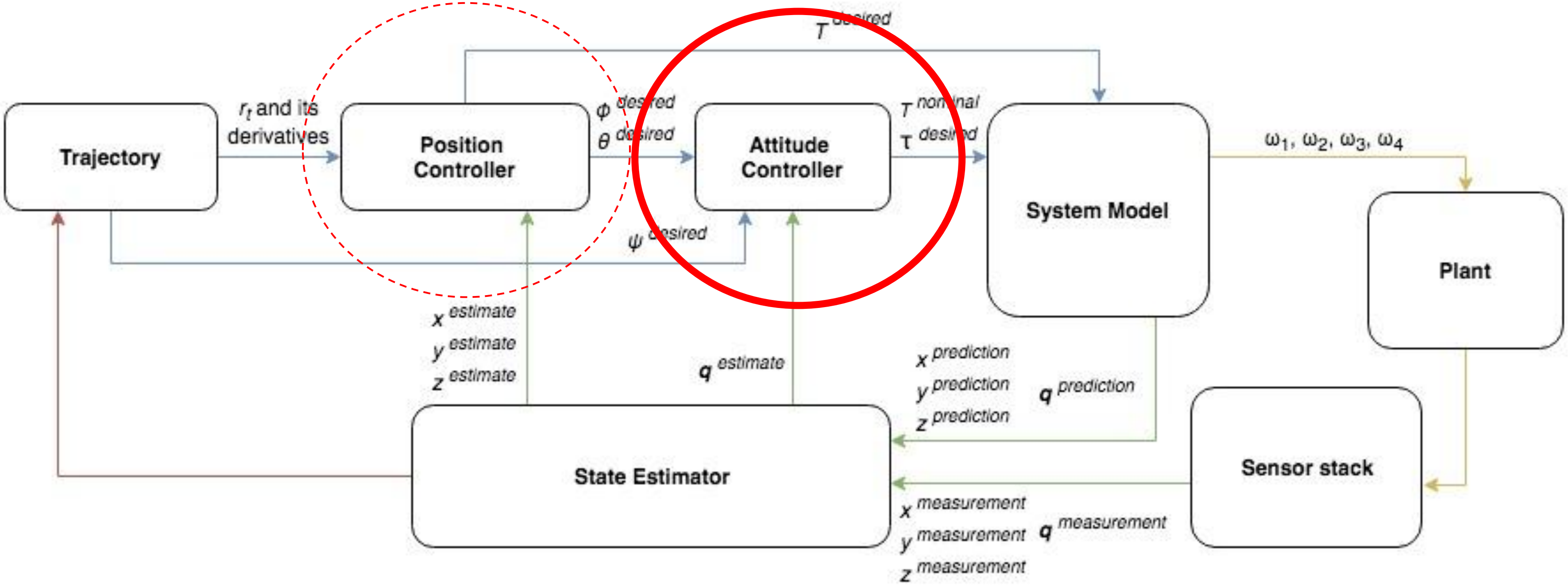


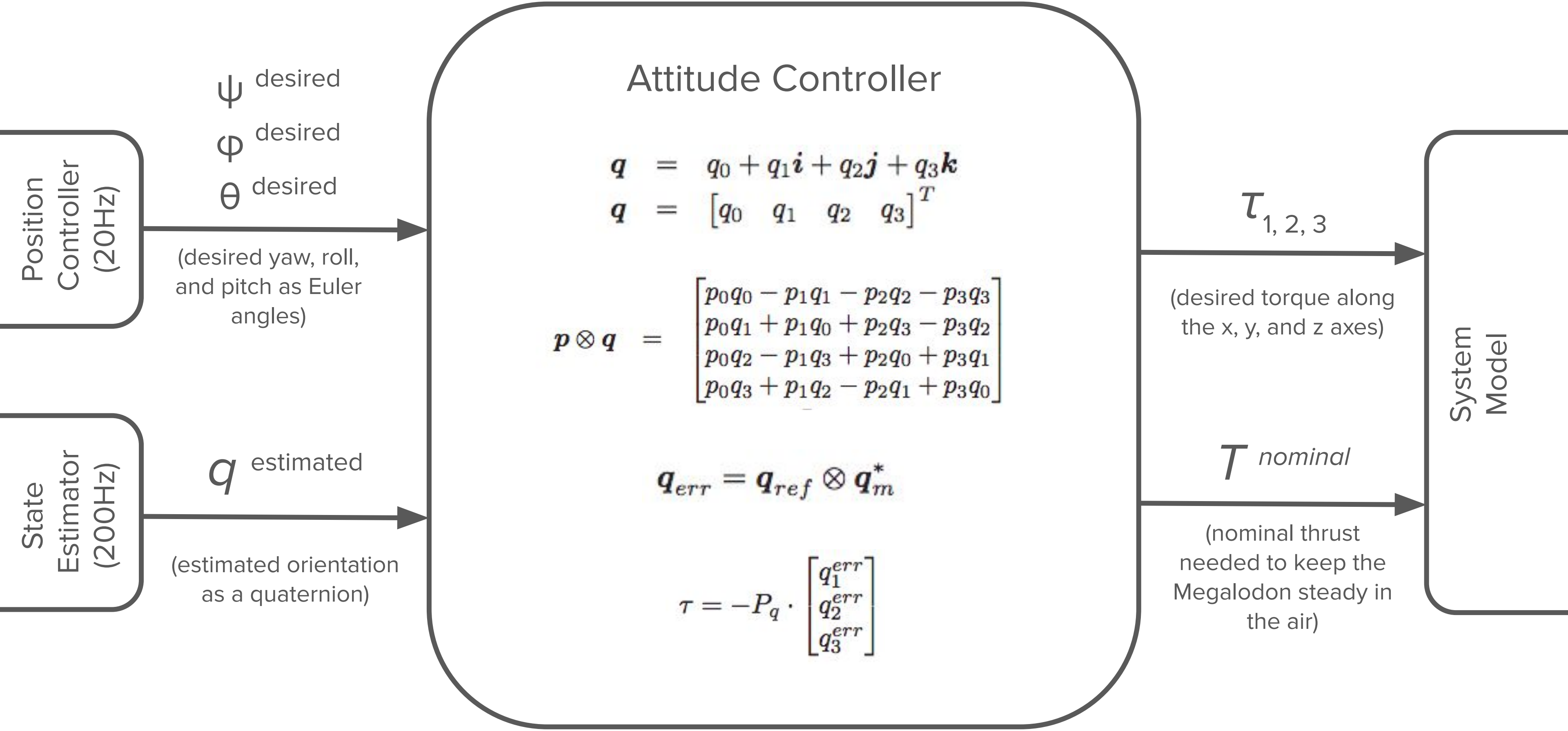
FLIGHT CONTROL
SOFTWARE




Trajectory (20Hz)
ψ_t
r_t
(trajectory point vector and its associated velocity and acceleration)
State Estimator (200Hz)
x, y, z estimated
(estimated x, y, z position and associated derivatives)
Position Controller
$(\ddot{r}_{i,T} - \ddot{r}_i^{\text{des}}) + k_{d,i}(\dot{r}_{i,T} - \dot{r}_i) + k_{p,i}(r_{i,T} - r_i) + k_{i,i}\int(r_{i,T} - r_i) = 0,$
$\phi^{\text{des}} = \frac{1}{g}(\ddot{r}_1^{\text{des}} \sin\psi_T - \ddot{r}_2^{\text{des}} \cos\psi_T)$
$\theta^{\text{des}} = \frac{1}{g}(\ddot{r}_1^{\text{des}} \cos\psi_T + \ddot{r}_2^{\text{des}} \sin\psi_T)$
$F_B^{\text{des}} = m(\ddot{r}_3^{\text{des}} + g).$
* There is a clash of notation here. We denote F^{des} in this equation as T^{des} elsewhere in our control algorithm.
ψ desired
φ desired
θ desired
(desired yaw, roll, and pitch)
Attitude Controller
T^{des}
(desired thrust force)
System Model

FLIGHT CONTROL
SOFTWARE



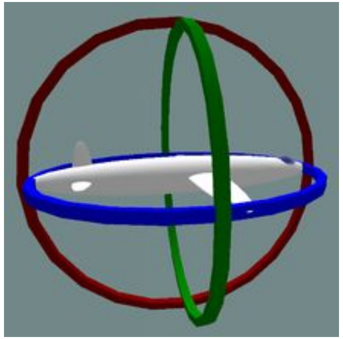

Position Controller (20Hz)
ψ desired
ϕ desired
θ desired
(desired yaw, roll, and pitch as Euler angles)
State Estimator (200Hz)
q estimated
(estimated orientation as a quaternion)
Attitude Controller
$$\boldsymbol{q} = q_0 + q_1\boldsymbol{i} + q_2\boldsymbol{j} + q_3\boldsymbol{k}$$
$$\boldsymbol{q} = \begin{bmatrix} q_0 & q_1 & q_2 & q_3 \end{bmatrix}^T$$
$$\boldsymbol{p} \otimes \boldsymbol{q} = \begin{bmatrix} p_0q_0 - p_1q_1 - p_2q_2 - p_3q_3 \\ p_0q_1 + p_1q_0 + p_2q_3 - p_3q_2 \\ p_0q_2 - p_1q_3 + p_2q_0 + p_3q_1 \\ p_0q_3 + p_1q_2 - p_2q_1 + p_3q_0 \end{bmatrix}$$
$$\boldsymbol{q}_{err} = \boldsymbol{q}_{ref} \otimes \boldsymbol{q}_m^*$$
$$\tau = -P_q \cdot \begin{bmatrix} q_1^{err} \\ q_2^{err} \\ q_3^{err} \end{bmatrix}$$
$\tau_{1, 2, 3}$
(desired torque along the x, y, and z axes)
T *nominal*
(nominal thrust needed to keep the Megalodon steady in the air)
System Model

ORIENTATION REPRESENTATION

SOFTWARE

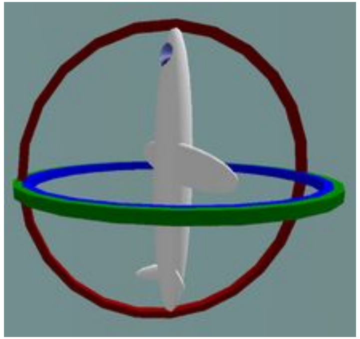
Euler Angles

- Rotation around each of the major axes.
- Represented by yaw, pitch, and roll.



Gimbal Lock

- When the rings align, we lose track of one degree of freedom
- Once we stop keeping track of that information, it's impossible to reorient the axes again.

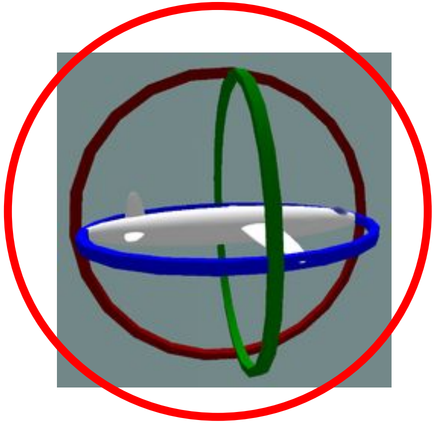


ORIENTATION REPRESENTATION

SOFTWARE

Euler Angles

- Rotation around each of the major axes.
- Represented by yaw, pitch, and roll.



Gimbal Lock

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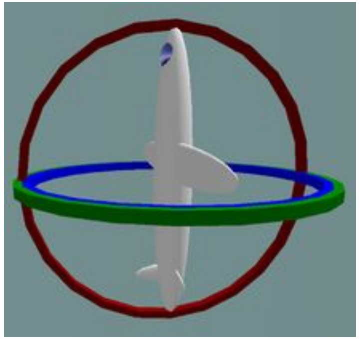
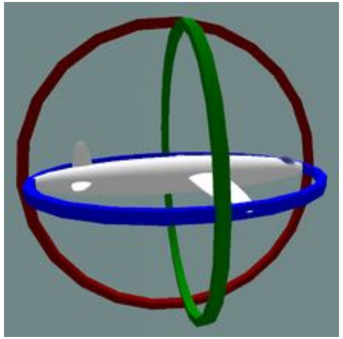


ORIENTATION REPRESENTATION

SOFTWARE

Euler Angles

- Rotation around each of the major axes.
- Represented by yaw, pitch, and roll.



Gimbal Lock

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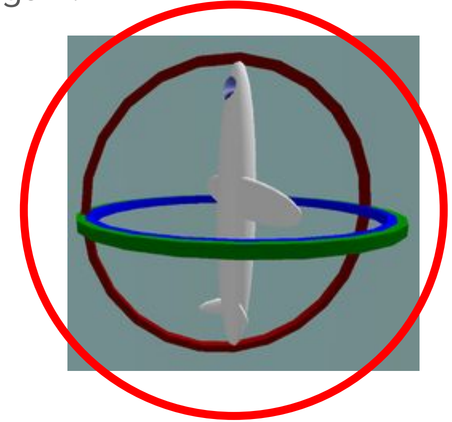
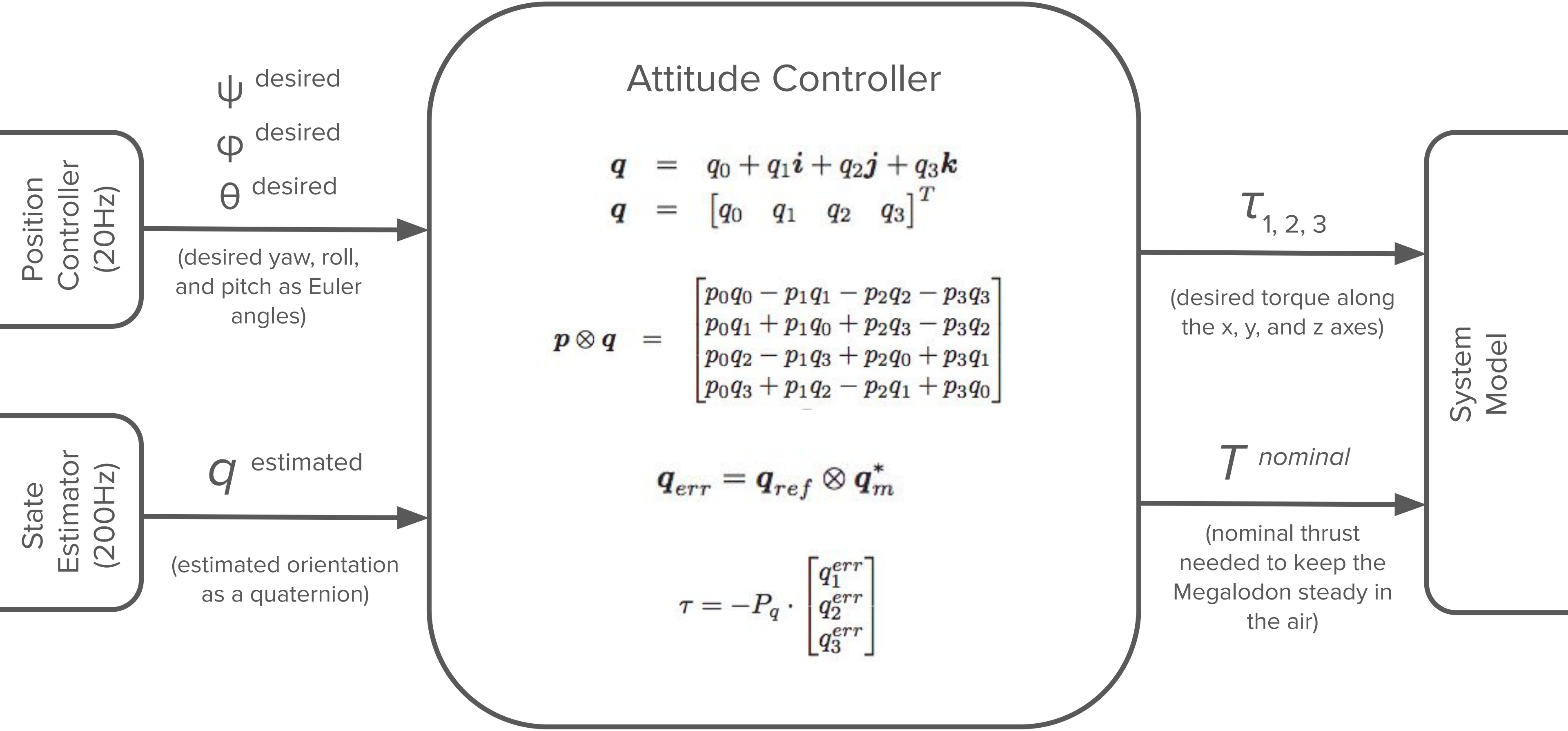
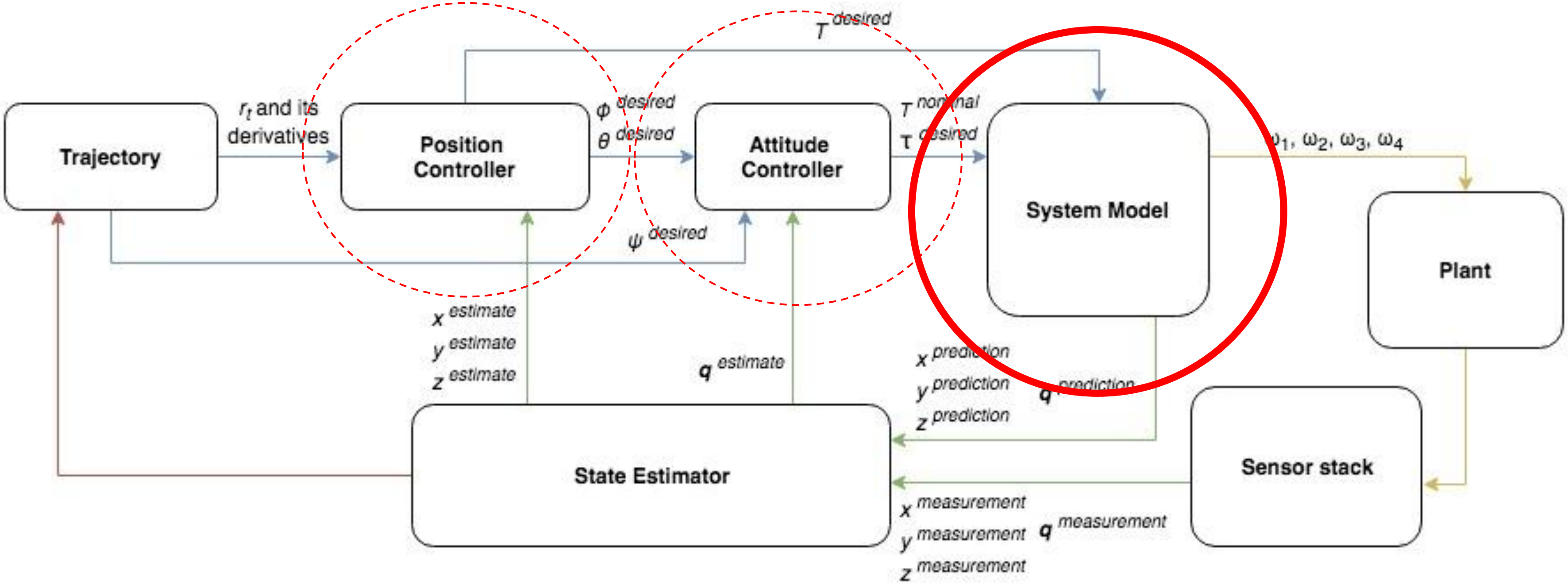




Position Controller (20Hz)
ψ desired
φ desired
θ desired
(desired yaw, roll, and pitch as Euler angles)
State Estimator (200Hz)
q estimated
(estimated orientation as a quaternion)
Attitude Controller
$$\boldsymbol{q} = q_0 + q_1\boldsymbol{i} + q_2\boldsymbol{j} + q_3\boldsymbol{k}$$
$$\boldsymbol{q} = \begin{bmatrix} q_0 & q_1 & q_2 & q_3 \end{bmatrix}^T$$
$$\boldsymbol{p} \otimes \boldsymbol{q} = \begin{bmatrix} p_0q_0 - p_1q_1 - p_2q_2 - p_3q_3 \\ p_0q_1 + p_1q_0 + p_2q_3 - p_3q_2 \\ p_0q_2 - p_1q_3 + p_2q_0 + p_3q_1 \\ p_0q_3 + p_1q_2 - p_2q_1 + p_3q_0 \end{bmatrix}$$
$$\boldsymbol{q}_{err} = \boldsymbol{q}_{ref} \otimes \boldsymbol{q}_m^*$$
$$\tau = -P_q \cdot \begin{bmatrix} q_1^{err} \\ q_2^{err} \\ q_3^{err} \end{bmatrix}$$
$\tau_{1,2,3}$
(desired torque along the x, y, and z axes)
T *nominal*
(nominal thrust needed to keep the Megalodon steady in the air)
System Model

FLIGHT CONTROL

SOFTWARE



Position Controller (20Hz)

T_Σ

(desired net thrust force)

Attitude Controller (200Hz)

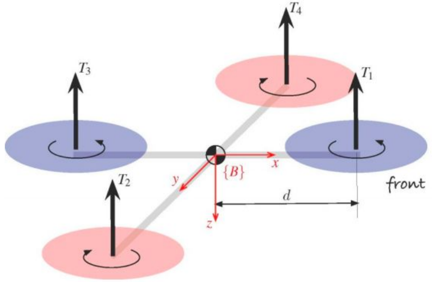
$\tau_{1,\,2,\,3}$

(desired torque along the x, y, and z axes)

System Model

$$T_i = c_T \varpi_i^2$$

$$Q_i := c_Q \varpi_i^2,$$



$$\begin{pmatrix} T_\Sigma \\ \tau_1 \\ \tau_2 \\ \tau_3 \end{pmatrix} = \underbrace{\begin{pmatrix} c_T & c_T & c_T & c_T \\ 0 & dc_T & 0 & -dc_T \\ -dc_T & 0 & dc_T & 0 \\ -c_Q & c_Q & -c_Q & c_Q \end{pmatrix}}_{\Gamma} \begin{pmatrix} \varpi_1^2 \\ \varpi_2^2 \\ \varpi_3^2 \\ \varpi_4^2 \end{pmatrix}$$

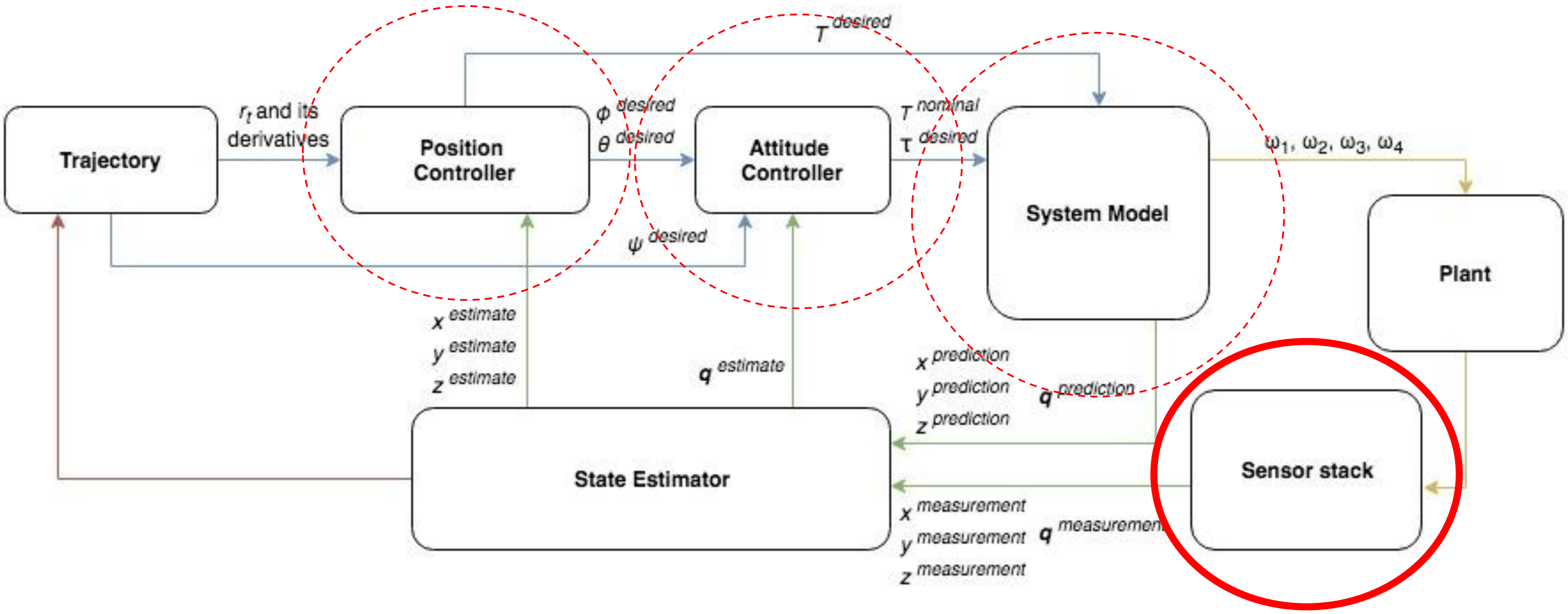
$\omega_{1,\,2,\,3,\,4}$

(commanded angular velocity for each rotor)

Plant (Megalodon) (500Hz)

FLIGHT CONTROL

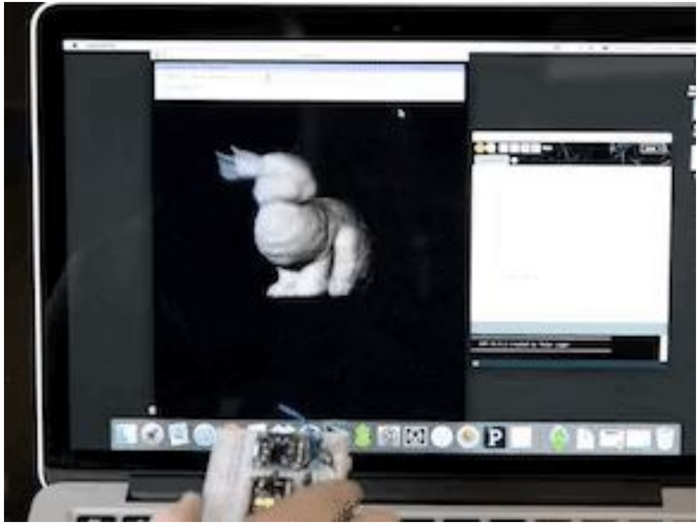
SOFTWARE

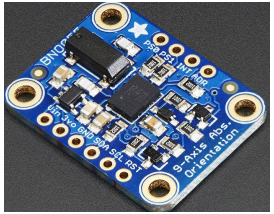


SENSOR STACK
SOFTWARE

Inertial Measurement Unit (IMU)

- Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout Model-BNO055
    - Absolute Orientation
    - Angular Velocity
    - Angular Acceleration
    - Magnetic Field Strength
    - Linear Acceleration
    - Gravity
    - Temperature

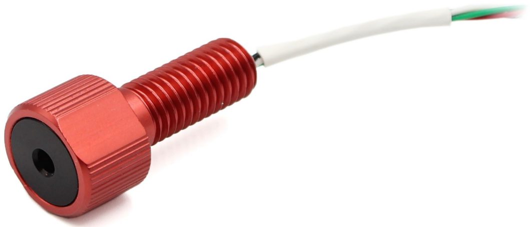




SENSOR STACK
SOFTWARE

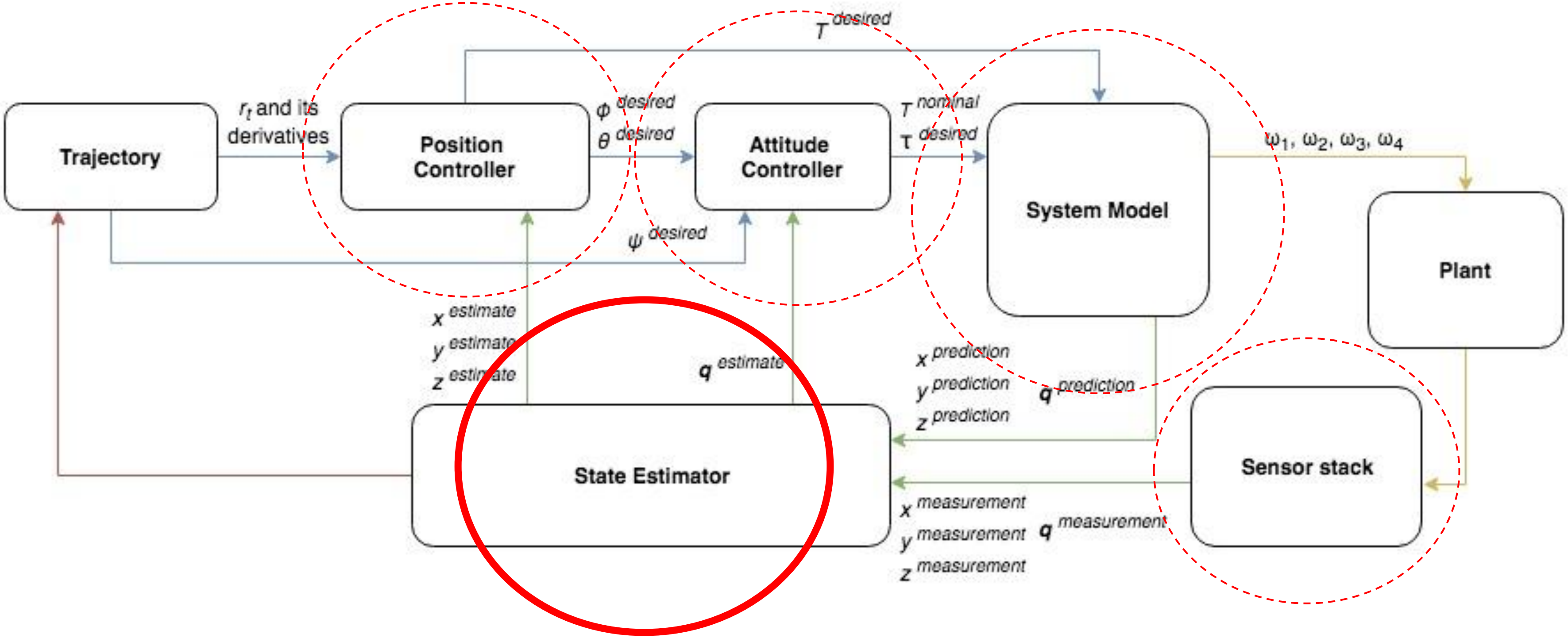
Pressure Sensor

- Bar02 Ultra High Resolution 10m Depth/Pressure Sensor
    - Depth: 10m
    - Water Depth Resolution: 0.16mm
    - Air Pressure Resolution: 13cm



FLIGHT CONTROL

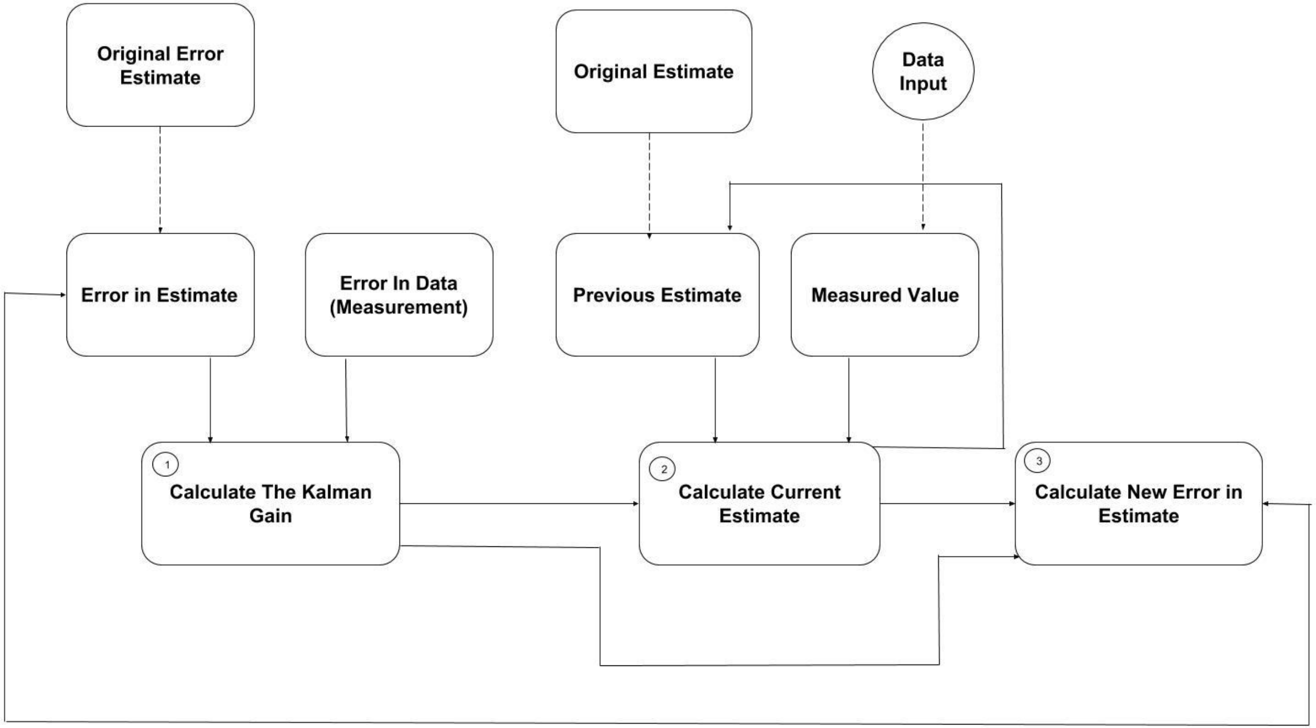
SOFTWARE



STATE ESTIMATION

SOFTWARE

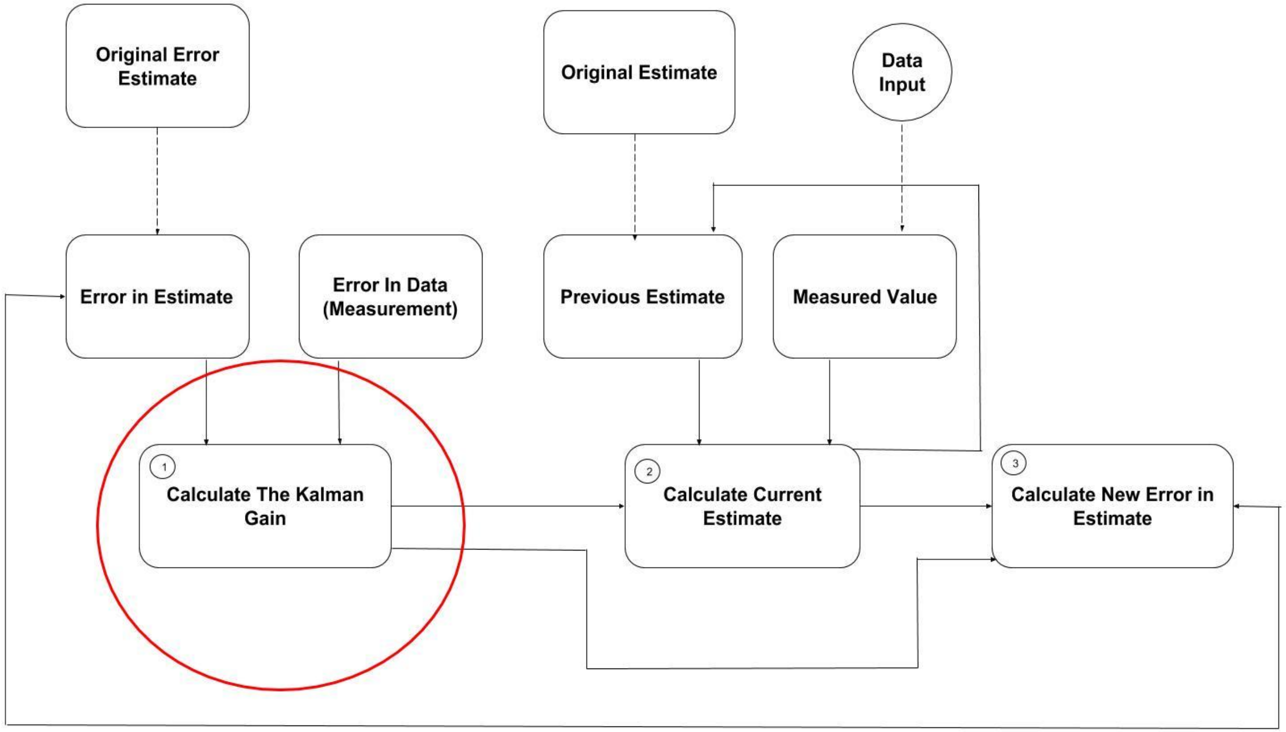
Kalman Filter - Linear Position, Angular Position & Velocity



STATE ESTIMATION

SOFTWARE

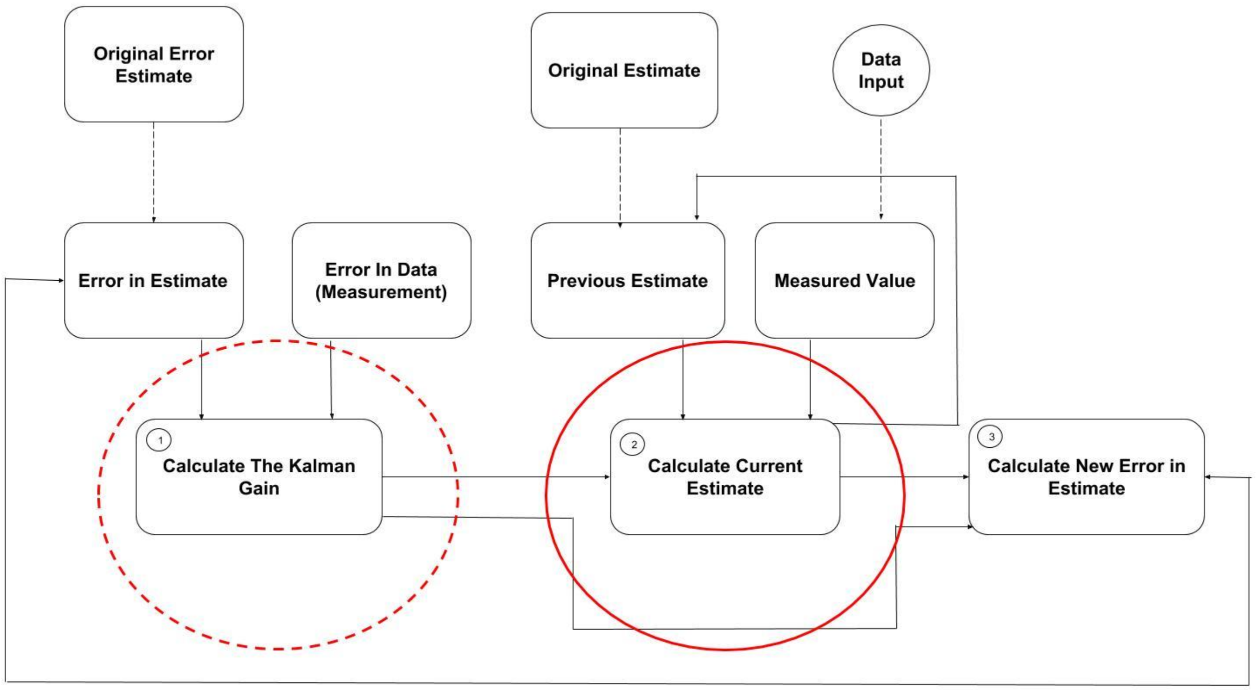
Kalman Filter - Linear Position, Angular Position & Velocity



$$K_n = \frac{p_{n,n-1}}{p_{n,n-1} + r_n} \quad (1)$$

STATE ESTIMATION
SOFTWARE

Kalman Filter - Linear Position, Angular Position & Velocity

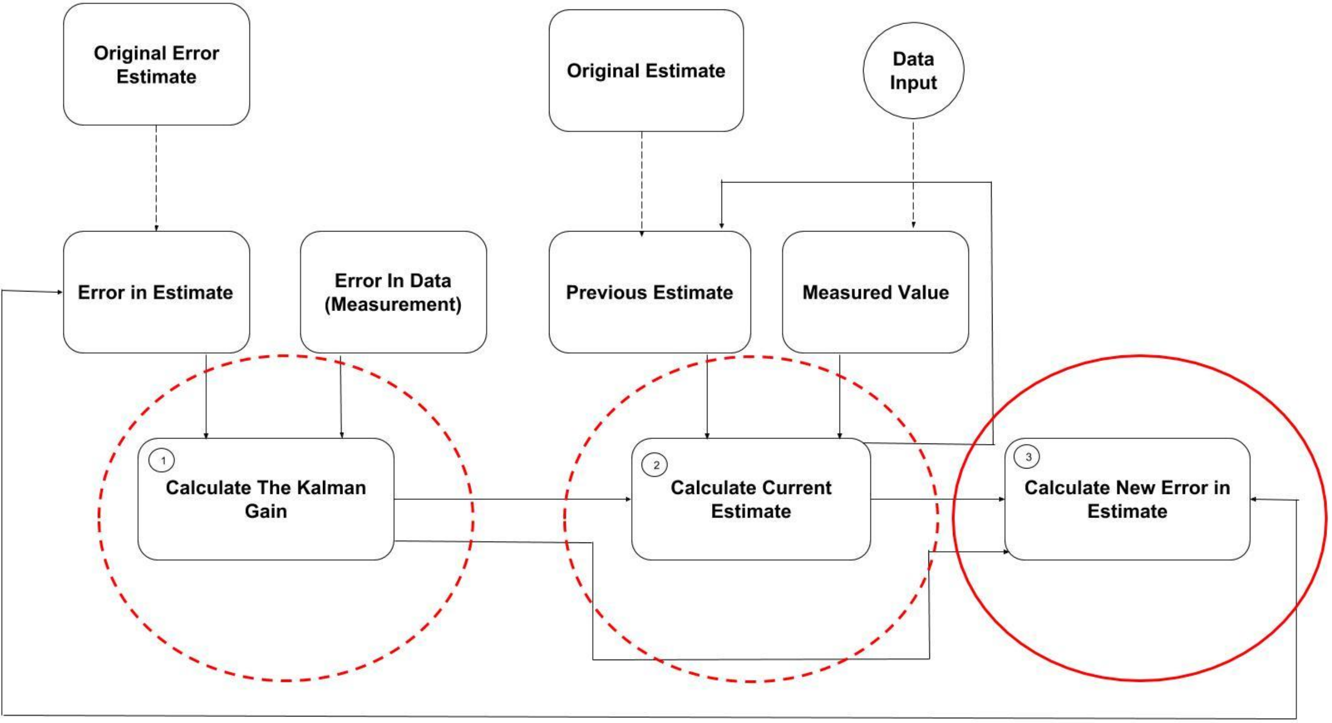


(2) $$\hat{x}_{n,n} = \hat{x}_{n,n-1} + K_n \left(y_n - \hat{x}_{n,n-1} \right)$$

STATE ESTIMATION

SOFTWARE

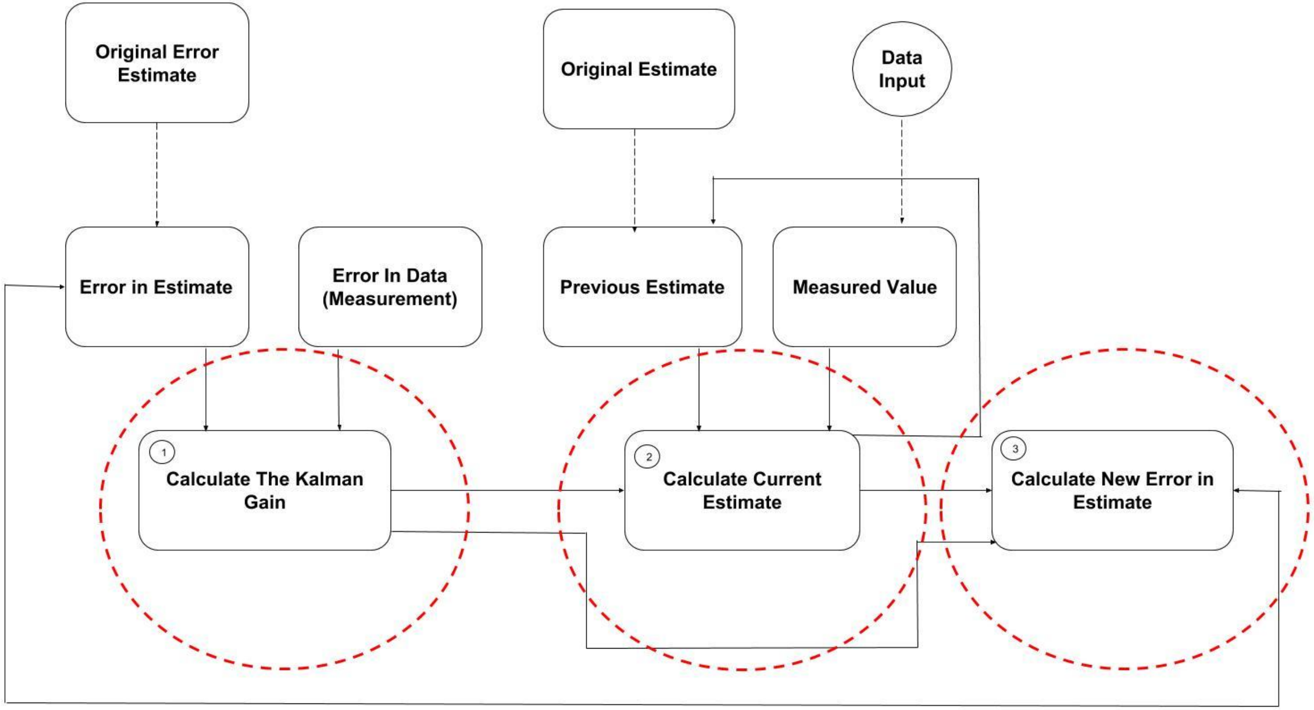
Kalman Filter - Linear Position, Angular Position & Velocity



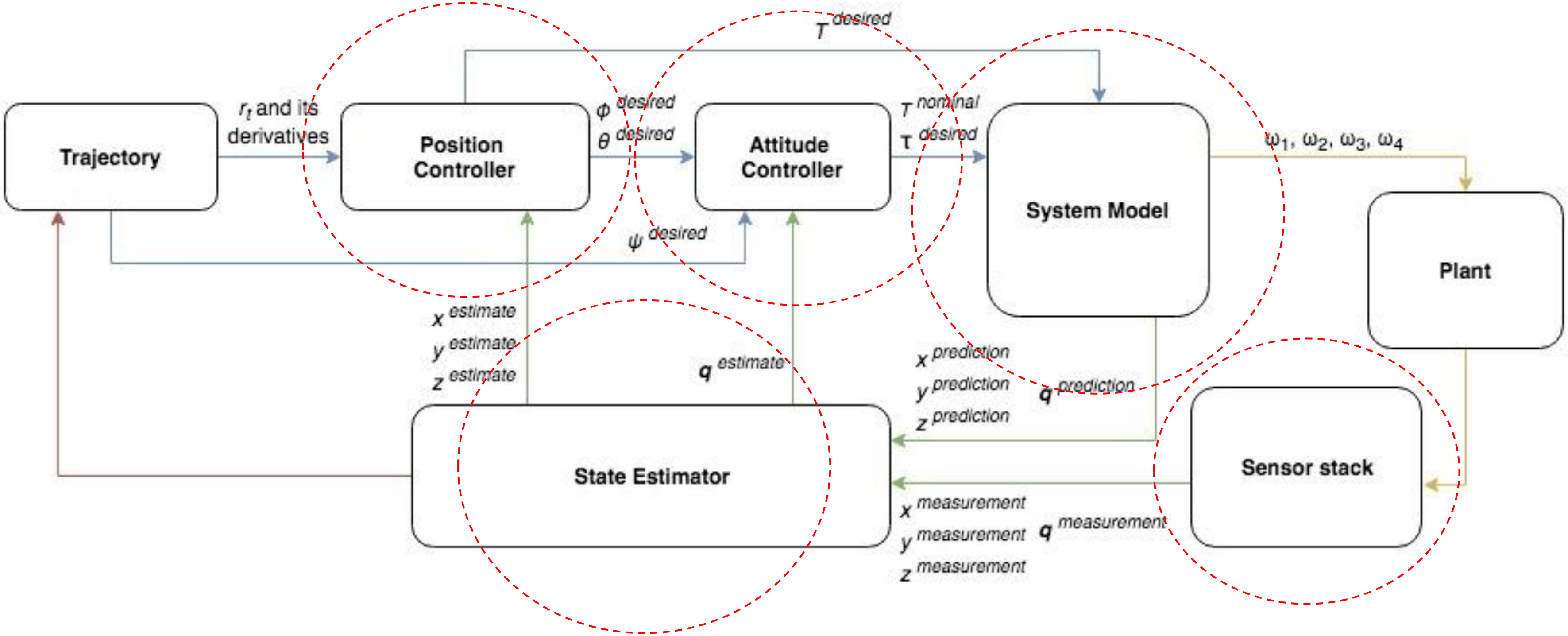
(3) $$p_{n,n} = (1 - K_n)p_{n,n-1}$$

STATE ESTIMATION
SOFTWARE

Kalman Filter - Linear Position, Angular Position & Velocity

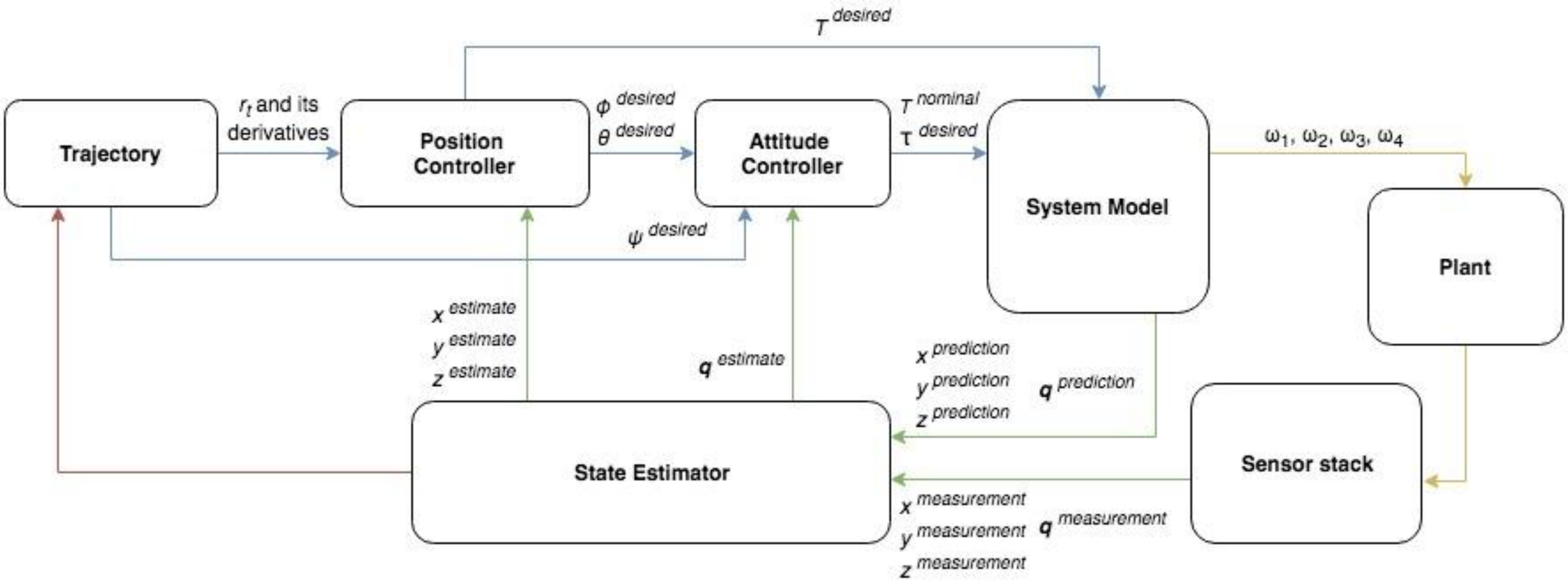


FLIGHT CONTROL
SOFTWARE



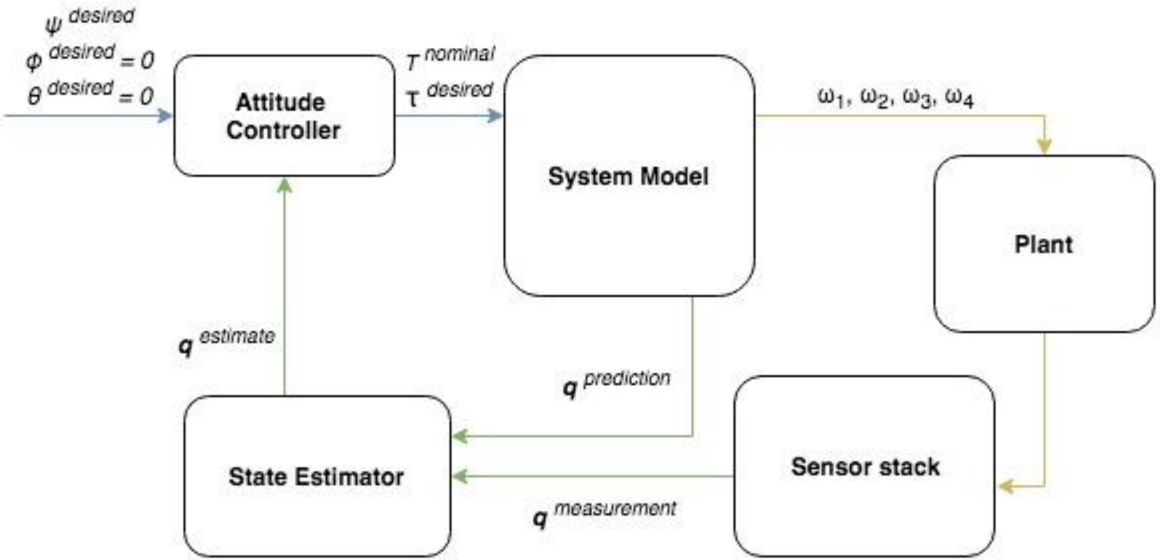
FLIGHT CONTROL

SOFTWARE



HOVER CONTROL

SOFTWARE

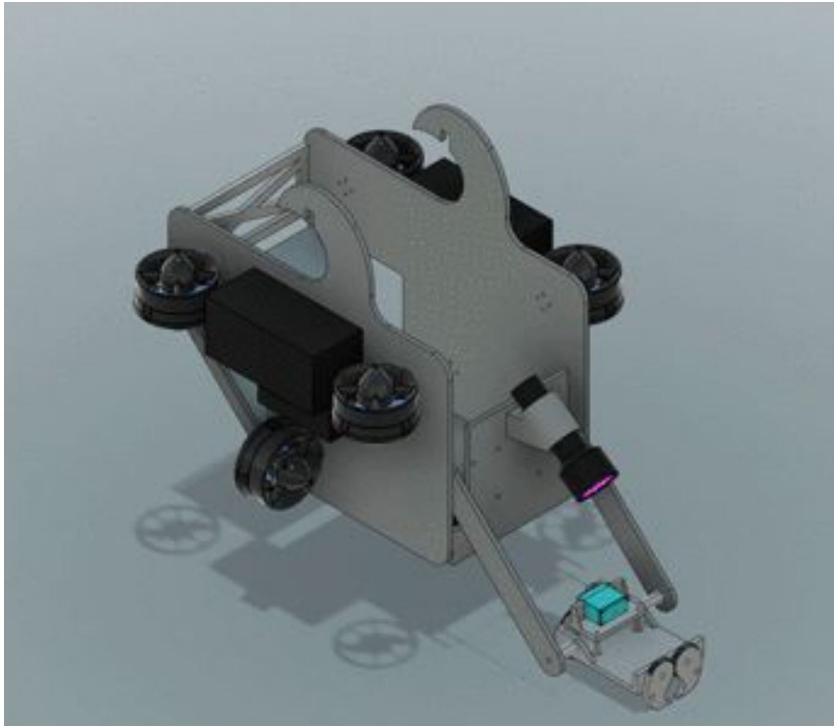


REMORA

MECHANICAL DESIGN

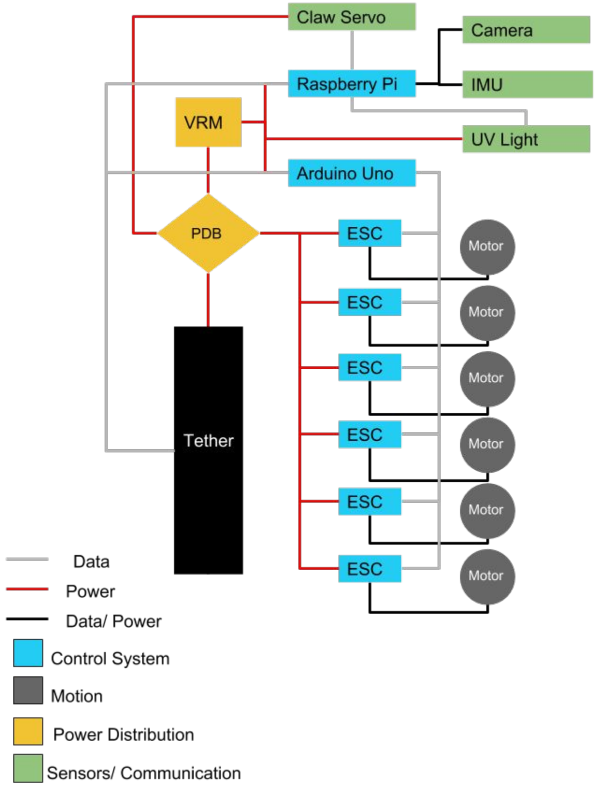
REMORA

- Central Receptacle
- ABS Plastic Sheets
- Motors
- Hooks



ELECTRICAL SYSTEM

REMORA



- External Control Box to Tether
  - Power & Data
- PDB to components
  - VRM
- Raspberry Pi
  - Sensors/ Modules
  - USB Power
- Arduino Uno
  - ESC/Motors

BALLAST SYSTEM

REMORA

- Pneumatic Ballast Tanks/System

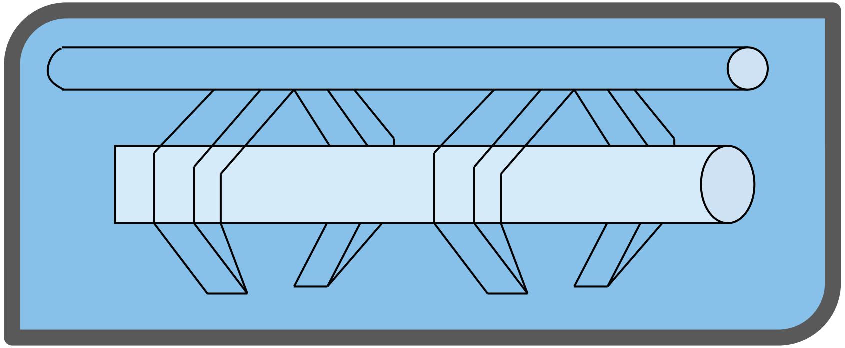
	Efficiency	Functionality	Cost	Complexity	Size/Weight	Time	Total
Ballast Tanks	5	5	3	3	3	3	22
Weights	3	3	4	4	3	4	21
Buoyancy Foam	2	3	4	5	2	4	20
Pool Noodles	1	2	5	5	2	4	19

RECOVERY SYSTEM

REMORA

Four Claw Missile Intake System

- Allows for top and bottom side of missile to be easily obtained
- Missile does not twist out of the claws' grips



	Cost	Weight	Efficiency	Time	Waterproof	Total
T Collector	1.25	3.75	2	0.25	2.5	9.75
Vacuum	0.25	1.5	1	0.25	1.5	4.5
Claw 2	1	3	3	1.25	1.5	9.75
Claw 4	0.75	2.25	5	1	1.5	10.5
Rollers	0.75	2.25	4	1	1.5	9.5

VISION CAPABILITY

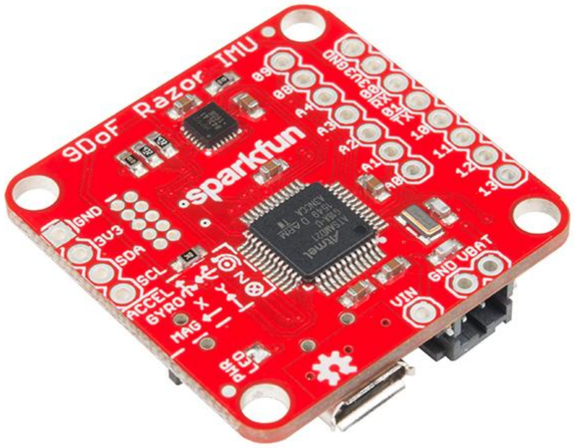
REMORA

- Two IP69K mini cameras
- Verification of the wreckage location
- Prevents collision and loss of cargo
- Prospective locations to position the beacon

LOCATION SENSING

REMORA

- SparkFun 9DoF Razor IMU M0
- 9 degrees of freedom
- Sense position relative to reference point
- Interface with Megalodon for Pickup



RADIOACTIVE DETECTION

REMORA

- Reflective with Uranium glass
- Visible in daylight
- Lightweight
- Meets recommended lumen requirement

BEACON

REMORA

- Ultrabright LED Flasher
- Detectable using camera
- Submersible
- 100 hr battery life
- Visible from ½ mile
- Weight: 0.5 oz

SYSTEM CONCEPTS

TESTING PROCEDURES

- Environments: Altitude of 201.9 feet and ≥11 feet underwater (pool water)
- Most components can survive in air, but not water.
- All components potentially contacting with water will go under the Waterproof Procedure (will be adjusted to be appropriate for each component).

Enclosure Test Procedure

Materials: 1 Braided Plastic Rope, 1 Roll of Thin Paper, 1 Heavy Weight, and # of Enclosures

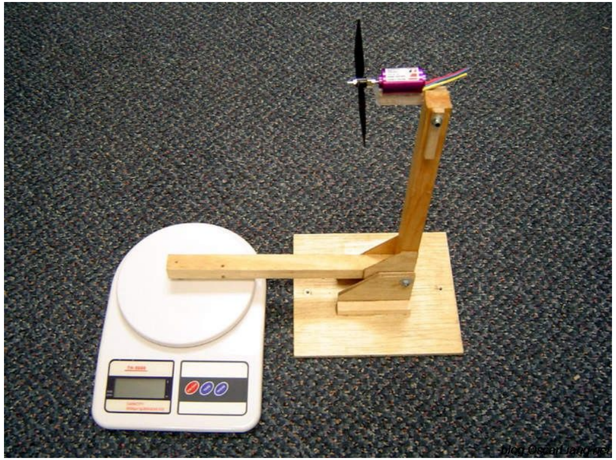
1. Open the enclosure.
2. Rip a strip of three squares of paper. Place it inside the enclosure.
3. Close the enclosure.
4. Place the enclosure on top of the weight and using the braided rope tie the two together by making parcel knots. Make sure the loose end(s) are coming from the top of the knotted object.
5. With one person holding the end of the rope, place the knotted enclosure and weight down into the pool at 7 ft.
6. Wait for 10 minutes before pulling it out of the water.
7. Open the enclosure and report the paper's current condition.
8. Repeat steps 1 to 8 for each number of enclosures being tested.

ENCLOSURE TEST

1150 Protector Pelican Case

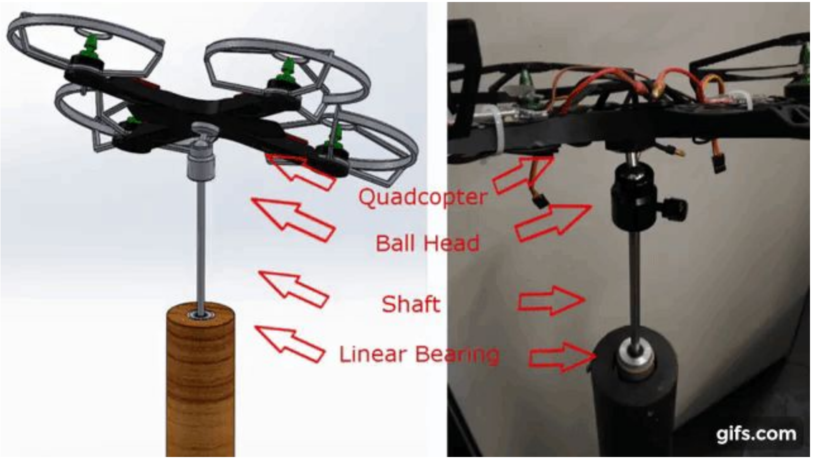
ML-58F*1508 ML Series Outdoor NEMA Enclosures Case

TESTING PROCEDURES



Mechanical: Motor Testing Rig

Programming: Drone Testing Bench



COMMUNICATION

3 Communication Systems: In-air AV, In-air RC, and Underwater

AV

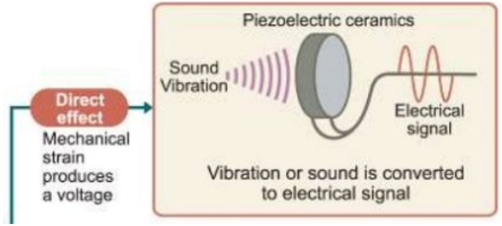
- For FPV (first-person view)
- 5.8 GHz, radio waves
- Camera -> transmitter -> receiver -> monitor at base
- PWM (pulse-width modulation) signals

RC

- For drone control
- 2.4 GHz, radio waves
- Remote input -> transmitter -> receiver on drone -> Raspberry PI #1 (signal processing)
- PWM

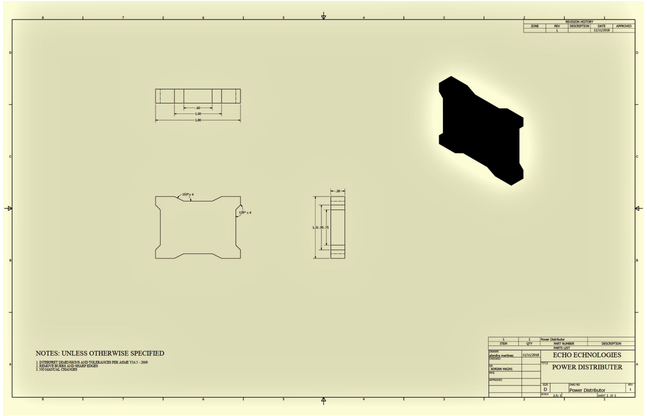
Underwater

- For aquatic ROV control
- 5 kHz, sound waves
- Button input -> transmitter (speaker) at base -> receiver on ROV (piezo condenser microphone) -> Raspberry PI #1
- Each frequency maps to specific commands



QUALITY ASSURANCE

- Consistent
- Accurate
- Precise



RISK AND ASSUMPTIONS

- Main Causes of Risk
  - Environment
  - Manufacturing
  - Testing
- Accessing the Largest Risks
- Actions Taken to Prevent Risk
- Safety Protocols and Procedures
  - Flight
  - Diving
  - Manufacturing
  - Removal and Reduction of Hazardous Objects
- Risks Relation to the Timeline

Risk Scales

	Severity			
Likelihood	Inconsequential	Insignificant	Noteworthy	Dangerous
Anticipated	Moderate	High	Unacceptable	Unacceptable
Possible	Acceptable	Moderate	High	Unacceptable
Improbable	Acceptable	Acceptable	Moderate	High
Unrealistic	Acceptable	Acceptable	Moderate	High

Risk Management					
Risk	Consequence	Likelihood	Severity	Risk Factor	Action
Testing	Damage to important components	Possible	Noteworthy	High	Testing procedures need to be prepared prior
Accidents that result in injuries	Personnel may need medical attention which may affect the timeline	Possible	Noteworthy	High	Personnel are required to follow many procedures for safety, using protective equipment, and being well informed
Inhalation of lead fumes	Cancer	Possible	Noteworthy	High	Have ventilation, use a fan while soldering, do not stay directly above fumes
Water damage	Timeline is delayed and systems may need to be rebuilt	Possible	Noteworthy	High	Test containment and ensure no water leakage before testing

FINANCIAL REPORT

BUSINESS PLAN

- Fundraising
  - Hold multiple successful fundraisers
  - Raise sufficient funds necessary to maintain status and purchase essential products
- Sponsorships
  - Reach out to companies and industries for sponsorships and or donations
    - Motivo, Blue Robotics, Home Depot
- Exploring Commercial Applications
  - Develop systems and strategies with a large range of applications
    - Communications, Search, Rescue, Recovery

BUSINESS PLAN

- Purchasing Strategies
  - Maintain a formal budget
  - Comply with all rules and regulations as presented by CAMS ASB
  - Maintain close relationship with CAMS administration
  - Require all products to be approved by Management, Mr. Carpenter, Financial Team, Quality Assurance Officer, and Risk Management Officer
- Maintaining Public Relations
  - Emphasize the importance of sustained public relations through ethical behavior and integrity in the industry
- F.O.M. Interns
  - Act as an extension of the Financial Team with similar responsibilities

APPROXIMATE BUDGET

SYSTEMS

Item No.	Vendor	Description	Part No.	Unit	QTY	Unit Price	Total Price
1	Blue Robotics	M200 Brushless Motors	M200	each	4	$95.00	$380.00
2	Amazon	Raspberry Pi Model B	RASPBERRYPI3-MODB-1GB	each	3	$37.30	$111.90
3	Amazon	eBoot Buck Converter	EXPSFD005794	each	1	$11.99	$11.99
4	Fox Tech	Tarot X4 Quadcopter Frame	1946	each	1	$234.99	$234.99
5	Amazon	CyclingDeal 20X Bike Bicycle Air Pump Inflator 16G Co2 Threaded Cartridges	CD-CO2-20	20	1	$24.00	$24.00
6	Amazon	Black CO2 Inflator for Bikes Tire By BriskMore	BT-003A	each	1	$14.90	$14.90

APPROXIMATE BUDGET

SYSTEMS CONT.

Item No.	Vendor	Description	Part No.	Unit	QTY	Unit Price	Total Price
7	Amazon	Revmega Tubeless Presta Valve Stem	VS02	each	1	$12.99	$12.99
8	Amazon	Nylon Vacuum Flexible Tubing	B0092L1MLE	each	1	$30.58	$30.58
9	Amazon	Pump Air Wedge Alignment	FAW-02	3	1	$16.99	$16.99
10	Amazon	Logitech USB Camera	B000VTQ3LU	each	1	$7.89	$7.89
11	Amazon	Adafruit 9-DOF Absolute Orientation IMU	ADA2472	each	1	$34.95	$34.95
12	Blue Robotics	Bar02 Ultra High Resolution 10m Depth/Pressure Sensor	BAR02-SENSOR-R1-RP	each	1	$88.00	$88.00

APPROXIMATE BUDGET

SYSTEMS CONT.

Item No.	Vendor	Description	Part No.	Unit	QTY	Unit Price	Total Price
13	Amazon	50.0 Mega Pixel USB HD Video Camera Webcam	NCOREJNJIJKKM 362	each	1	$4.69	$4.69
14	Amazon	Pelican 1150 Camera Case With Foam	1150-000-110	each	1	$40.00	$40.00
15	Polycase	ML Series Outdoor NEMA Enclosures	ML-58F*1508	each	1	$42.00	$42.00
16	Blue Robotics	Cast Acryllic Tube (6" Series)	WTE6-ASM-R1-VP	each	1	$90.00	$90.00
17	Blue Robotics	O-Ring Flange	WTE6-ASM-R1-VP	each	2	$59.00	$118.00
18	Blue Robotics	Aluminum End Cap with 15 Holes (6" Series)	WTE6-ASM-R1-VP	each	2	$44.00	$88.00

APPROXIMATE BUDGET

SYSTEMS CONT.

Item No.	Vendor	Description	Part No.	Unit	QTY	Unit Price	Total Price
19	Blue Robotics	Enclosure Vent and Plug	WTE6-ASM-R1-VP	each	1	$8.00	$8.00
20	Blue Robotics	T200 Thruster	T200-THRUSTER-R1-RP	each	4	$169.00	$676.00
21	Adafruit	USB Type-A Jack	2225	each	15	$0.69	$10.35
22	Amazon	Assorted M3 M2.5 Nylon Screws Nut Standoffs	B06Y591NKK	210	2	$9.99	$19.98
23	Amazon	Mudder Black Aluminum Heatsink Cooler Cooling Kit	LYSB01LXWK626-ELECTRNCS	10	2	$5.99	$11.98
24	Amazon	Sandisk Ultra 32GB Micro SDHC UHS-I Card with Adapter	1 A1 - SDSQUAR-032G-GN6MA	each	3	$9.59	$28.77
						Total Cost	**$2,106.95**

APPROXIMATE BUDGET

MISCELLANEOUS

Item No.	Vendor	Description	Part No.	Unit	QTY	Unit Price	Total Price
1	Amazon	BookFactory Black Engineering Notebook	LIRPE-168-SGR-A-LKT4	each	1	$29.99	$29.99
2	Name Cheap	Website Domain (echotechnologies.org)	N/A	each	1	$11.69	$11.69
3	Tie Mart	Blue Staff Tie	AC58NW-0014	each	50	$2.50	$125.00
4	Signarama	Team Canvas Banner	N/A	each	1	$154.80	$154.80
5	FedEx	SPS Document	N/A	each	1	$197.36	$197.36
						Total Cost	**$518.84**

APPROXIMATE BUDGET

INTERNS

Item No.	Vendor	Description	Part No.	Unit	QTY	Unit Price	Total Price
1	Amazon	ABS Plastic Sheet	B004UBWEVI	each	3	$9.98	$29.94
2	Blue Robotics	T100 Thruster	T100-THRUSTER-R1-RP	each	6	$119.00	$714.00
3	Alibaba	Waterproof IR Truck security Side View Camera	720P AHD IP69K	each	2	$28.50	$57.00
4	Blue Robotics	Fathom ROV Tether R2	FATHOM-TETHER-NB-4P-26AWG-100-R2	each	1	$500.00	$500.00
5	Blue Robotics	Waterproof Servo	HITEC-D646WP	each	8	$56.00	$448.00
6	Arduino	ARDUINO UNO REV3	A000066	each	1	$22.00	$22.00

APPROXIMATE BUDGET

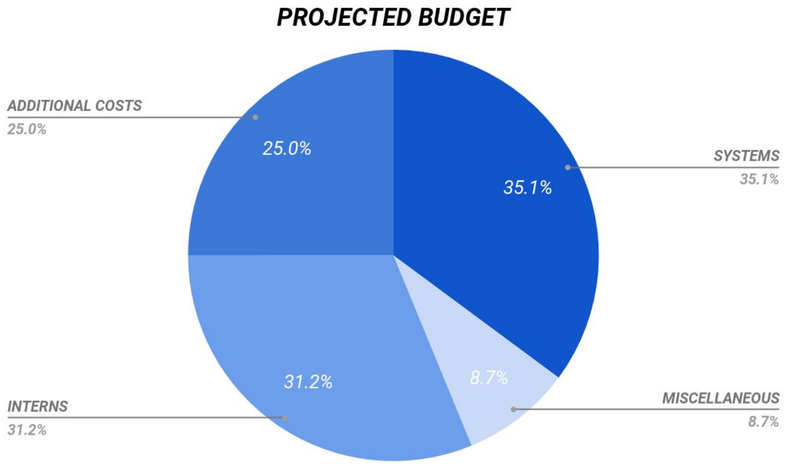
INTERNS CONT.

Item No.	Vendor	Description	Part No.	Unit	QTY	Unit Price	Total Price
7	Blue Robotics	Basic ESC	BESC30-R3	each	1	$25.00	$25.00
8	Amazon	Raspberry Pi 3 Model B Motherboard	RASPBERRYPI3-MODB-1GB	each	1	$34.99	$34.99
9	Blue Robotics	Subsea Buoyancy Foam: R-3312	FLOAT-R3312-R1-VP	each	1	$21.00	$21.00
10	Amazon	Loctite Epoxy Quick Set	1395391	each	1	$6.65	$6.65
11	Amazon	MG Chemicals Silicone Modified Conformal Coating	422B-55ML	each	1	$12.95	$12.95

Total Cost	**$1,871.53**

PROJECTED BUDGET

SYSTEMS	$2,106.95	35.1%
MISCELLANEOUS	$518.84	8.7%
INTERNS	$1,871.53	31.2%
ADDITIONAL COSTS	$1,500	25.0%
TOTAL	$6,000	



OUTREACH

PURPOSE

OUTREACH

- Educate the youth about Science, Technology, Engineering, Art & Math (STEAM) career pathways through interactive presentations and collaborative activities.

- Diversity within in each STEAM field.

- Give back to the community by helping students develop skills that will aid them in their future endeavours

GOALS & PLANS
OUTREACH

As the Outreach team, our main goal is to educate the youth about the possibilities that the STEAM fields possesses and to inspire the community to pursue a career in those fields.

How?

- Hosting multiple STEAM events and workshops
- Interactive lessons
- Finding Nemo Themed Activities

Where?

- Local middle schools and elementary schools
- Community Day

MEDIA AND PUBLICATIONS

PURPOSE

MEDIA AND PUBLICATIONS

- Documentary
- Company Profile
- Sponsorships
- Social Media
- Official Guides/Manuals
- Legacy

QUESTIONS, COMMENTS, CONCERNS?

THANK YOU!

ECHO
TECHNOLOGIES