15th Annual AUVSI RoboSub Competition – *The Ides of TRANSDEC*

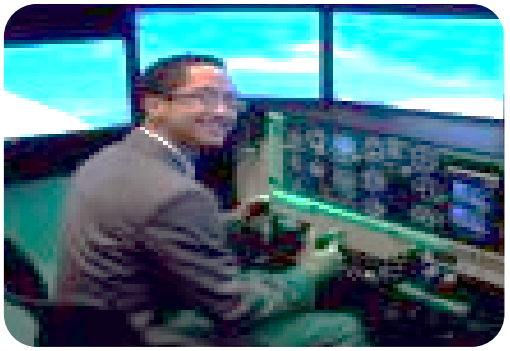
Tra Hunter, Antony Jepson, Ryan Kopinsky, Kashief Moody, Eric Sloan, Hang Zhang

Tuesday April 3rd, 2012

Team Members

ECE

Antony Jepson *ECE*
Project Manager



Ryan Kopinsky
Secretary

Hang Zhang
Treasurer

ME

Eric Sloan
ME Project Manager

Kashief Moody
Secretary

Tra Hunter
Treasurer

Presentation Overview

- Introduction
- Functional System Diagram
- Concept Descriptions
- Final AUV Design + Test Results
  - Complete System
  - Mechanical Subsystems
  - Electrical System
  - Guidance System
- Engineering Economics – Budget/Expenditures
- Concluding Remarks + Questions

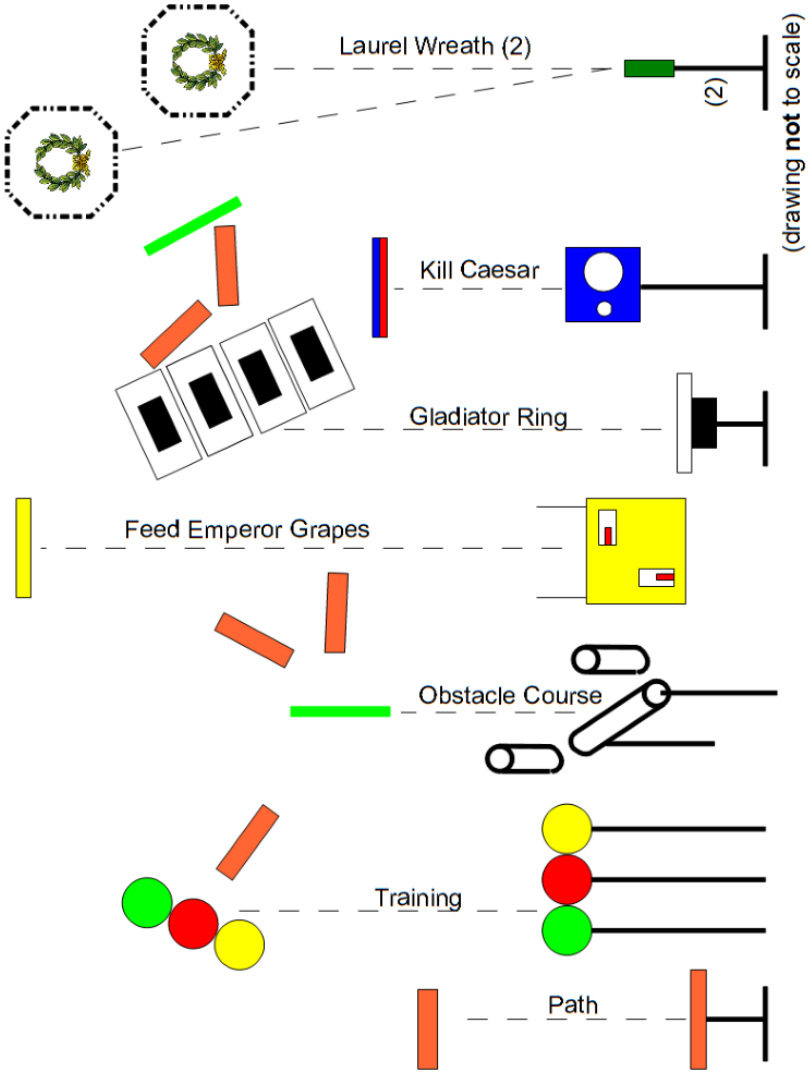
SSC Pacific TRANSDEC Anechoic Saltwater Pool

AUVSI foundation
ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS INTERNATIONAL

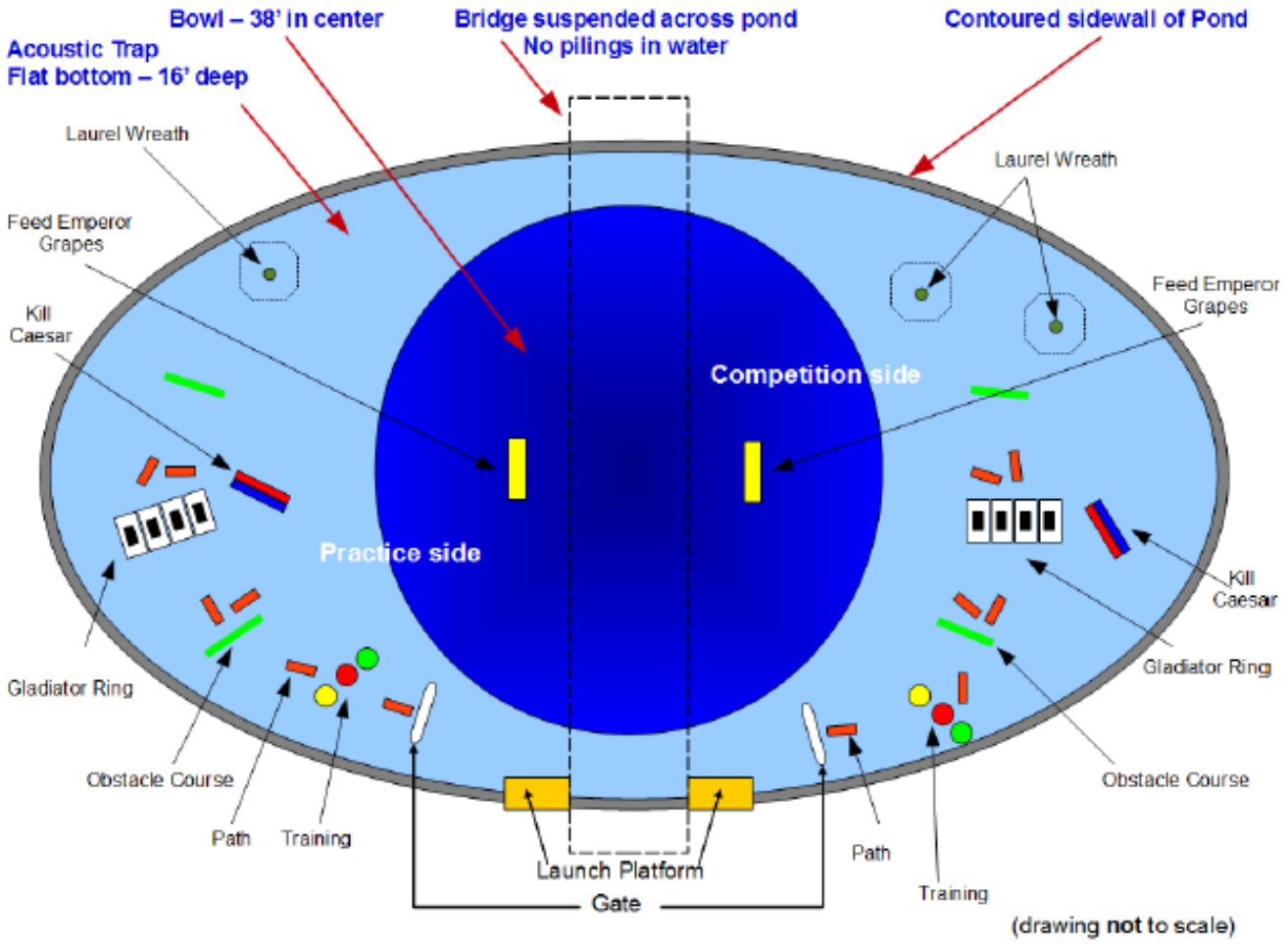
ONR
Office of Naval Research

Mission Tasks

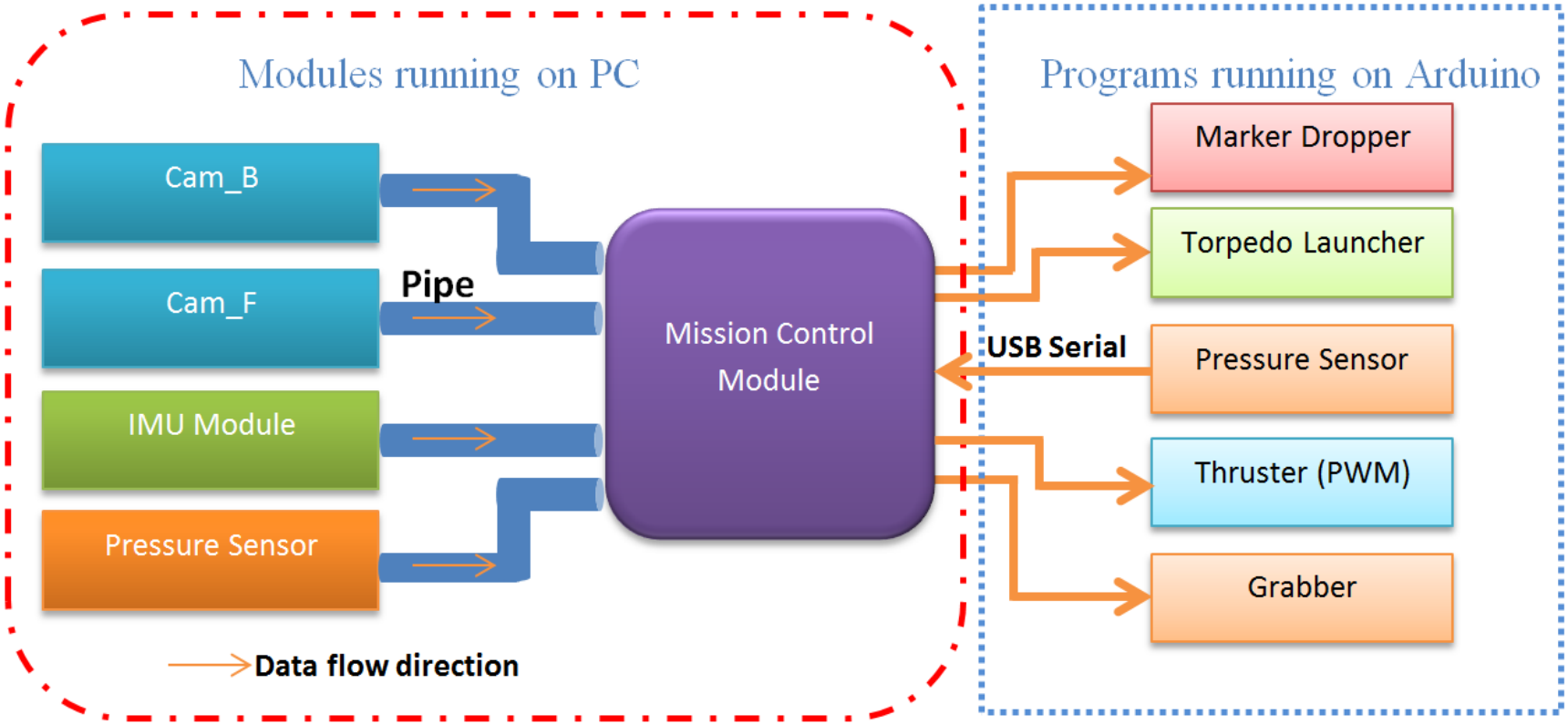
- Path (Follow to Navigate Through Course)
- Strike Buoys
- PVC Pass-Over
- Gladiator Ring (Drop Markers in Bins)
- Kill Caesar (Launch Torpedoes Through PVC Cutouts)
- Laurel Wreath (Locate, Recover, Surface, and Release)



Course Layout – Practice/Competition



Functional Diagram



Concept Descriptions

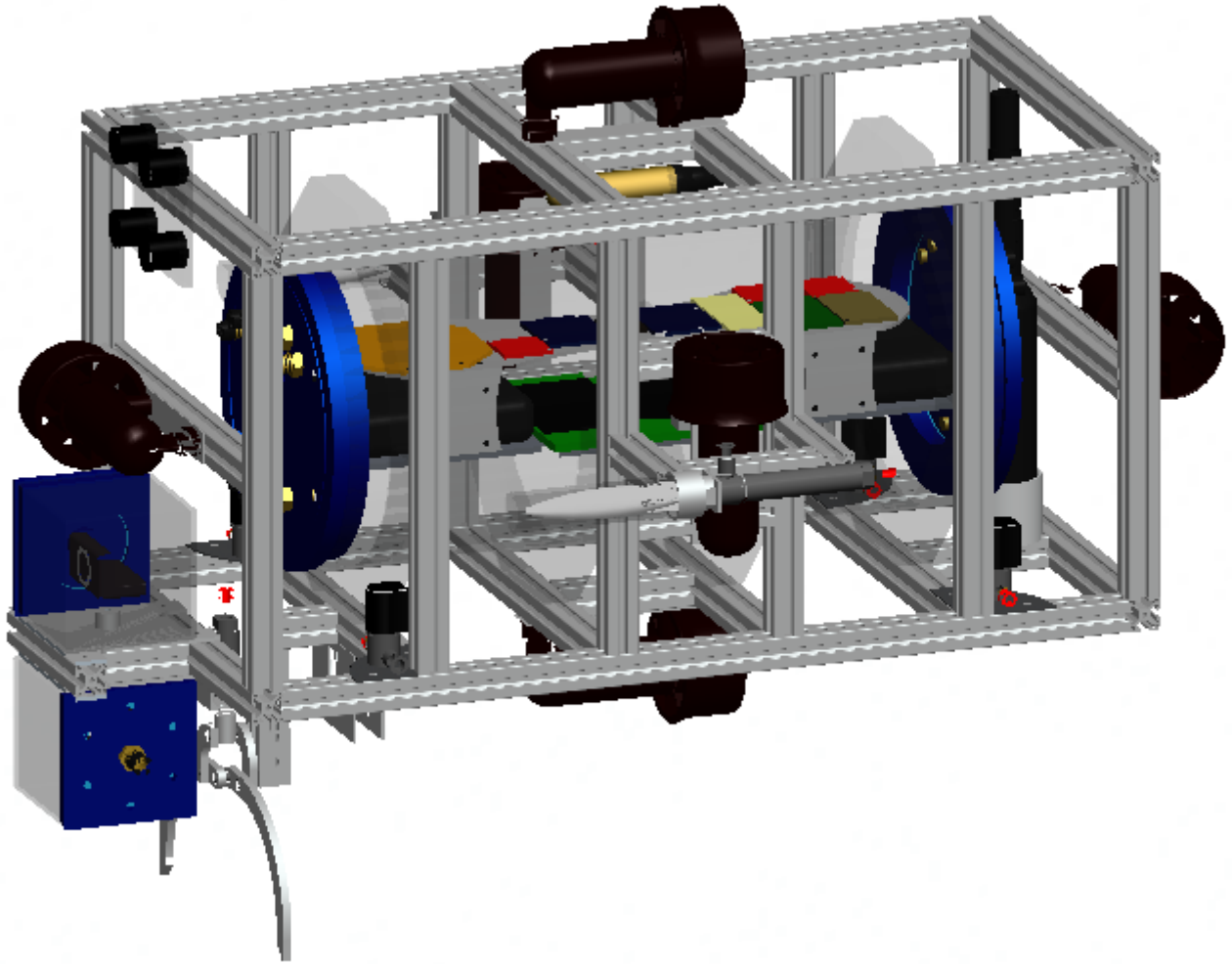
- Hull/Frame –
  - Solid Enclosure
  - Hydrodynamic/Biomimetic Shape (e.g. Sting Ray)
  - Open External Frame + Internal Enclosure
- Propulsion –
  - Pneumatics
  - Thrusters
    - Quantity
    - Locations
- Camera Enclosures –
  - Cylindrical + Optically Transparent
  - Spherical + Optically Transparent
  - Box (i.e. Flat-Faced) + Optically Transparent
    - Locations

Concept Descriptions

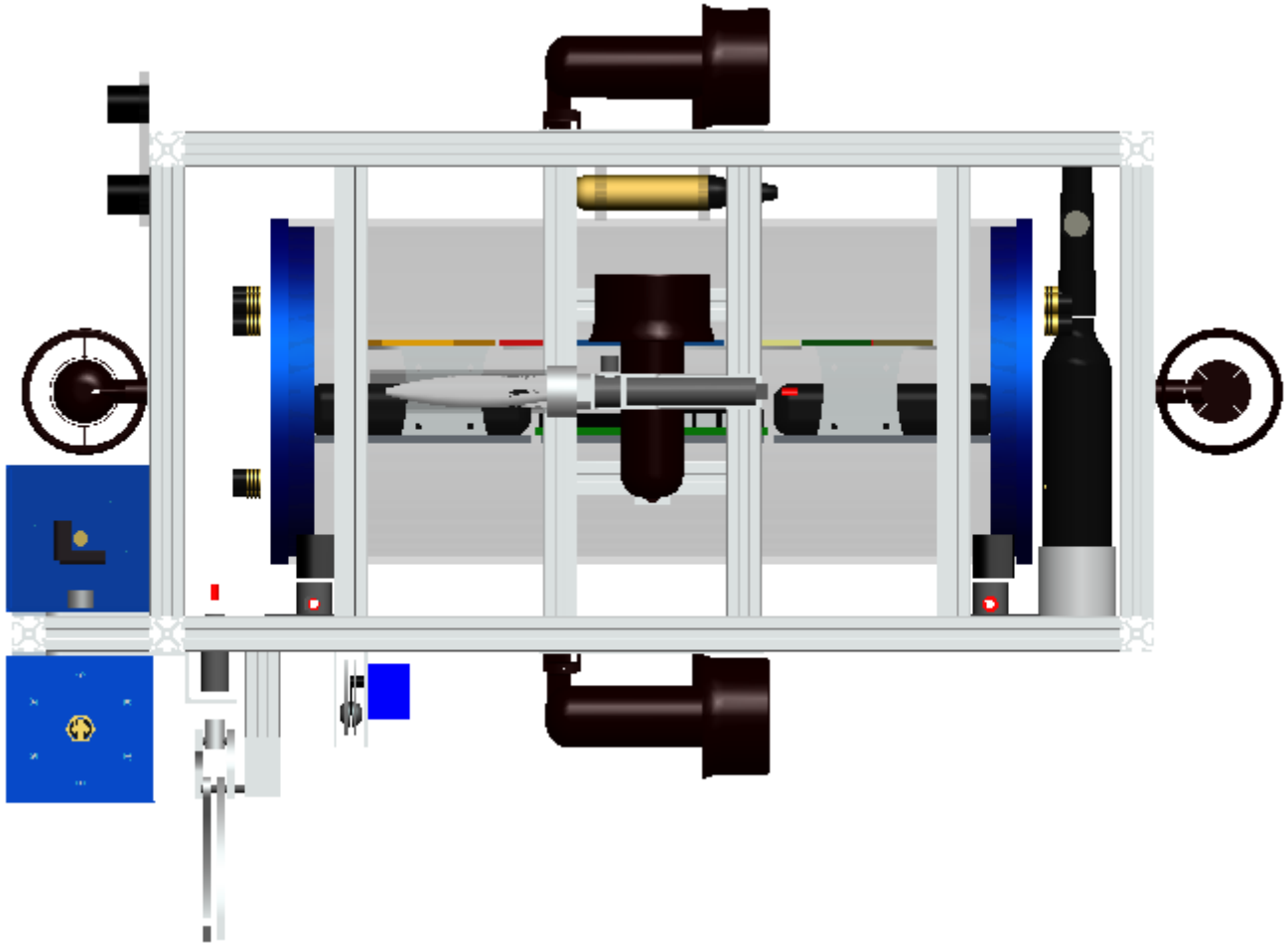
- Torpedo Launchers –
  - Self-Propelled
  - Spring Actuated
  - Pneumatically Actuated
    - Regulated Compressed Air Tank
    - Solenoid Valves
    - Gas Lines + Adapters

- Grasp/Release Mechanism –
  - Grab vs. Scoop
  - Number of Claws/Jaws
  - Pneumatically Actuated
    - Regulated Compressed Air Tank
    - Solenoid Valves
    - Gas Lines + Adapters

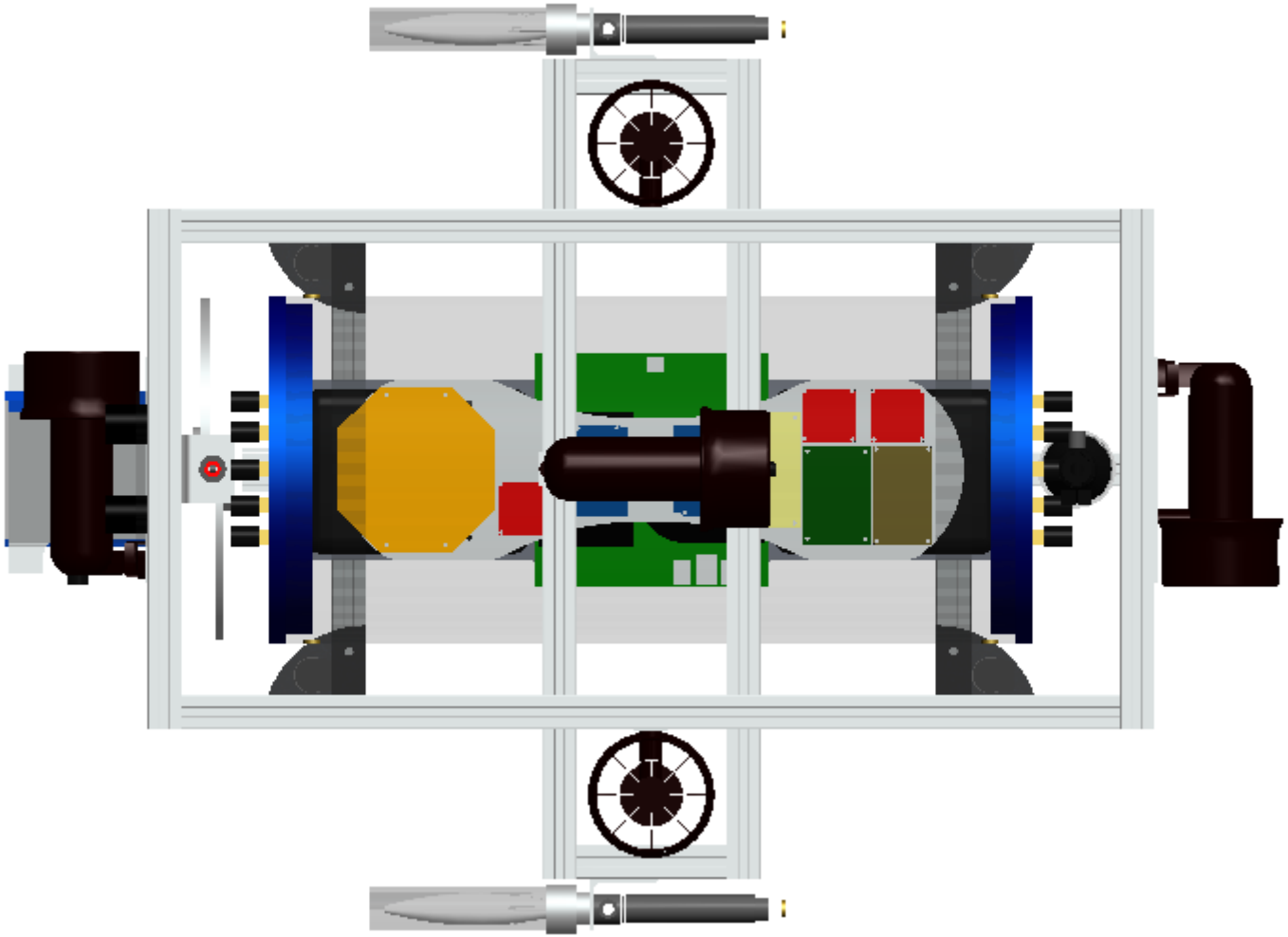
Final AUV Design



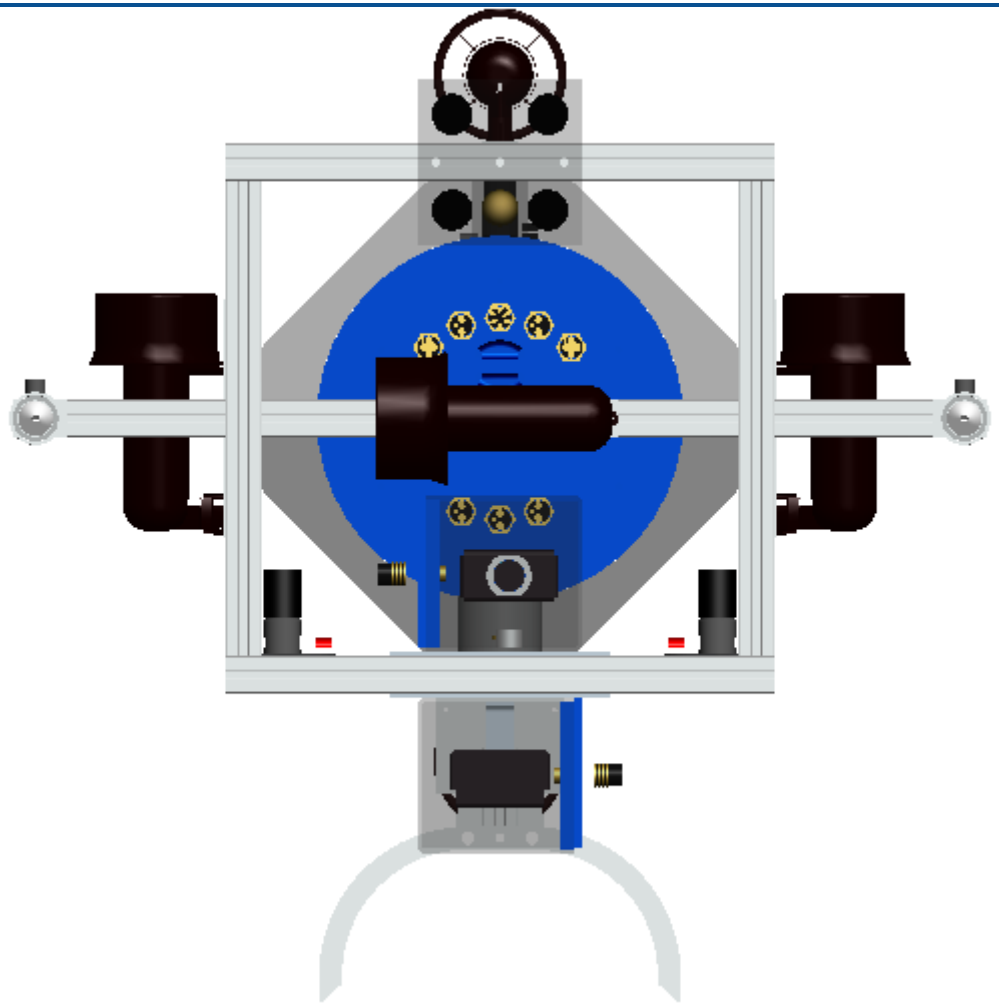
Side View



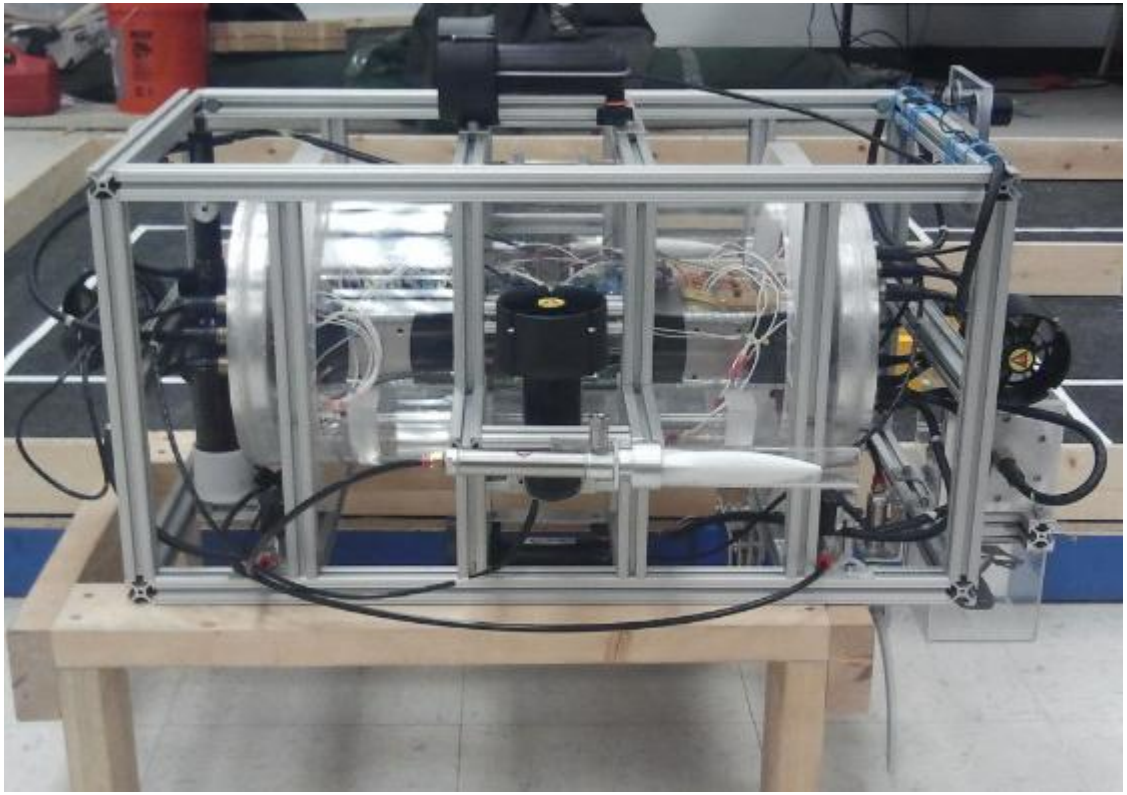
Top View



Front View



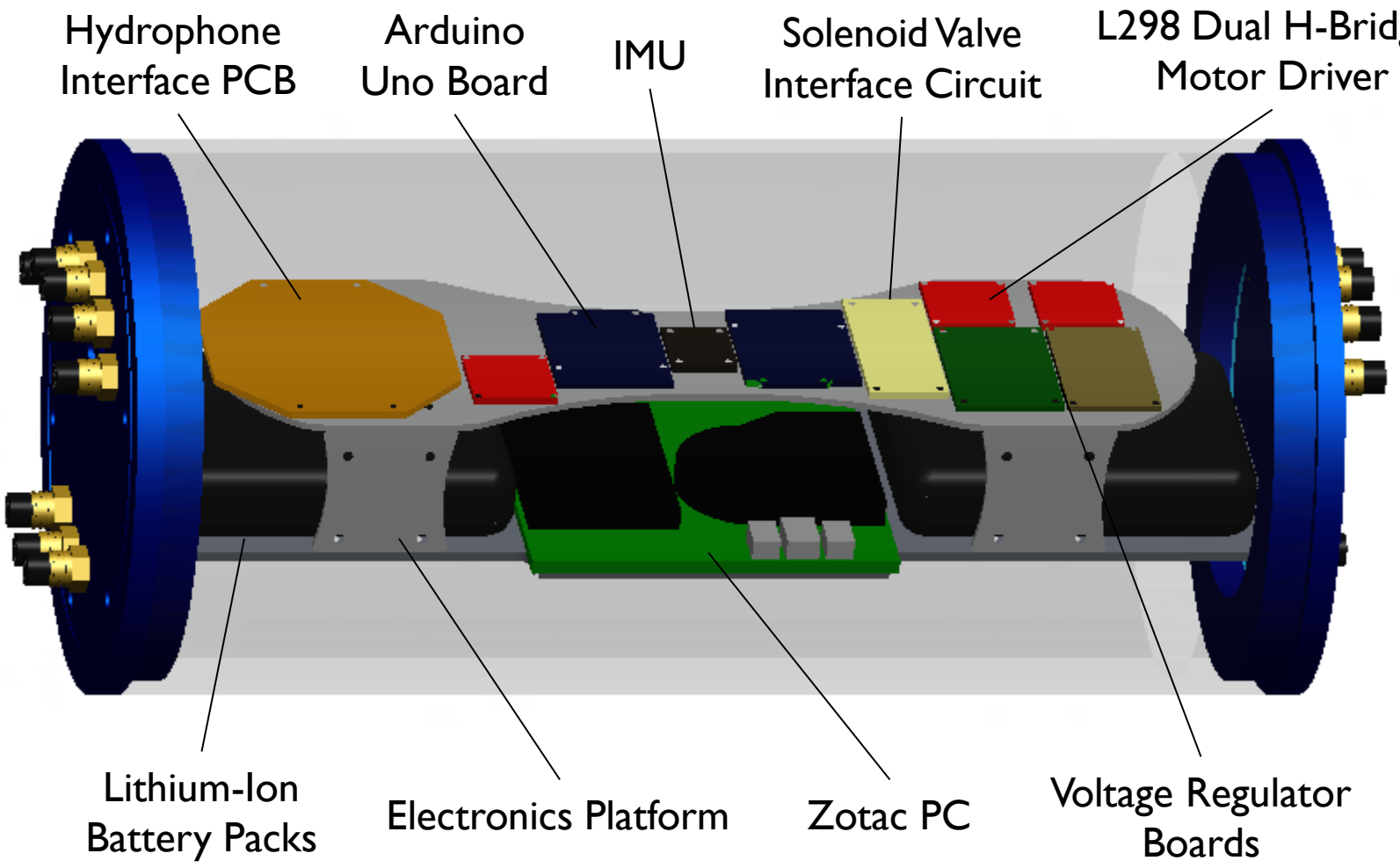
Photograph of Assembled AUV



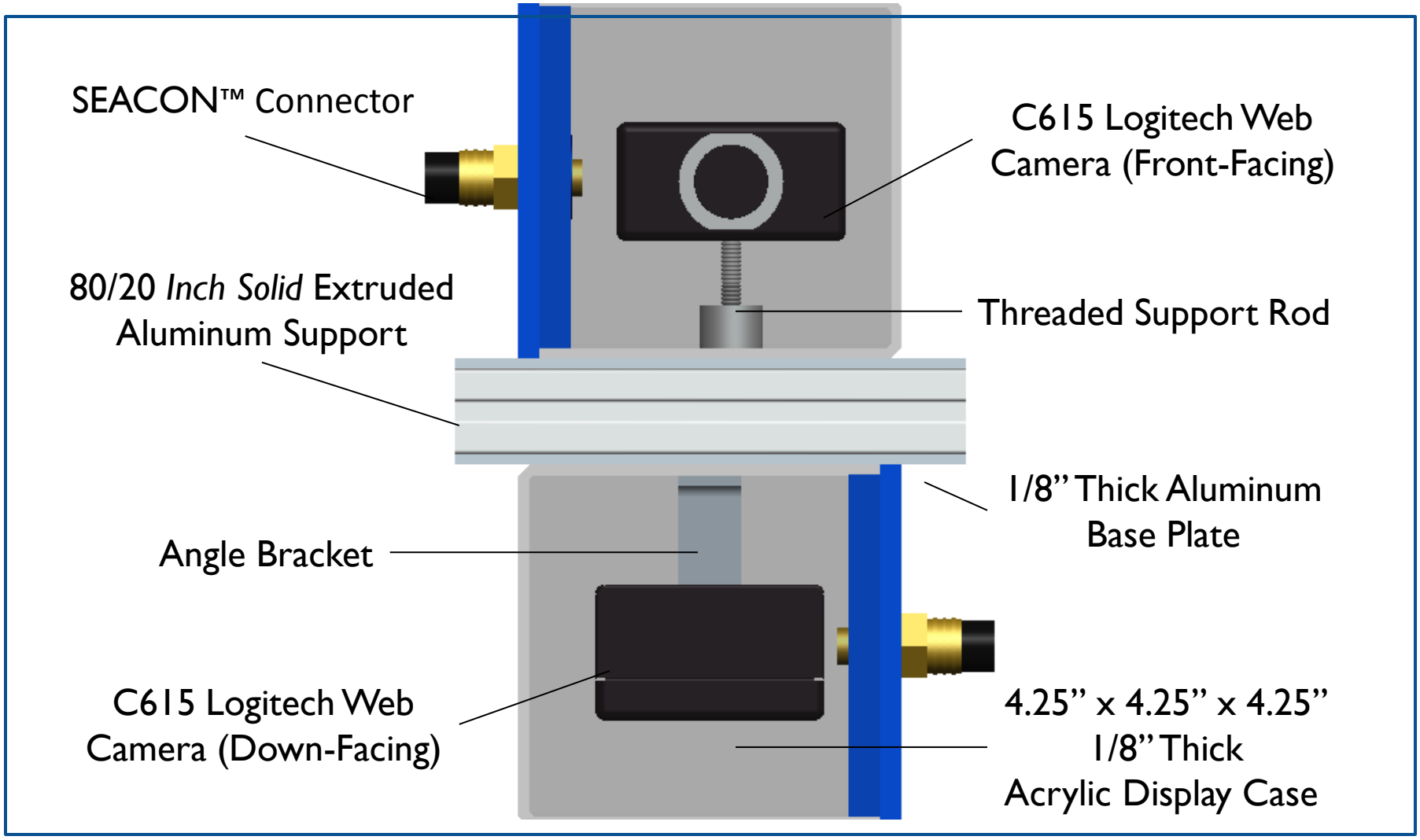
Tests

Test Description	Outcome
Vehicle Weight	Pass (87.7 lbs)
Vehicle Density	Pass (0.0360 lb/in^3)
Vehicle Balance	Pass
Vehicle Dimensions	Pass (37” L x 27” W x 27” H)
Watertight Hull	Pass

Interior Hull Layout (Revised)



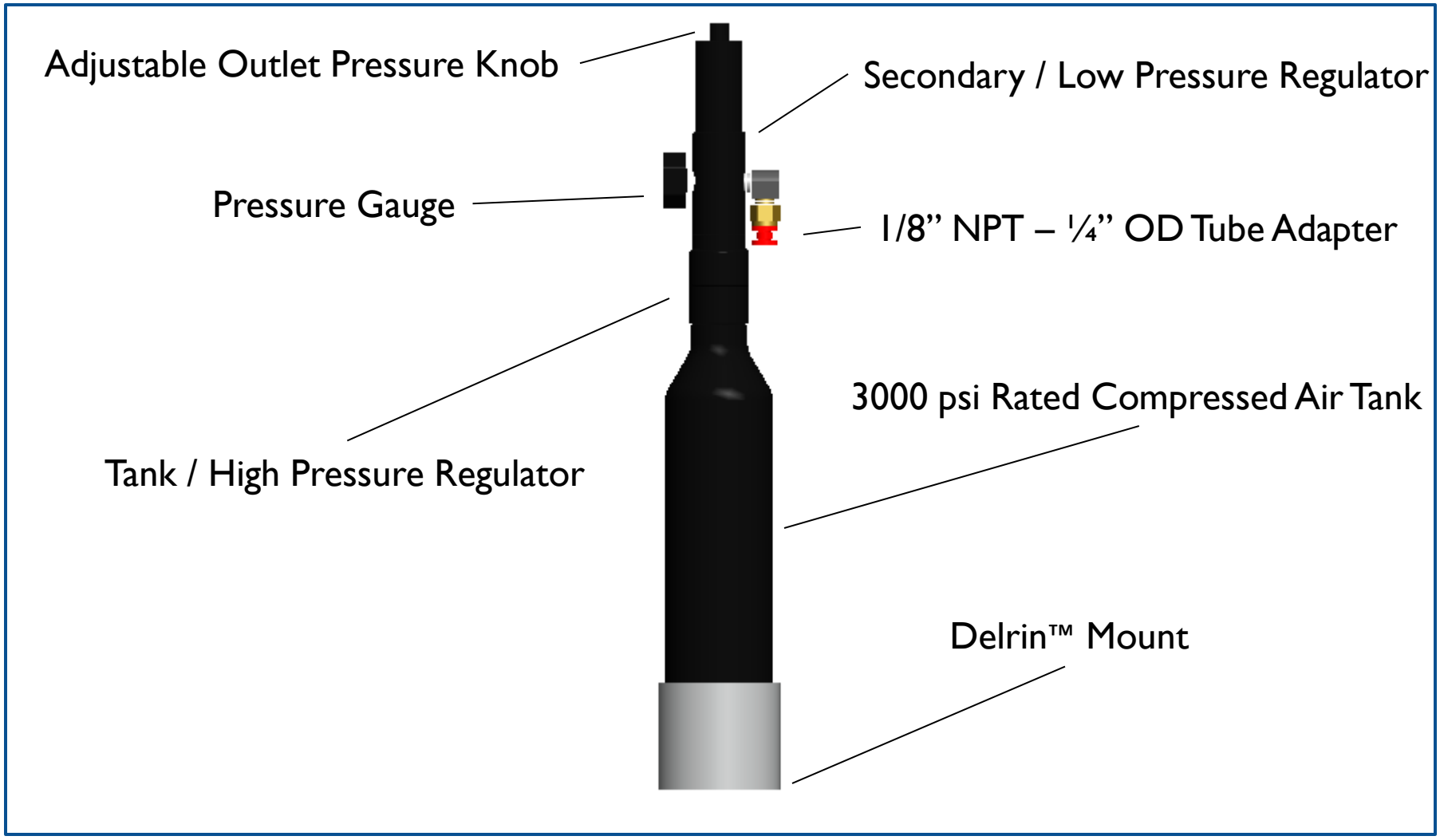
Camera Enclosures (Revised)



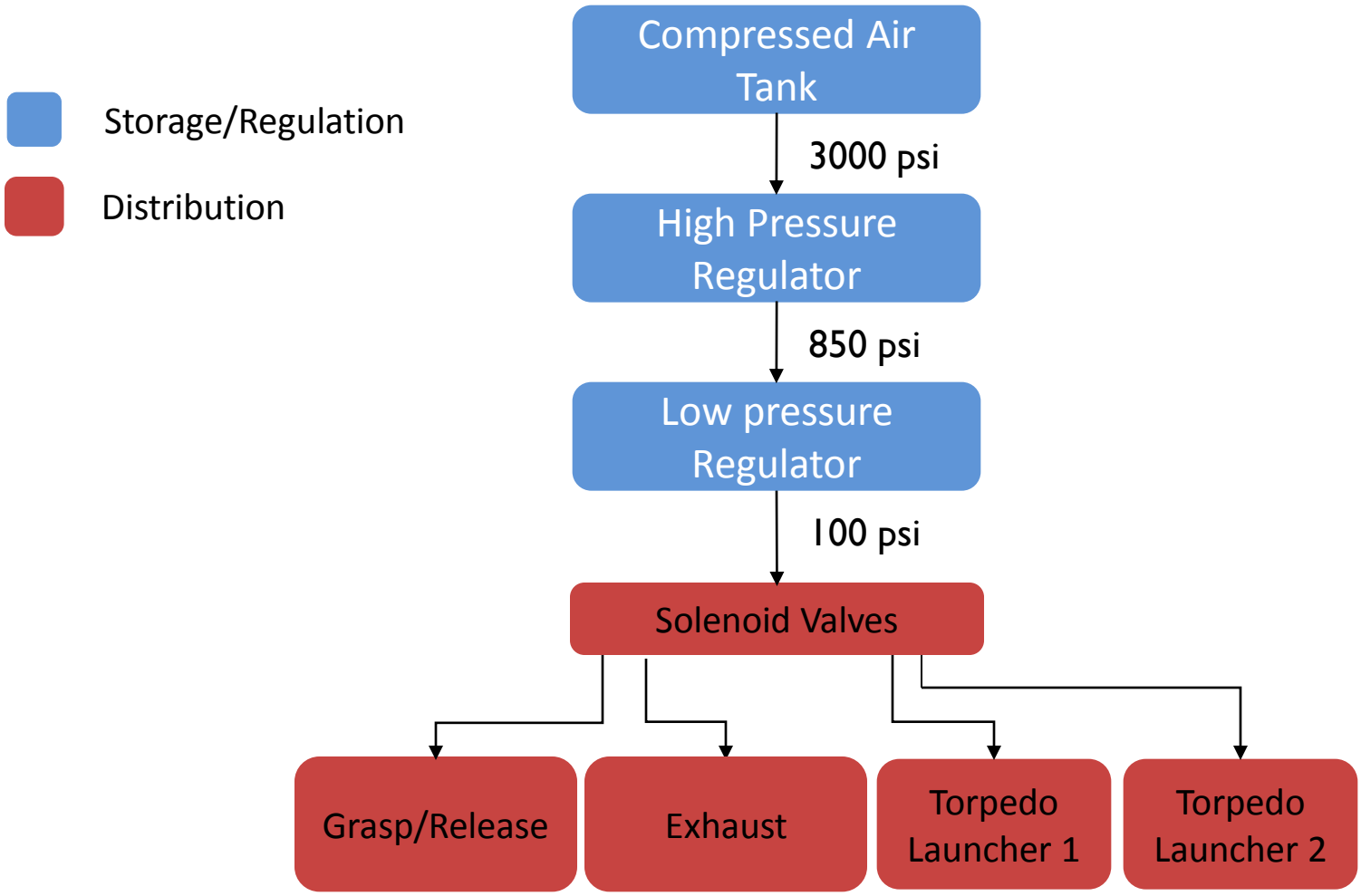
Tests

Test Description	Outcome
Watertight Camera Enclosures	Pass
Computer Vision – Gate Detection	Pass
Computer Vision – Path Detection	Pass
Computer Vision – Buoy Detection	N/A
Computer Vision – Drop-In Bin Detection	N/A
Computer Vision – Torpedo PVC Cut-Out Detection	N/A

Compressed Air Tank and Regulators



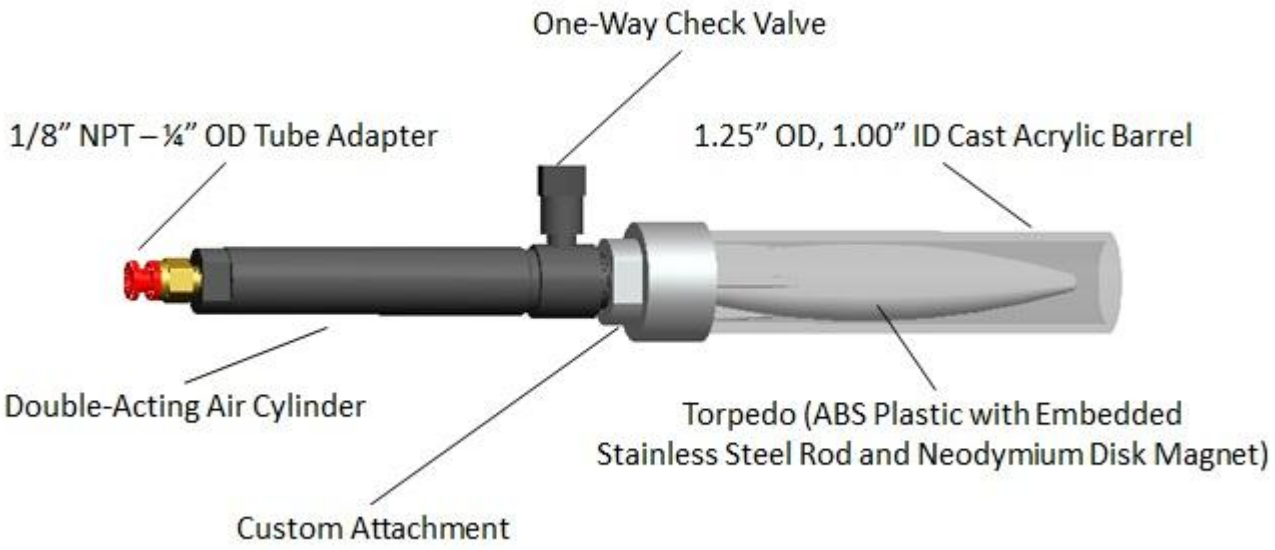
Compressed Air Distribution System Diagram



Tests

Test Description	Outcome
Proper Regulated Output Pressure	Pass (~100 psi)
Watertight Gas Lines (No Air Leakage)	Pass
Solenoid Valve Actuation/Integration	Pass
One-Way Check Valve Purging System	Pass

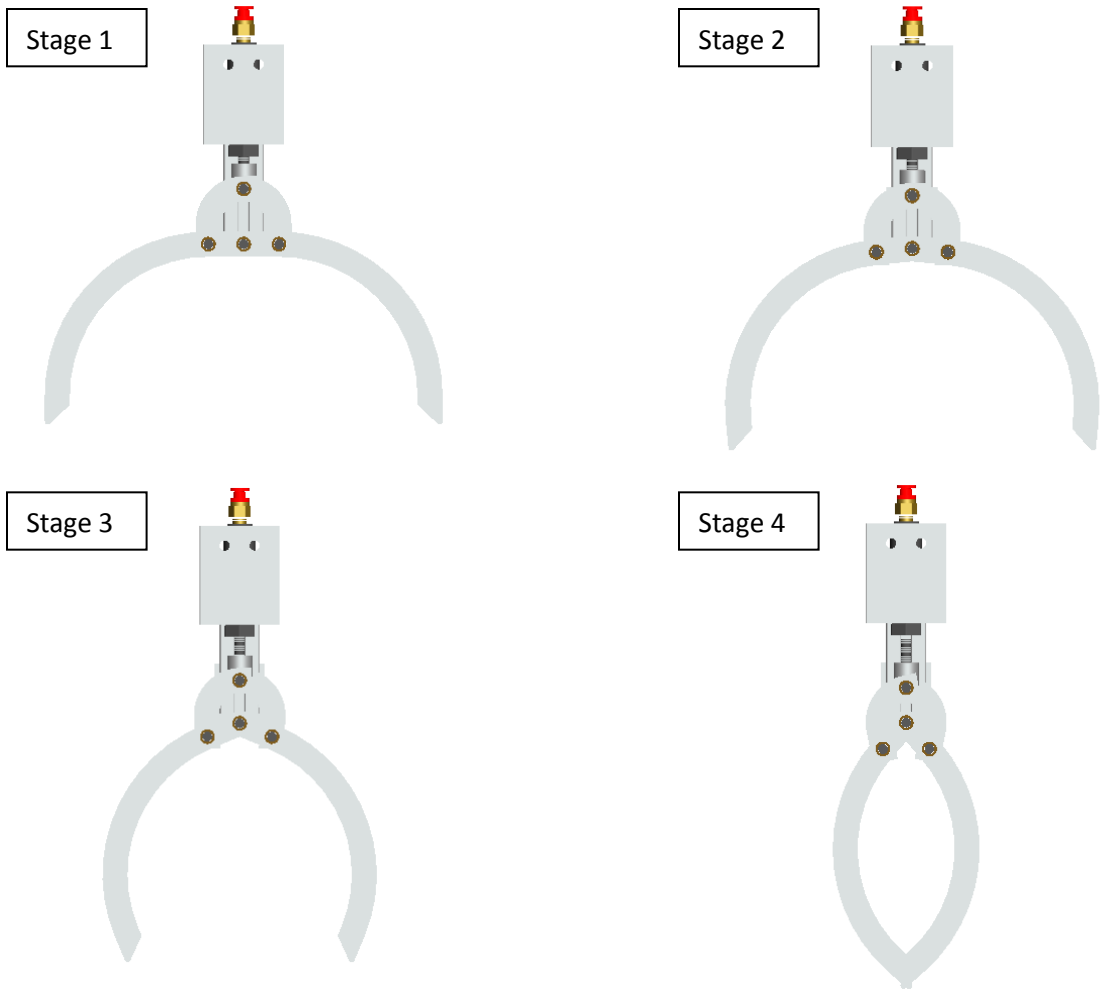
Torpedo Launcher Design



Tests

Test Description	Outcome
Torpedo Density	Pass (0.037 lb/in^3)
Torpedo Balance	Pass
Torpedo Hydrodynamics	Pass
Torpedo Dimensions	Pass (0.95” L x 0.95” W x 5.00” H)
Torpedo Launch – Air	Pass
Torpedo Launch – Water	Fail (Modification In Progress)

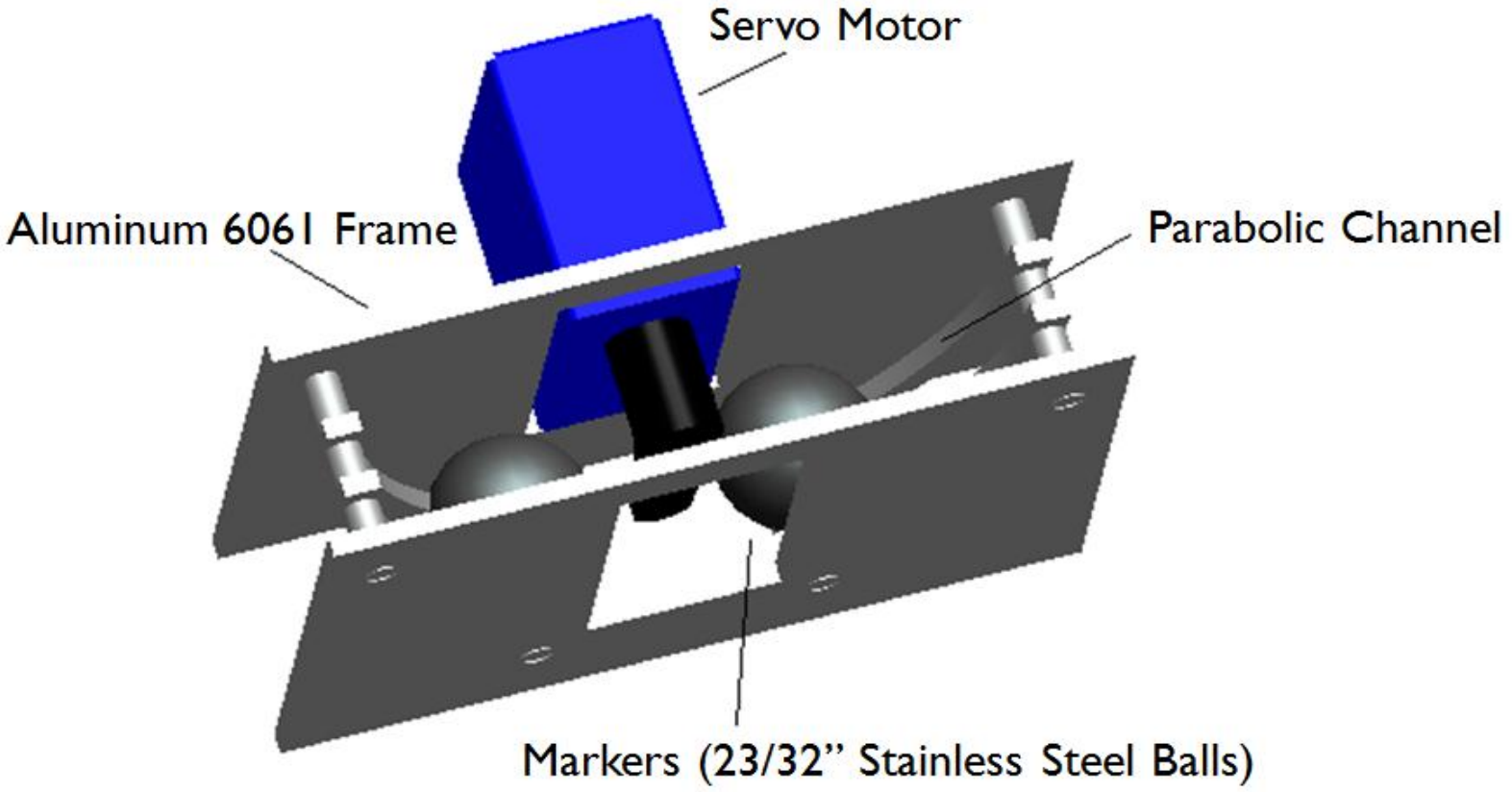
Grasp/Release Mechanism Design



Tests

Test Description	Outcome
Simulation (Pro/E Mechanism + Adams)	Pass
Grasp/Release Test – Air	Pass
Grasp/Release Test – Water	Pass

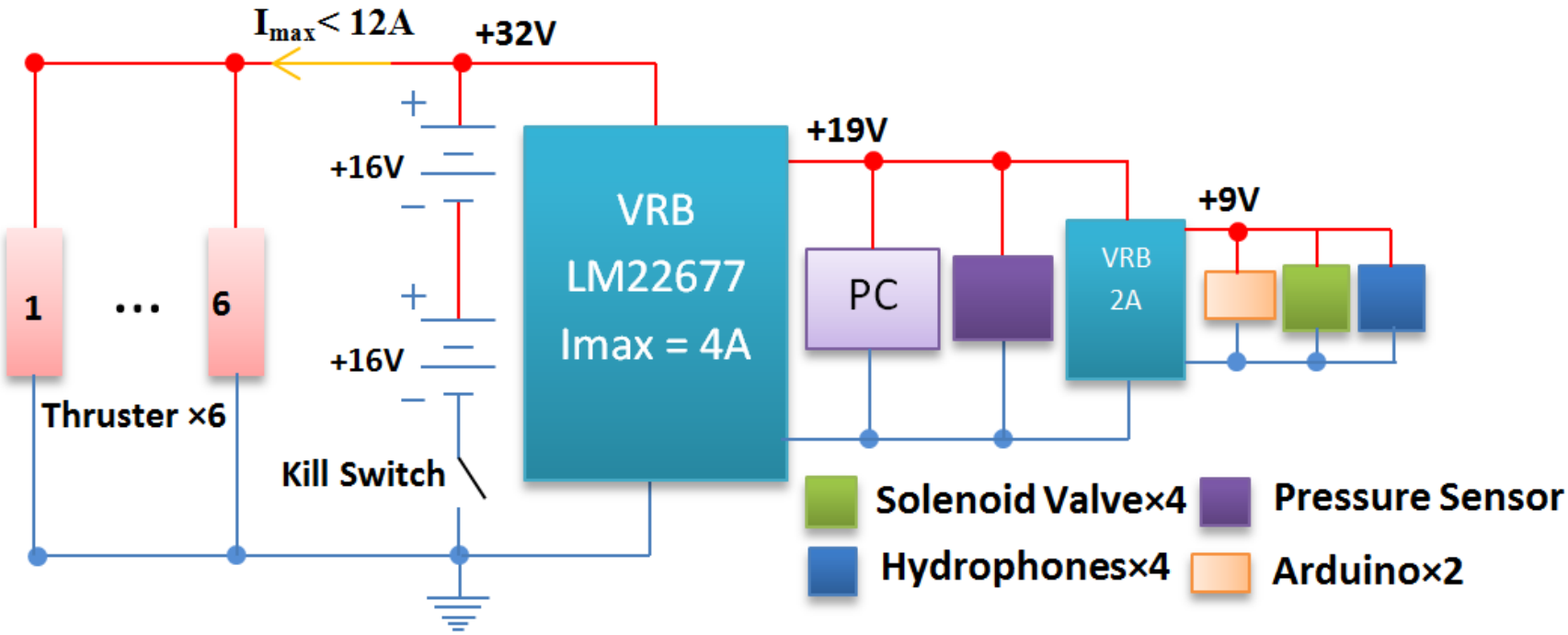
Marker Dropper Design



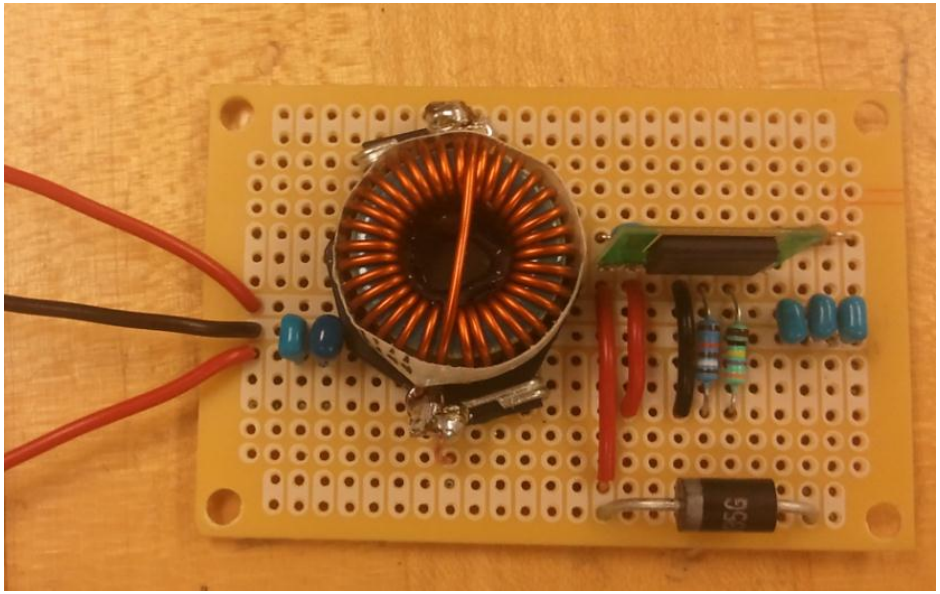
Tests

Test Description	Outcome
Servo Motor Actuation/Control (Using Dragon Board)	Pass
Marker Dropper Test – Air (Using Dragon Board)	Pass
Marker Dropper Test – Water	N/A

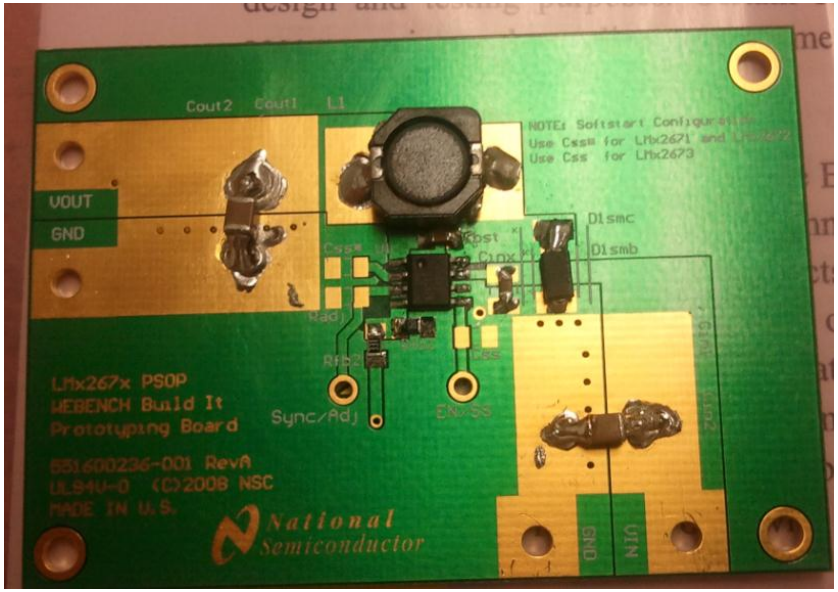
Electrical System



Voltage Regulator Boards



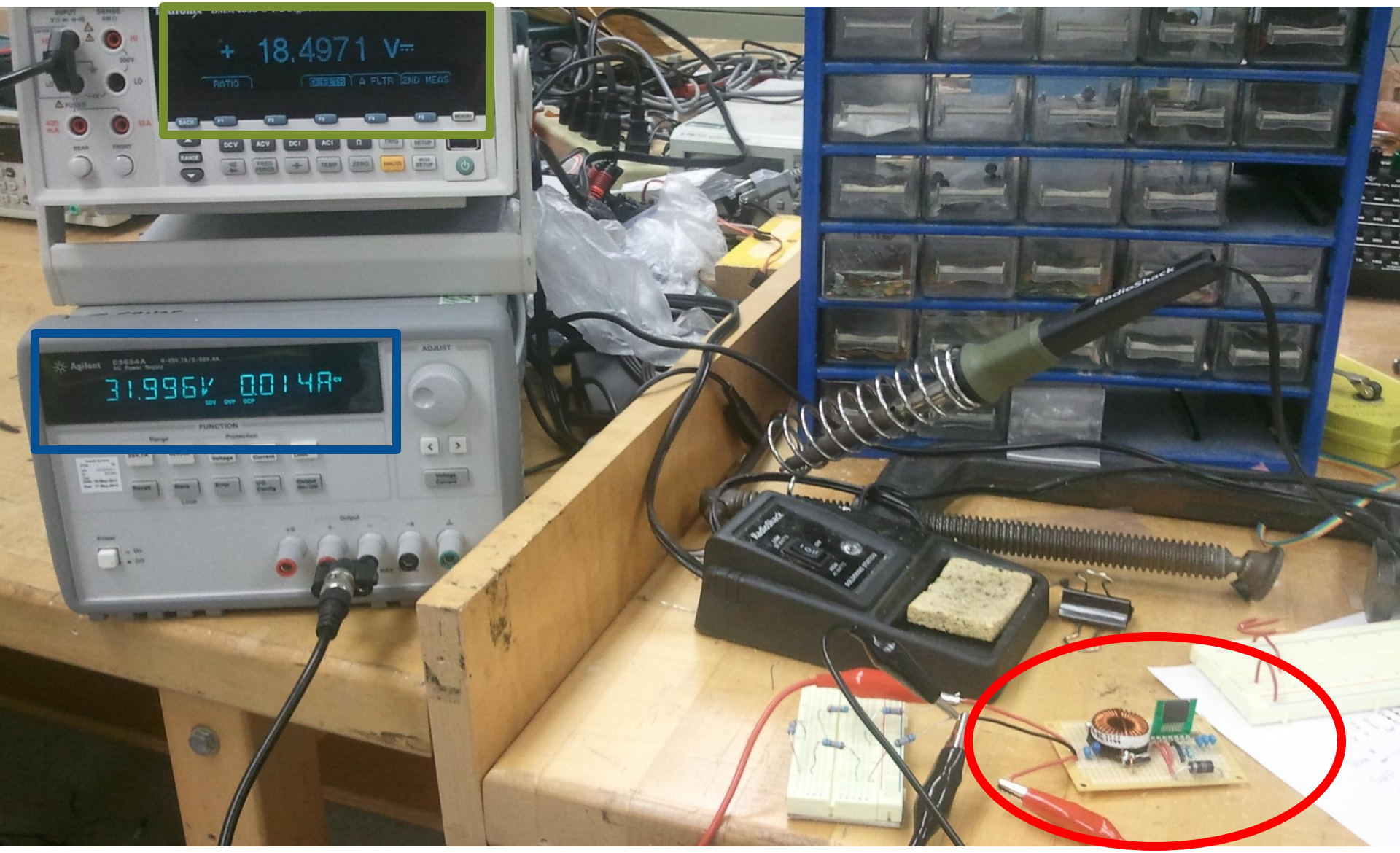
LM22677 For Zotac PC and Pressure Transducer (Input: 32 V – Output: 19 V)



LM22676 For Arduino Uno Boards and Hydrophone Interface PCB (Input: 19V – Output: 9 V)

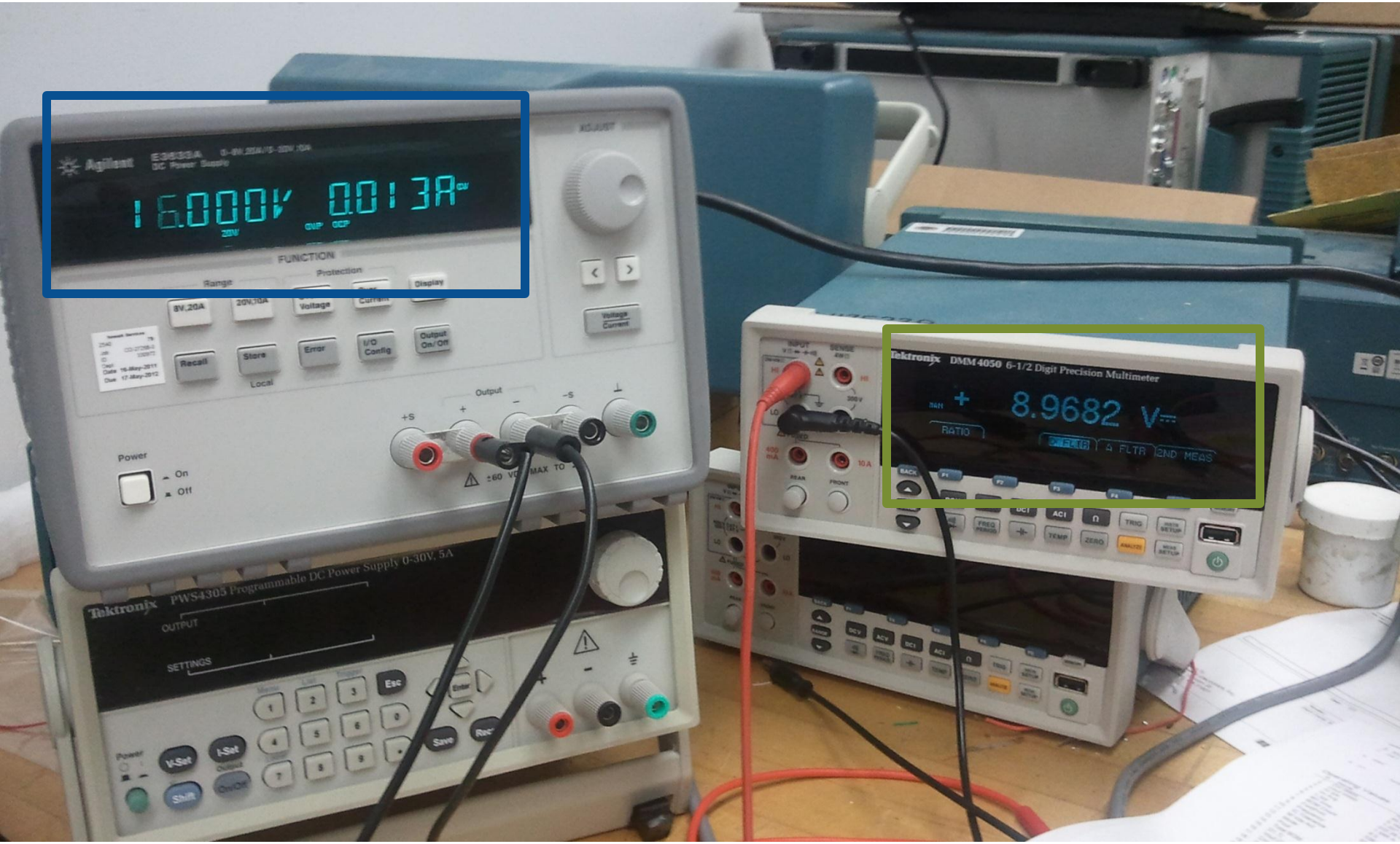
Input

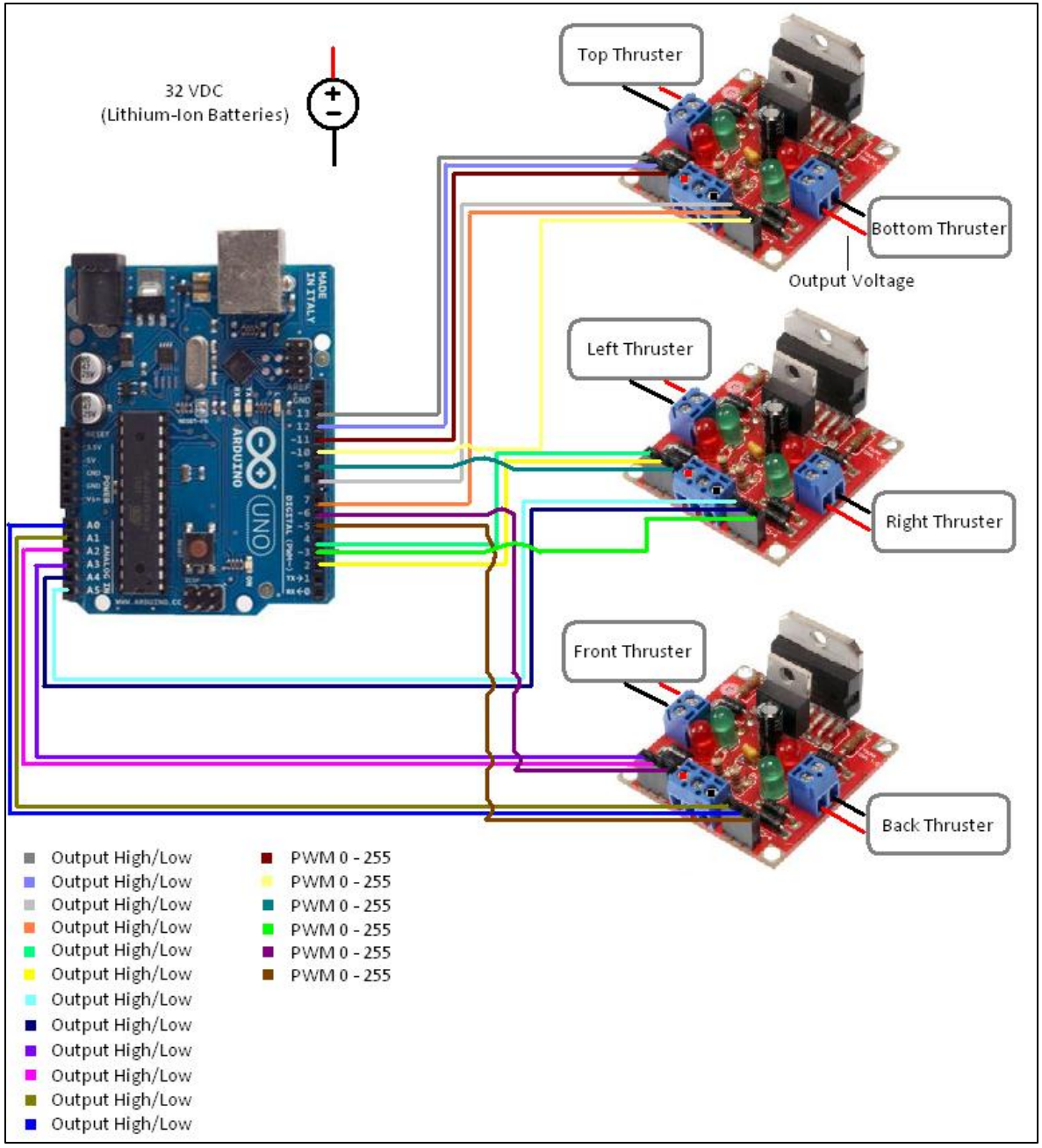
Output



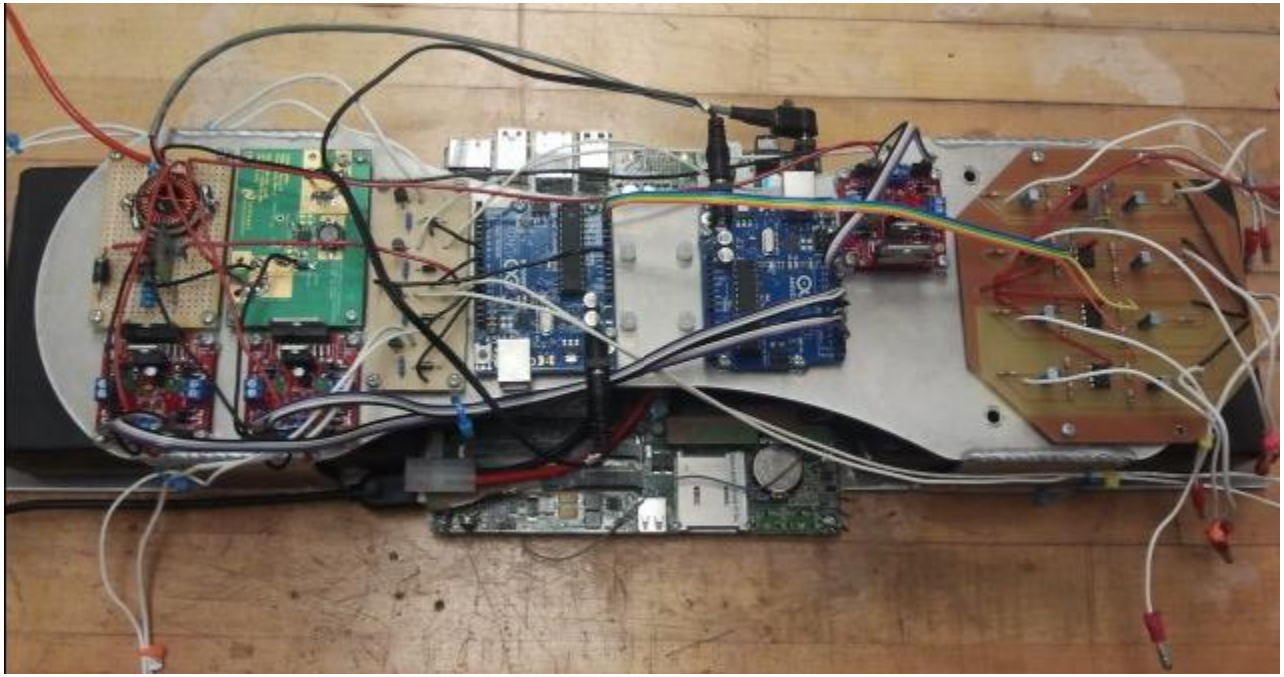
Input

Output

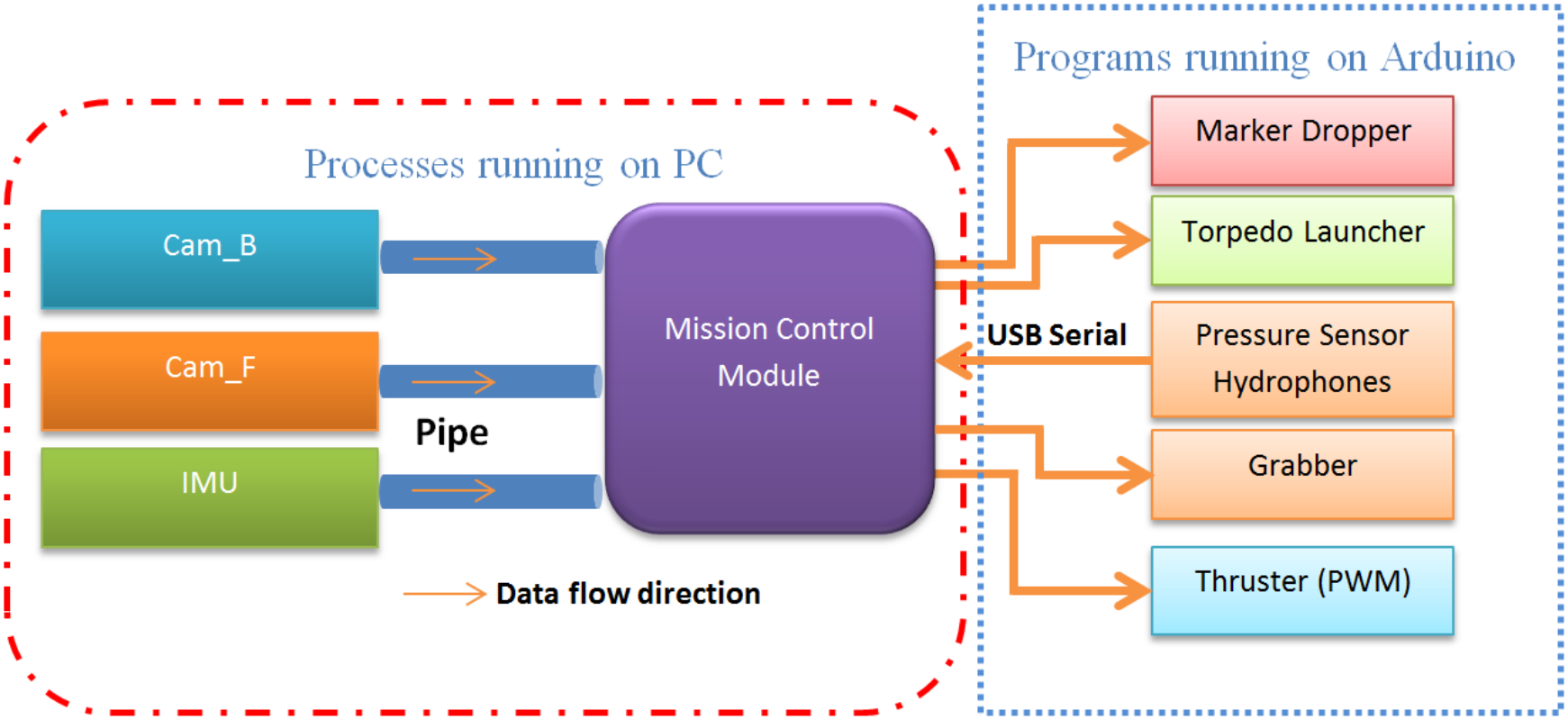



32 VDC
(Lithium-Ion Batteries)
Top Thruster
Bottom Thruster
Output Voltage
Left Thruster
Right Thruster
Front Thruster
Back Thruster
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
Output High/Low
PWM 0 - 255
PWM 0 - 255
PWM 0 - 255
PWM 0 - 255
PWM 0 - 255
PWM 0 - 255

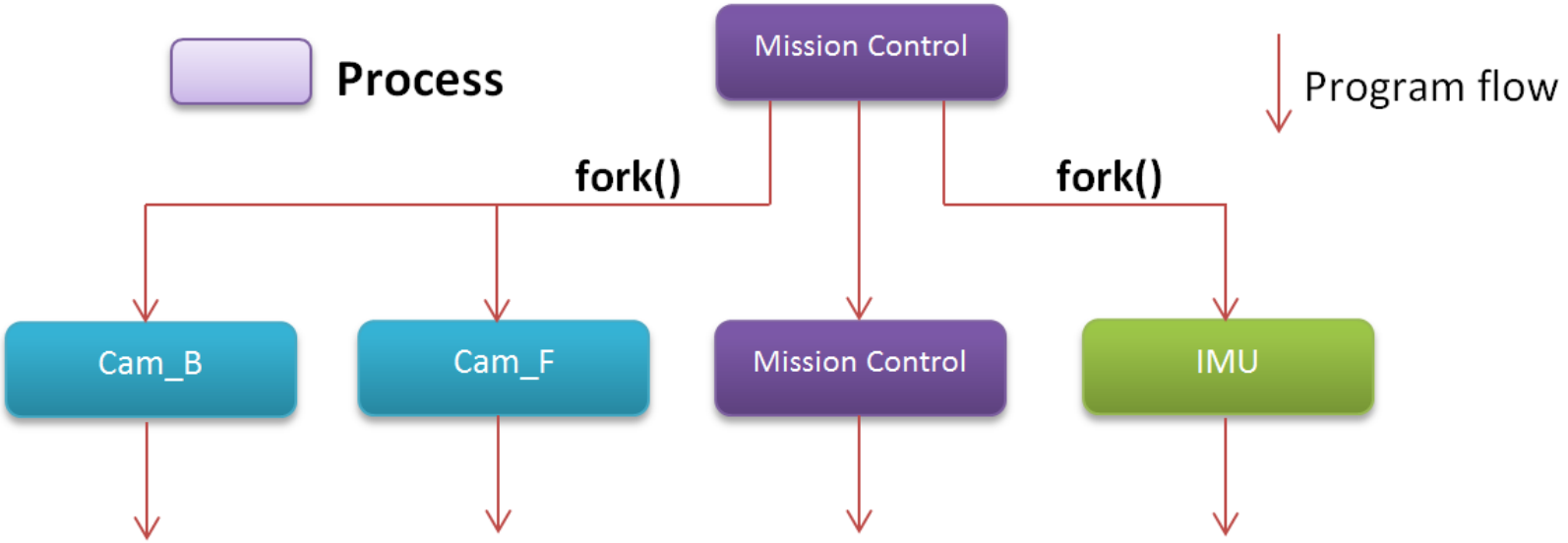
Electronics Platform



Mission Control



Mission Control



Guidance System – IMCL Submersible Pressure Transducer

Key Features:

- Sealed Gauge
- 0 – 10 mWG Range
- 0 – 5 V Output
- Marine Bronze Housing
- PUR Cable
- Ceramic Piezoelectric Sensor

Function:

- Accurately Measure Depth of the AUV Underwater

Guidance System – Inertial Measurement Unit (IMU)

Key Features:

- 3-Axis Gyro
- 3-Axis Accelerometer
- Compact 1.2” x 1.4” Footprint
- Micro-USB Input
- Built-In System Clock/Timer

Function:

- Accurately Measure Orientation, Acceleration, and Relative Position of AUV Underwater

Guidance System – Inertial Measurement Unit (IMU)

Code Sample

```
SpatialData {
        double acceleration[3];
        double angularRate[3];
        double magneticField[3];
        Timestamp time;
};
```

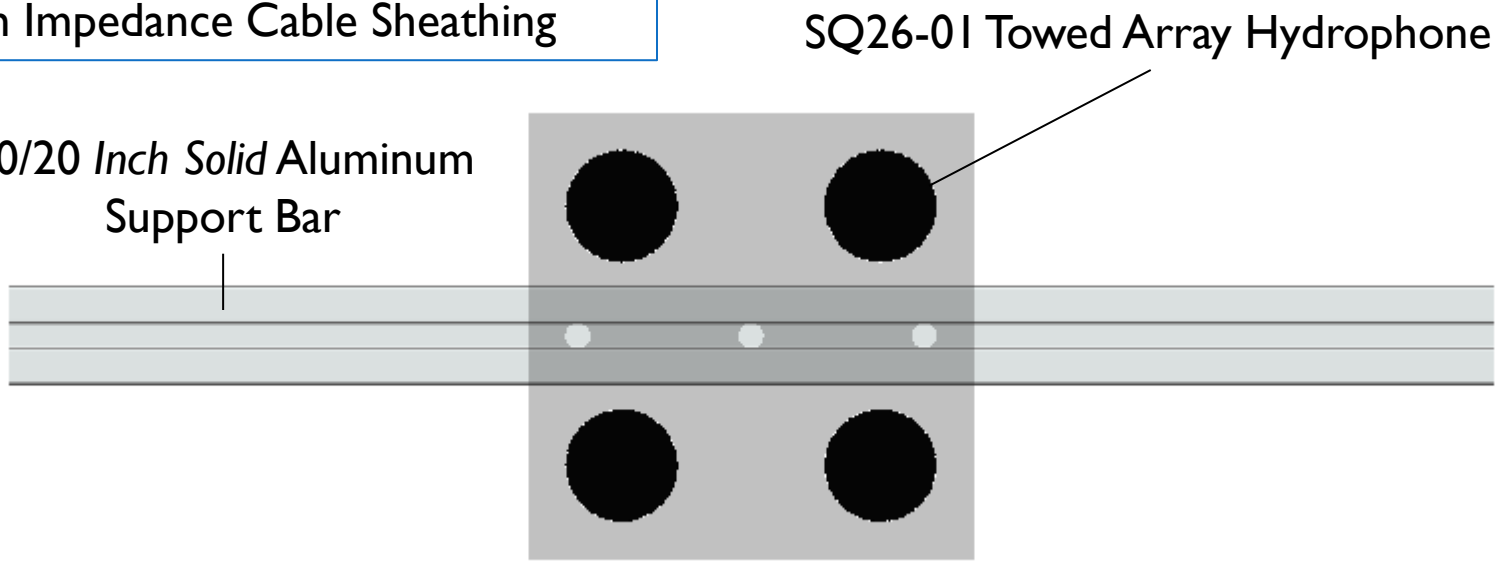
$$P_{k-1|k-1} \rightarrow P_{k|k-1}$$
$$P_{k|k-1} + y_k \rightarrow P_{k|k}$$
$$k \rightarrow k+1$$

Kalman Filter

Guidance System – Hydrophone Array

Key Features:

- Omnidirectional Sensitivity
- Compact Size (1.13” x 1.13” x 1.2”)
- High Impedance Cable Sheathing



Function:

- Accurately Measure Orientation, Acceleration, and Relative Position of AUV Underwater

Guidance System – Computer Vision

Logitech C615

USB 2.0

Zotac Zbox ID41 Plus

Auto-Light
Auto-Focus

Intel Atom D525 1.8GHz Dual-Core CPU, 2GB RAM, 250GB HDD, 512MB NVIDIA ION2 GPU

Computer Vision Framework

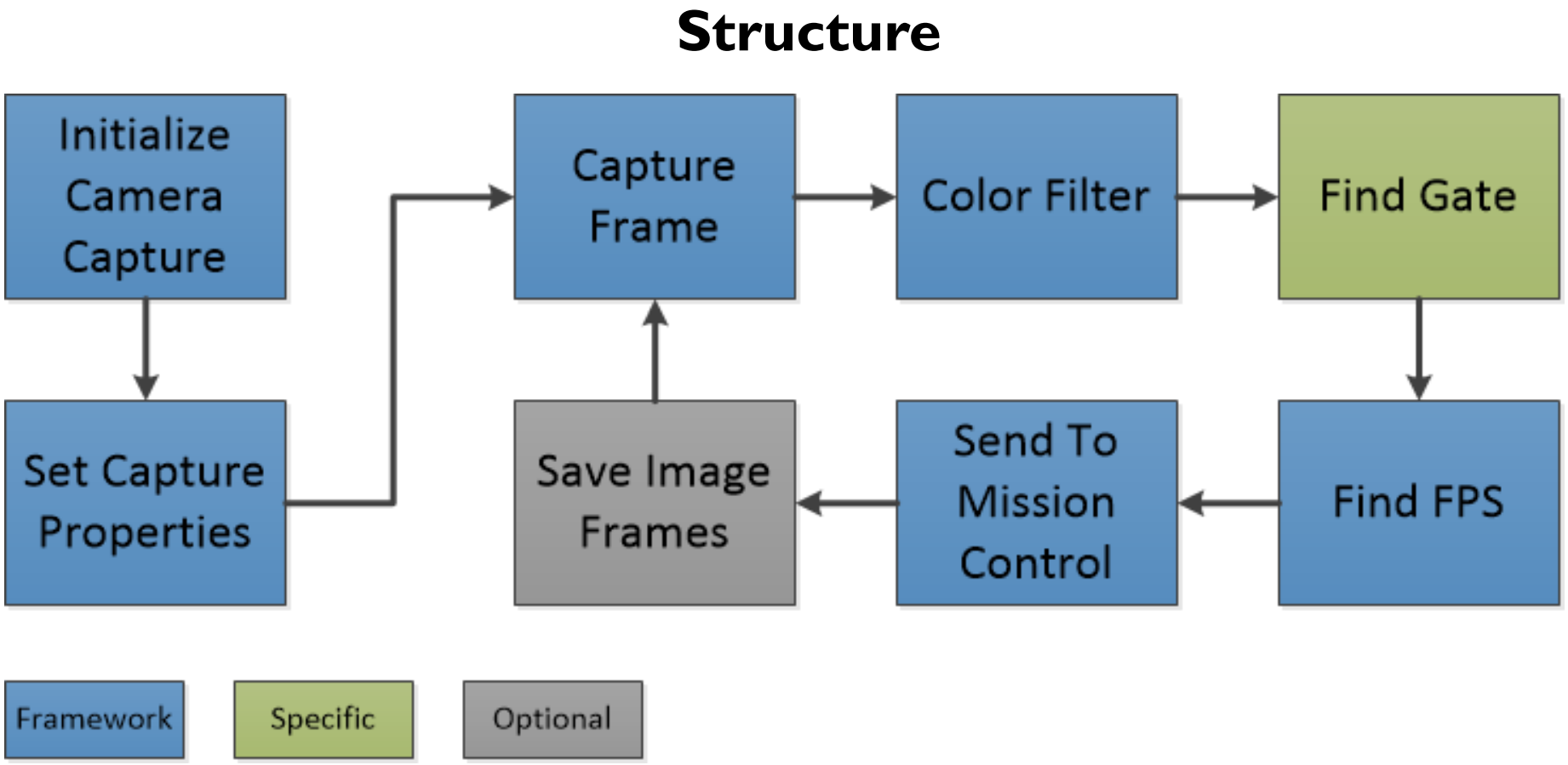
Features

- Modules can be reused
- Optimized for performance/ efficiency

Modules

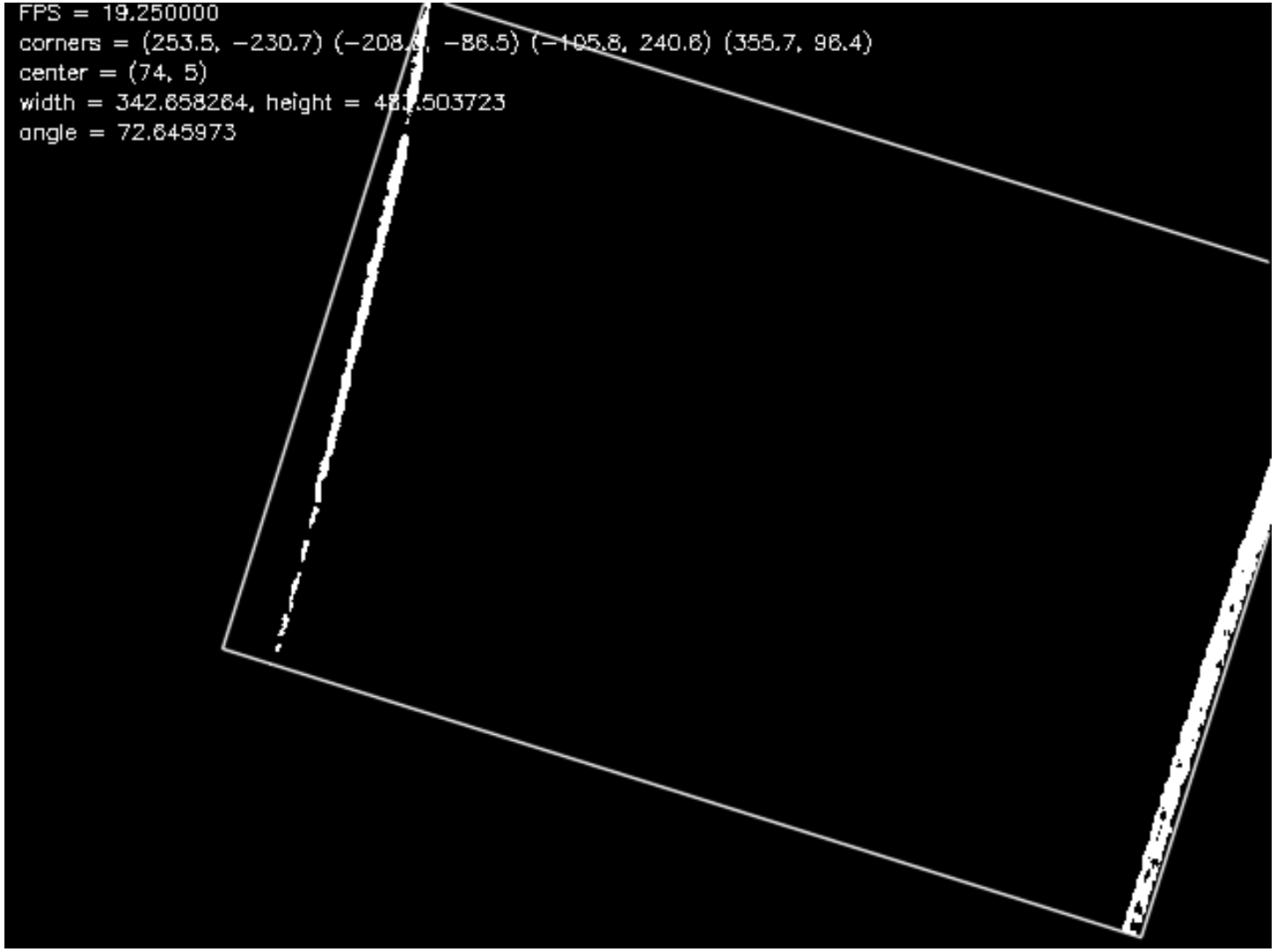
- Find FPS
- Save Images
- Color Filter
- Find Task
  - Find Gate
  - Find Path
  - Find Buoy
- Send To Mission Control

Computer Vision Framework

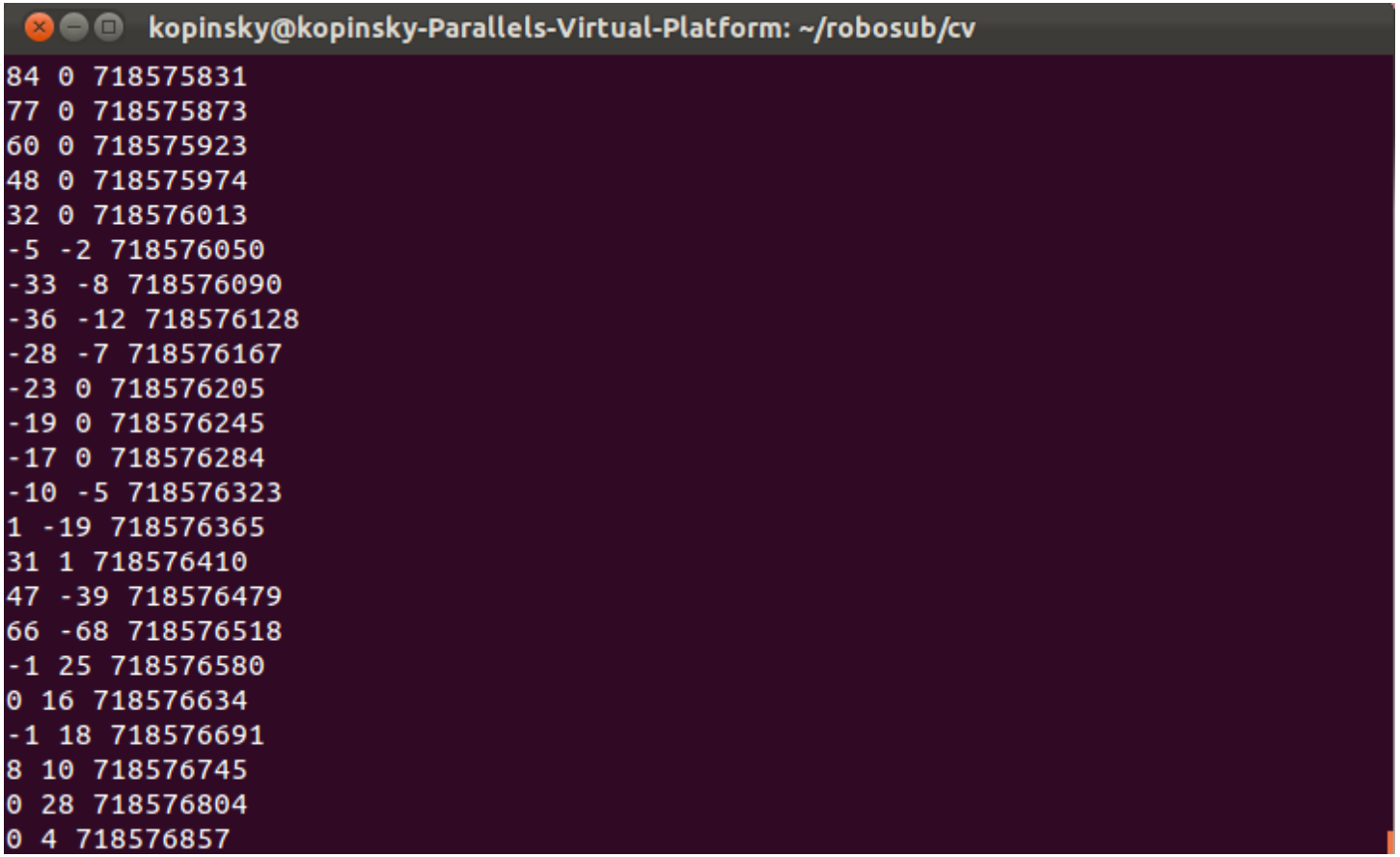


Computer Vision Framework

Computer Vision Framework



Computer Vision Framework



Tests

Test Description	Outcome	Notes
Color Filter	Pass	N/A
Find FPS	Pass	7- 8 FPS Per Web Camera
Send to Mission Control	Pass	Center Coordinates + Timestamp Sent to Mission Control
Save Image Frames	Pass	N/A
Find Gate	Pass	Center + Corner Coordinates, FPS, Height, Width, Angle Displayed

Budget – Project Expenditures

	Item Description	Price
Fall Expenditures	80/20 Framing + Fasteners	$359.88
	Cast Acrylic Hull + Torpedo Cannons	$340.19
	SeaBotix BTD150 Thrusters	$1005.18
	SEACON Underwater Micro Wet-Mate Connectors	$1191.14
	Raw Materials (Aluminum/Acrylic)	$974.52
	Miscellaneous	$883.44
Spring Expenditures	Compressed Air Distribution System	$443.56
	SQ26-01 Hydrophones (2)	$410.75
	SEACON Underwater Micro Wet-Mate Connectors	$183.33
	IMCL Submersible Pressure Transducer	$401.87
	Zotac PC	$293.98
	Microcontrollers, Interface Circuits, Motor Drivers	$578.52
	C615 Logitech Web Cameras	$108.49
	Miscellaneous	$733.06
Summary	**Build Total**	**$7,907.91**

Budget – Competition Expenditures/Summary

	Item Description	Price
Competition Expenditures	Travel/Shipping/Lodging Expenditures	$6,700.00
	Competition Fee	$500.00
Summary	**Project Total**	**$15,107.91**
	Current Budget	**$11,433.00**
	Remaining Balance	**-$3,674.91**

Conclusion

- Completed Objectives
  - Vehicle Mechanically Complete
    - Watertight
    - Proper Weight, Density, and Balance
    - Integrated Peripheral Subsystems
  - Computer Vision
    - Gate Detection
    - Path Detection
    - C615 Logitech Web Cameras Installed Inside Enclosures
- Current Setbacks
  - Electrical System – Wiring Scheme and Accident Shortage Issues
    - Arduino Uno Board Failures
    - L298 Dual H-Bridge Motor Driver Failures
    - Switching Voltage Regulator Board Failures

Conclusion

- Remaining Goals
  - Fix/Replace Malfunctioning Circuitry
  - Obtain Proper Functionality of the Thrusters and Marker Dropper
  - Integrate Inertial Measurement Unit (IMU) and Sealed Gauge Pressure Transducer
  - Establish PID Controllers to Maintain Vehicle Stability
  - Progress/Refine Computer Vision and Mission Control to Enable the Successful AUV Completion of the Gate-Passing, Buoy-Striking, and Torpedo Launching (i.e. "Kill Caesar") Tasks