Design and Development of an Autonomous Underwater Vehicle

Design Review II: Interim Presentation
Team 23
March 15th, 2016

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Presenters: Jordan Clein, Erik Olson, Corey Cavalli

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The Competition

- AUVSI International Robosub Competition
- Objective of the competition:
  - Design an autonomous underwater vehicle to perform a series of tasks
- Rules posted as of January 2016

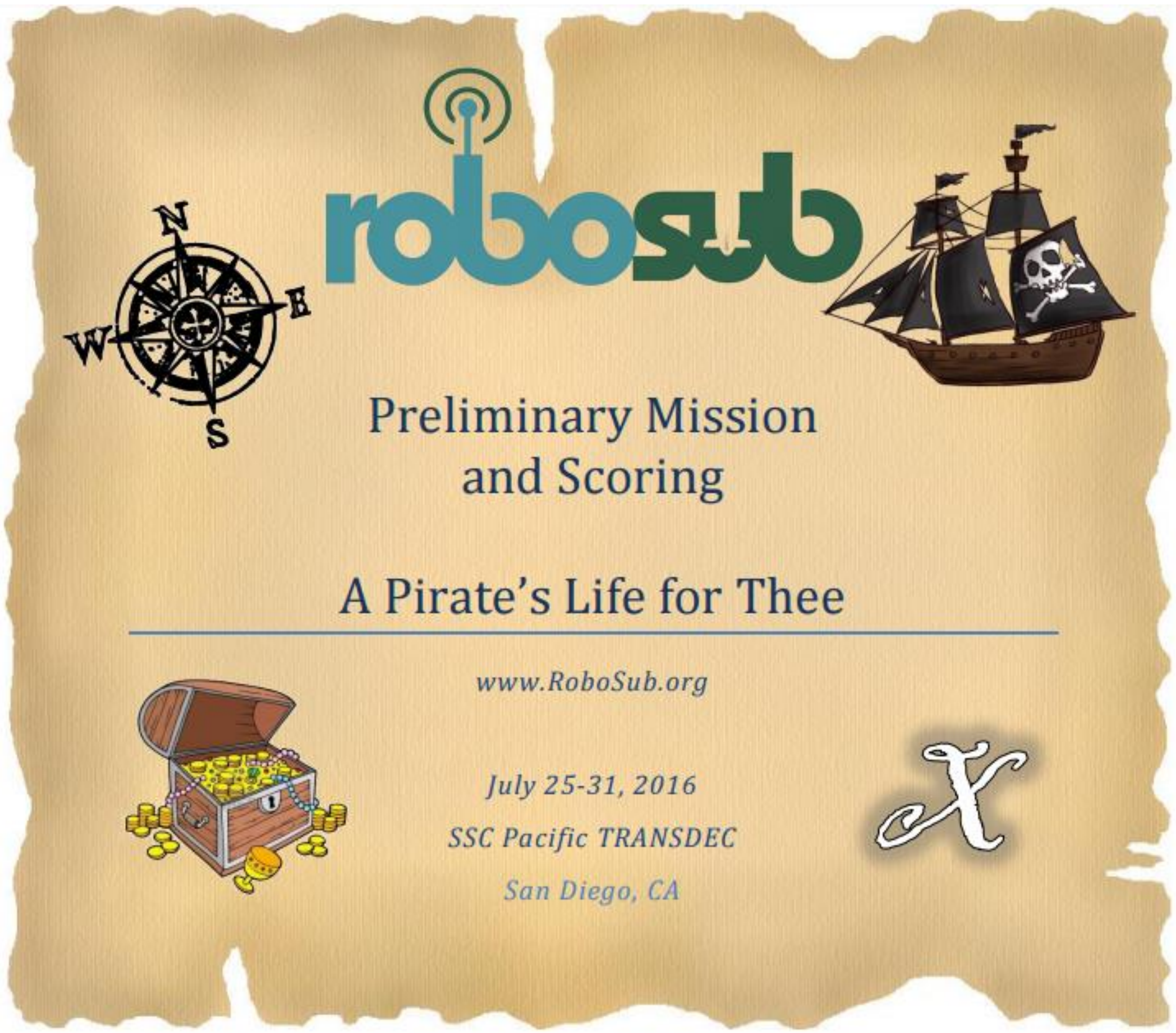


Figure 1: Robosub Competition Rules Cover Image

Competition Tasks

1. Follow path markers between tasks
2. Interact with colored buoys
3. Pass over an Obstacle
4. Drop markers at a specified location
5. Fire Torpedoes through a specific target
6. Locate an object and pickup and move to a specified location

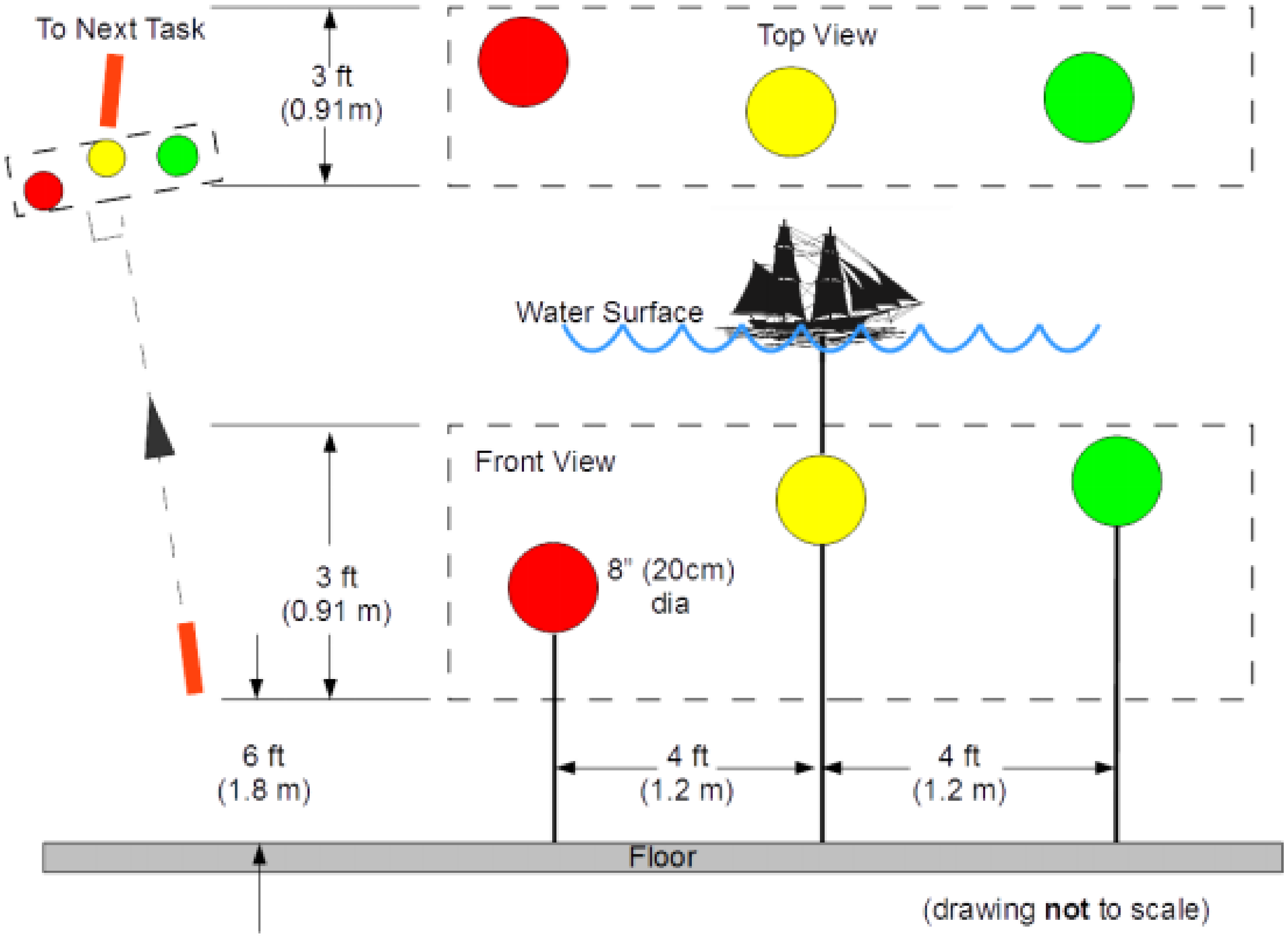


Figure 2: Buoy Interaction Task

Team Robosub Breakdown

- ME Semester Objectives
  - Fabricate, test, and transfer electronics to new hull
  - Finish air system adaptation and integrate with gripper
  - Physical systems integration
  - Troubleshoot and Debug final design to ensure robust functionality of mechanical and electronic components

- ECE Team Work
  - Replaced broken CPU with upgraded version (Zotac Mini PC)
  - Beginning to implement a new shape identification program
  - Parsed through the inherited code and begun modularizing for efficiency
  - Development of the gripper
  - Responsible for software integration

Project Background

- The AUV
  - Designed and Built in 2013
  - Weighs about 84 lbf
    - Contains 22.5 pounds of weights within the hull
  - Components
    - 6 Seabotics thrusters
    - Zotac Mini Computer (CPU)
    - Arduino Mega and Uno
    - 3 Motor Controllers
    - Inertial Measurement Unit (IMU)
    - 2 Cameras
    - Depth Sensor

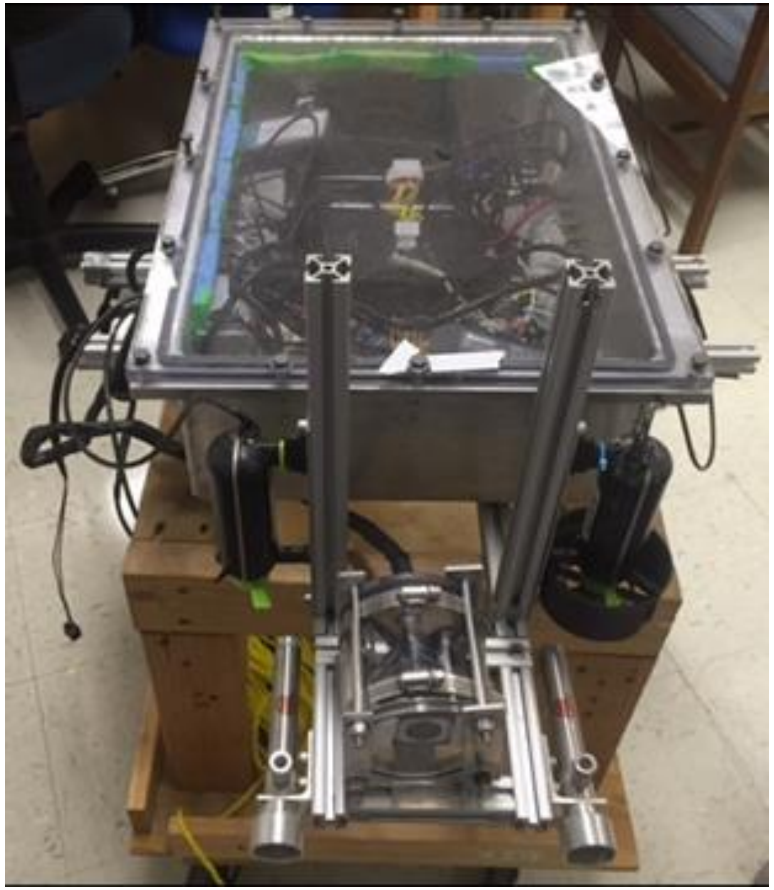


Figure 3: Current AUV

Robosub Signal Diagram

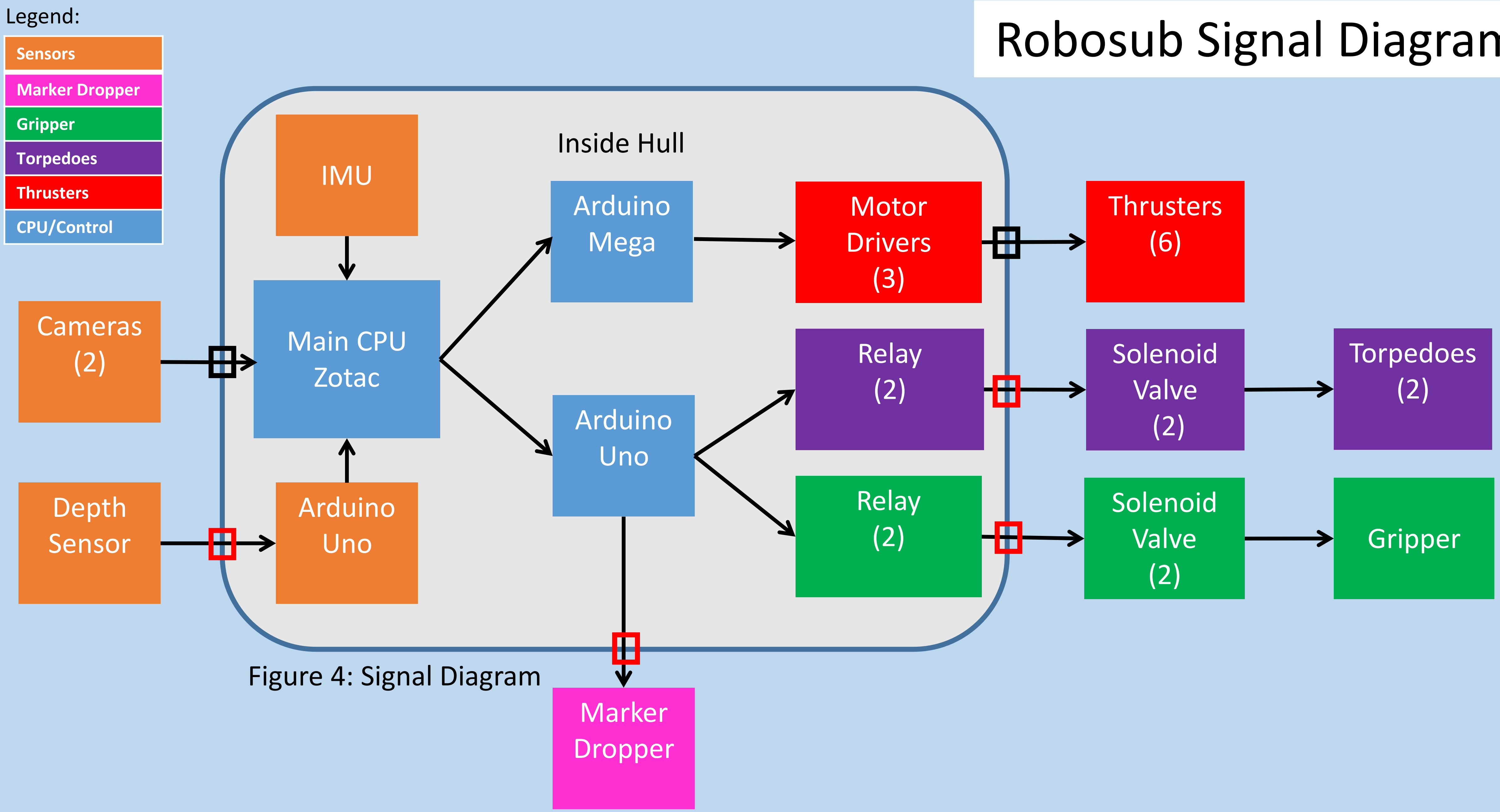
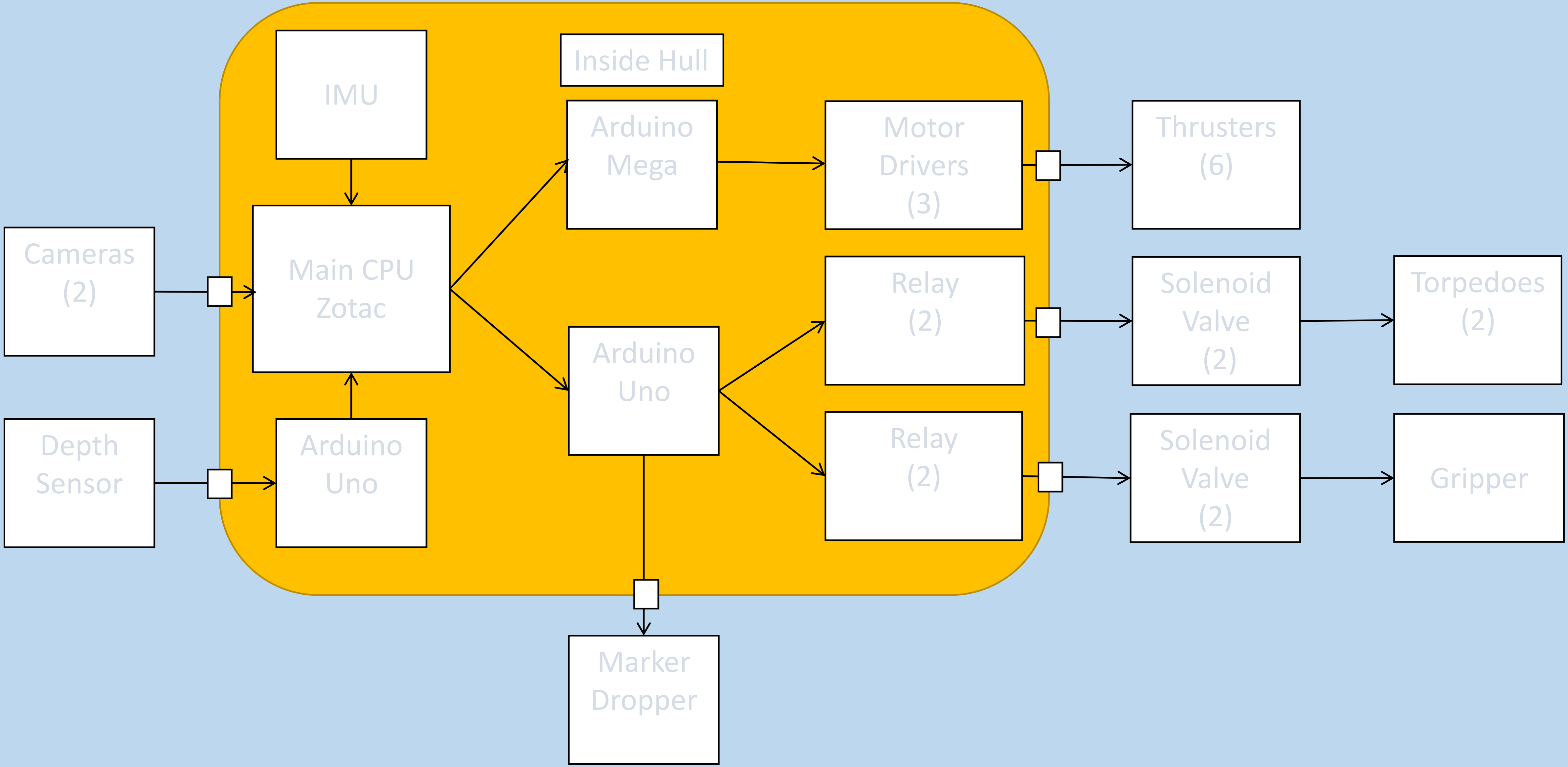


Figure 4: Signal Diagram

The Hull



Inside Hull
IMU
Cameras (2)
Main CPU Zotac
Depth Sensor
Arduino Uno
Arduino Mega
Arduino Uno
Motor Drivers (3)
Relay (2)
Relay (2)
Thrusters (6)
Solenoid Valve (2)
Solenoid Valve (2)
Torpedoes (2)
Gripper
Marker Dropper

The Hull

- From old to new
  - Decrease weight by 13 lbf
  - Decreased buoyancy by 28 lbf
  - Decreased volume by 900 in^3
- Switched from aluminum to stainless steel for higher density
- 6 toggle latches instead of 16 nuts and bolts for easier access

Table 1: Hull Properties

Property	Equations	Old Hull	Revised Hull
Material Density (lb/in3)	m/V	0.0975	0.2781
Dimensions (inches)	$L \times W \times H$	22x15x6	12x18x5
Weight (lbf)	$m \times g$	84	71
Buoyancy (lbf)	$\rho_{water} \times V_{displaced} \times g$	100	72

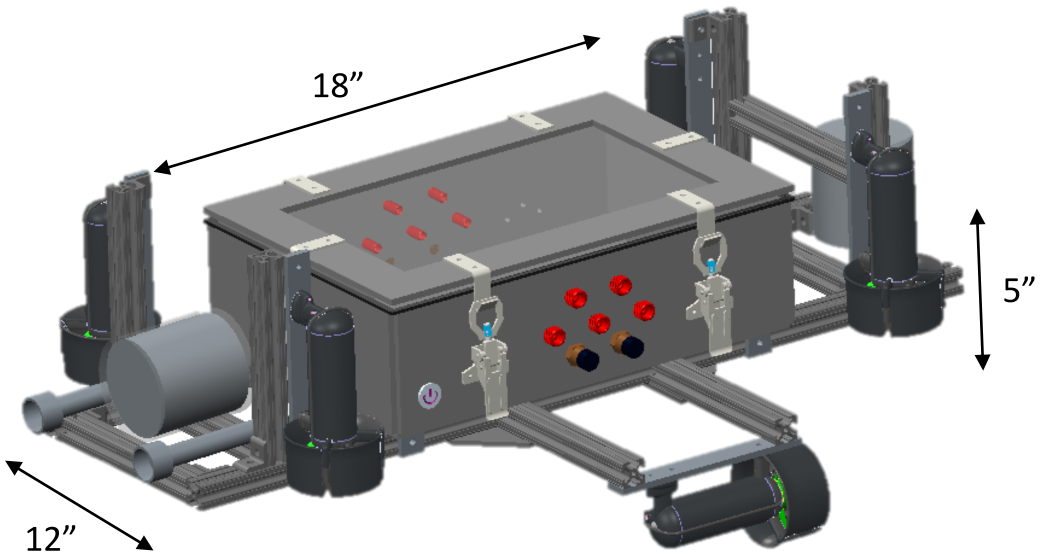
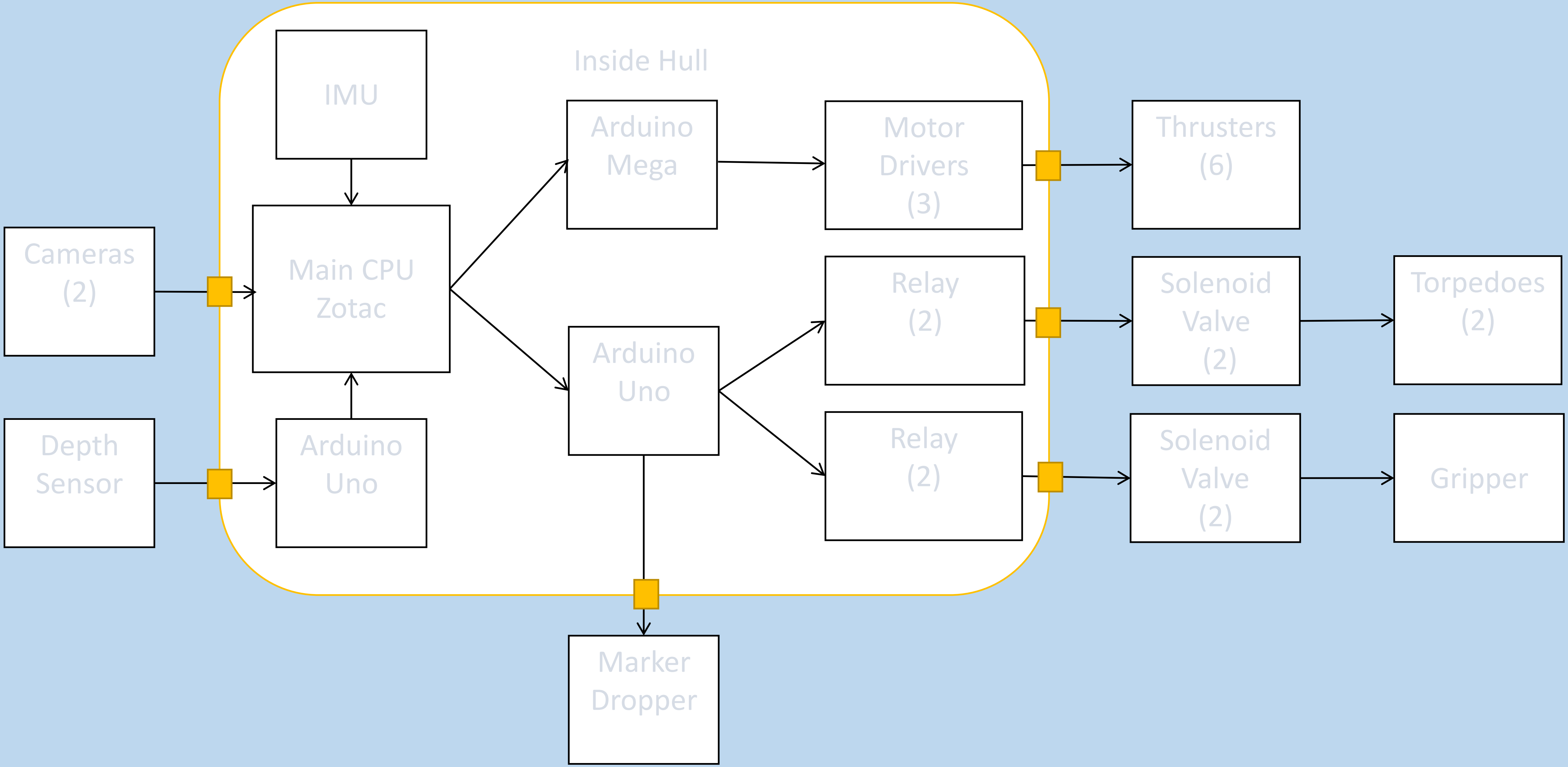


Figure 5: Hull and Frame Assembly

Waterproof Electrical Connectors



Waterproof Electrical Connectors

- Decision was made to keep some existing ports and replace others
- 4 Seacon heavy duty ports will be salvaged from old hull to accommodate thrusters and cameras
- 10 new cable penetrators will replace remaining Seacon ports
  - Pros: Cheap
  - Cons: Held with permanent marine epoxy

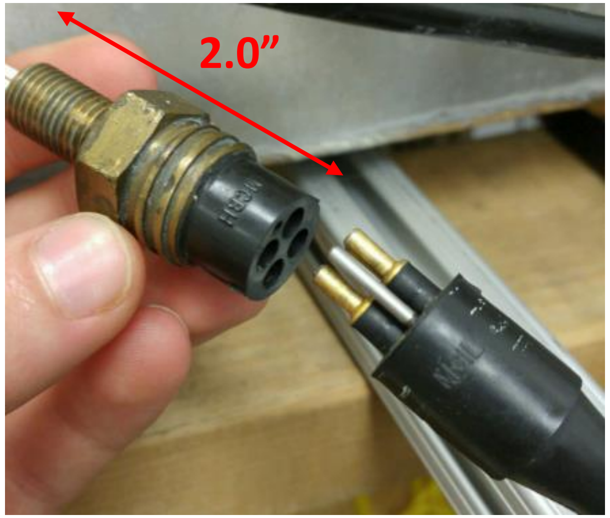


Figure 6: Seacon Port

Table 2: Port Comparison

Item	Old hull	New hull
Seacon ports	\$100 X 16	\$100 X 4
Cable penetrators	\$4 X 0	\$4 x 10
Total Cost	\$1600	\$440

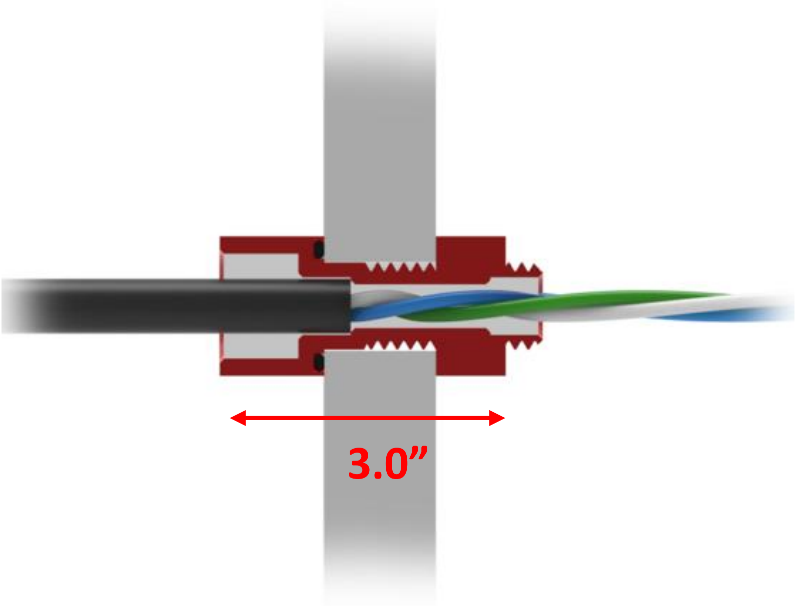
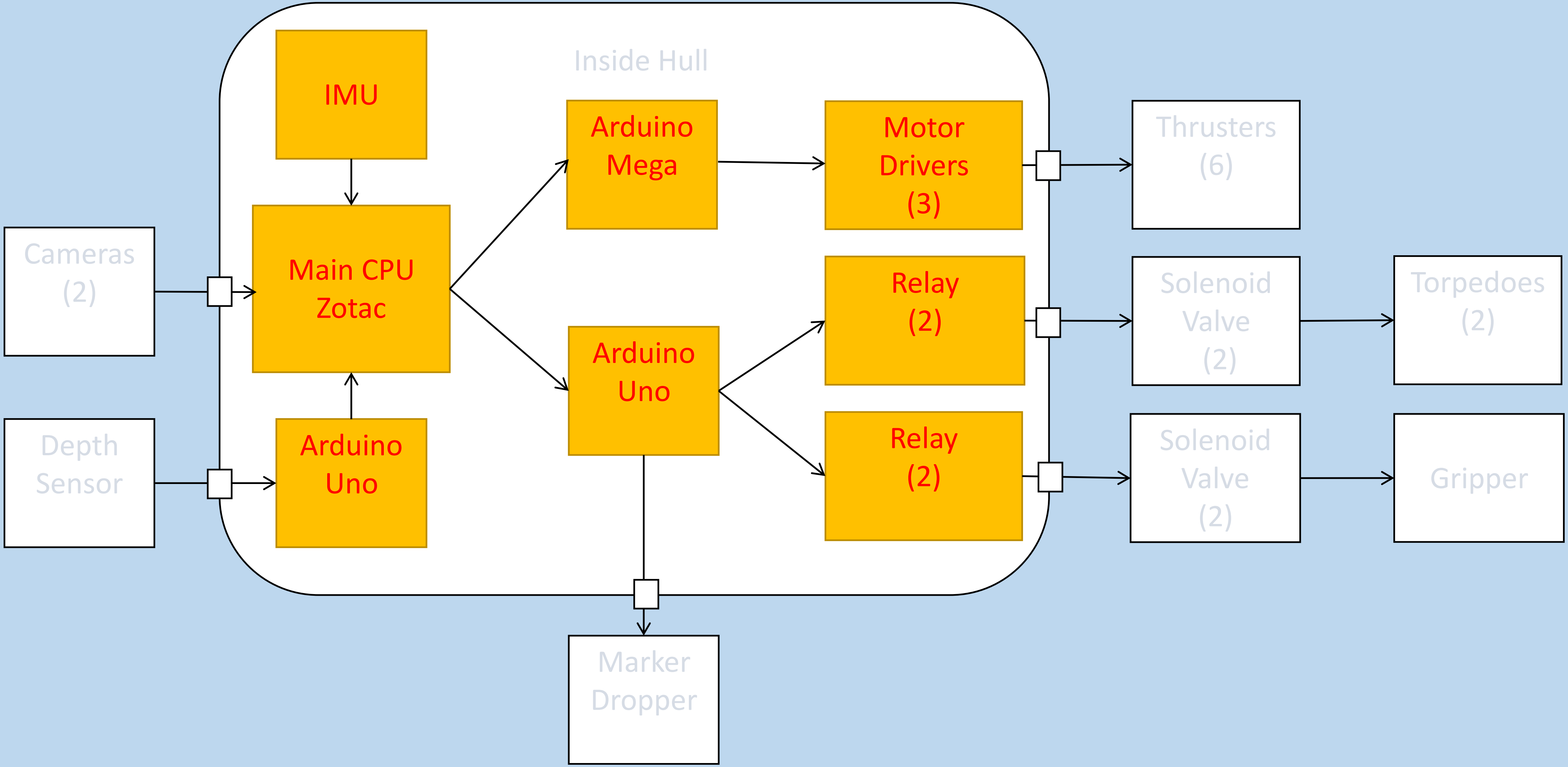


Figure 7: Cable Penetrator Cross Section

Internal Electronics



Battery

- 24V 2200 mAh battery pack
  - 3.5A preinstalled switch- if current gain becomes greater then 4A for a given component the battery shuts itself off
  - Max Discharge: 3.5A
  - Average continuous discharge: 1.8A
  - Weight: 1 lb
- Voltage regulators used to step down voltage to the different components
- 12v 5Ah lead acid battery to power smaller components
  - LED Strip
  - Blue LED ring on kill switch
  - Cooling fans
  - Common port for relays to open valves

Figure 8: 24V battery pack

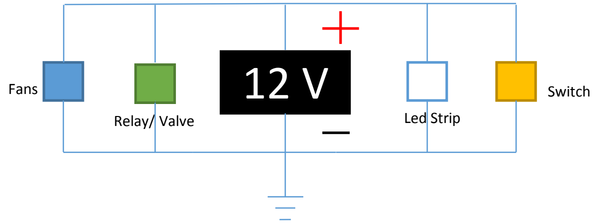


Figure 9: 12V battery circuit

Table 3: Component Requirements

Components	Max Current (A)	Ave. Current (A)	Voltage Required (V)
Zotac PC Board	3.5	1.5	19.0
Arduino UNO	0.75	0.5	7.0 - 12.0
Arduino Mega	0.75	0.5	7.0 - 12.0
Motor Controllers	2.0	1.5	5.0
IMU	0.075	0.060	3.5 - 16.0
Thrusters	12.0	3.0	19.1
Depth Sensor	0.020	0.012	8.0 - 11.0

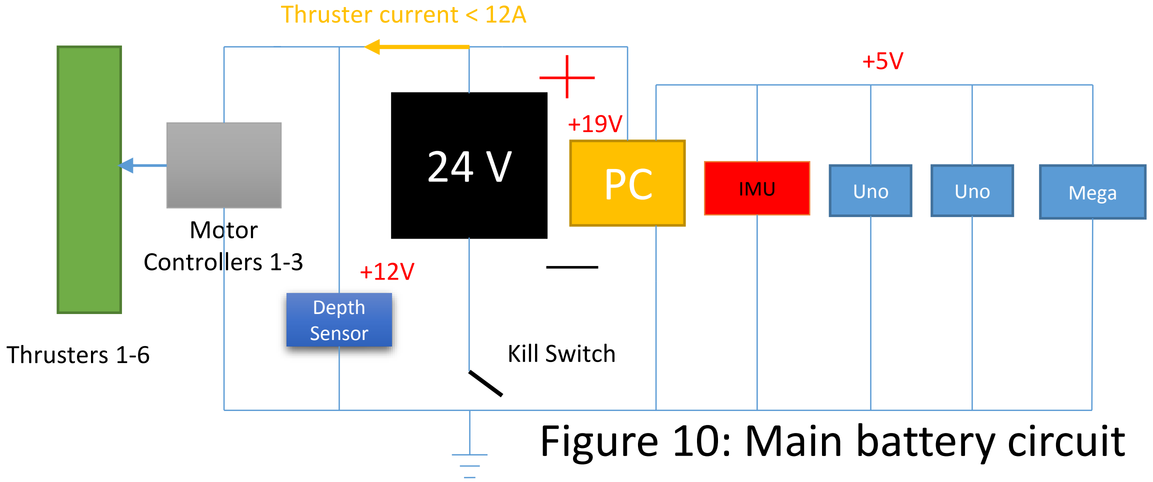


Figure 10: Main battery circuit

Reorganization of Internal Electronics

- Original layout
  - Motor controllers in breadboard
  - Arduinos laying around
  - Wires everywhere
- Messy
- Not organized

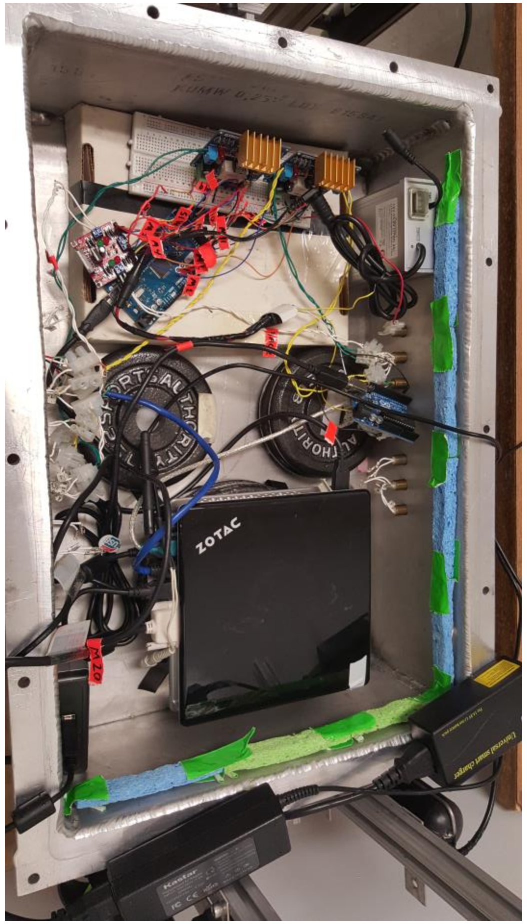


Figure 11: Original Hull Interior

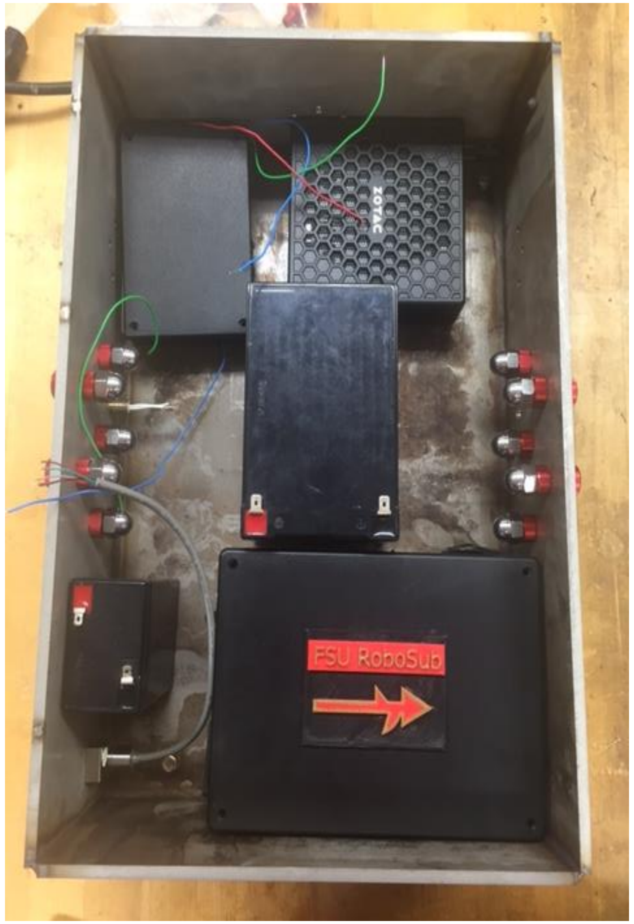
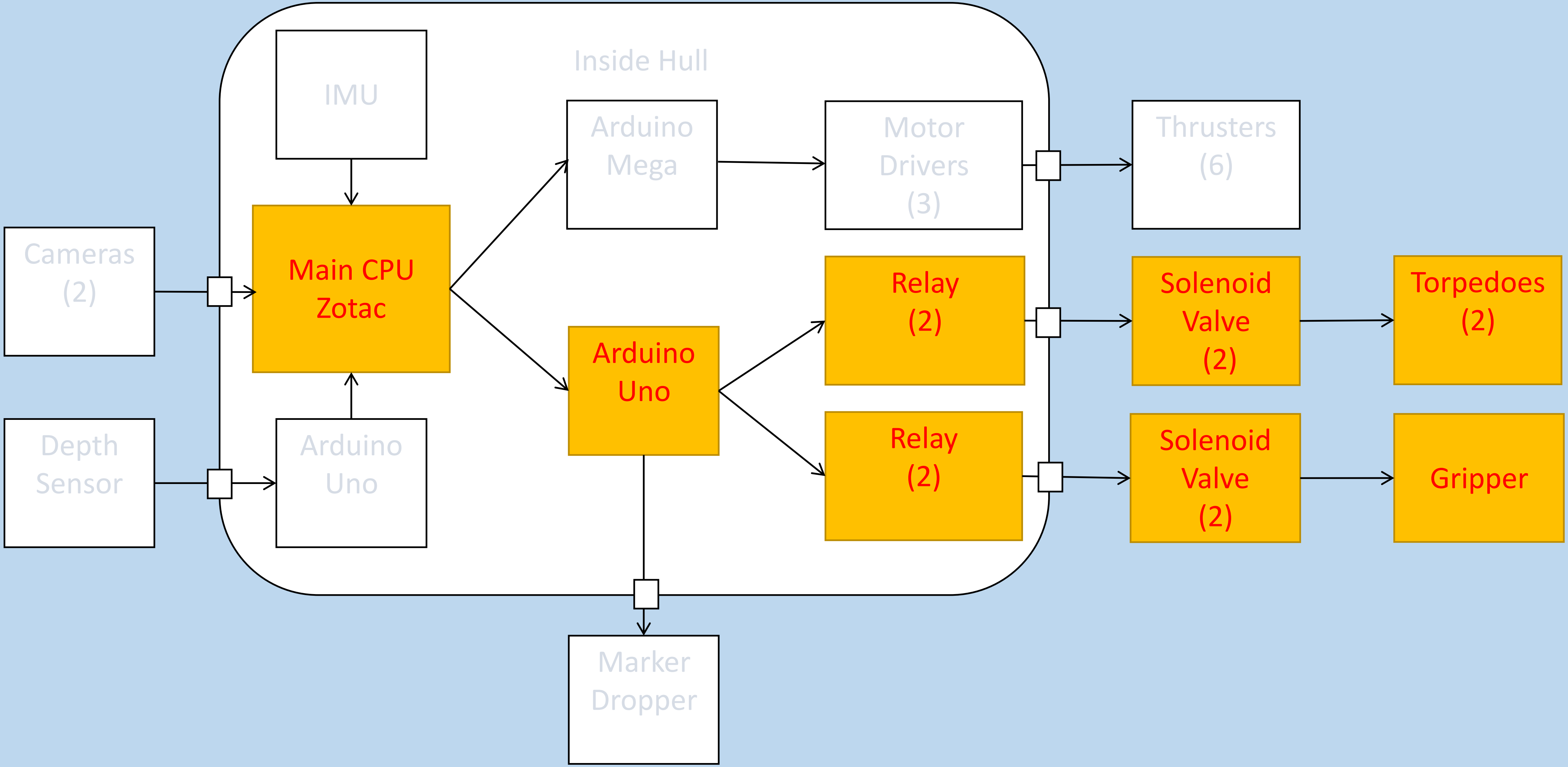


Figure 12: Updated Hull Interior

- Eliminated breadboard
  - Reorganized in black boxes
    - Thruster Box
      - 3 Motor controllers
      - 1 Arduino Mega
    - Torpedo/Gripper Box
      - Arduino Uno
      - Four relays
- Further improvements
  - Implement cooling fans
    - Ensure electronics do not overheat

Air System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Gripper
Marker Dropper

Air System

- Fully Assembled
  - Actuators
  - Tubing
  - Airtight and waterproof seals
  - Electronic relays for actuators
  - 12v battery
- Functioning Code
  - Can launch left and right torpedo based off of keyboard input
  - Next Step is changing keyboard input to identifying image

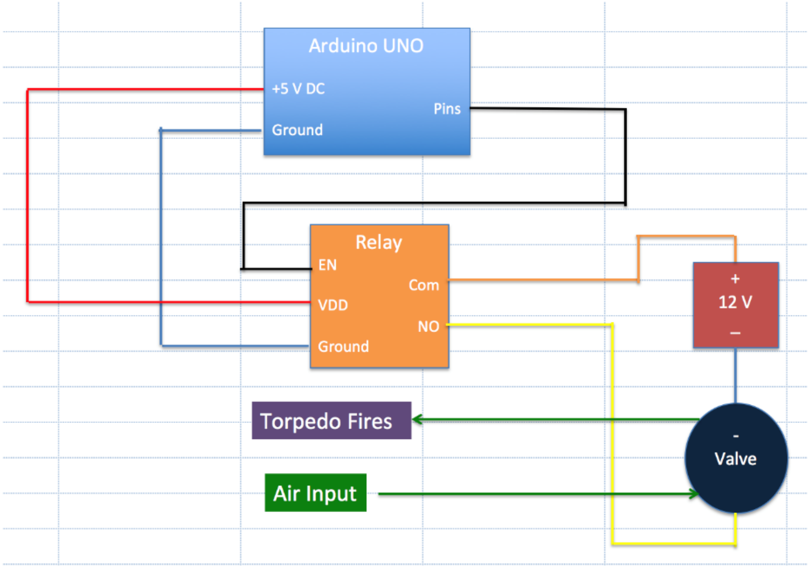


Figure 13: Air System Diagram

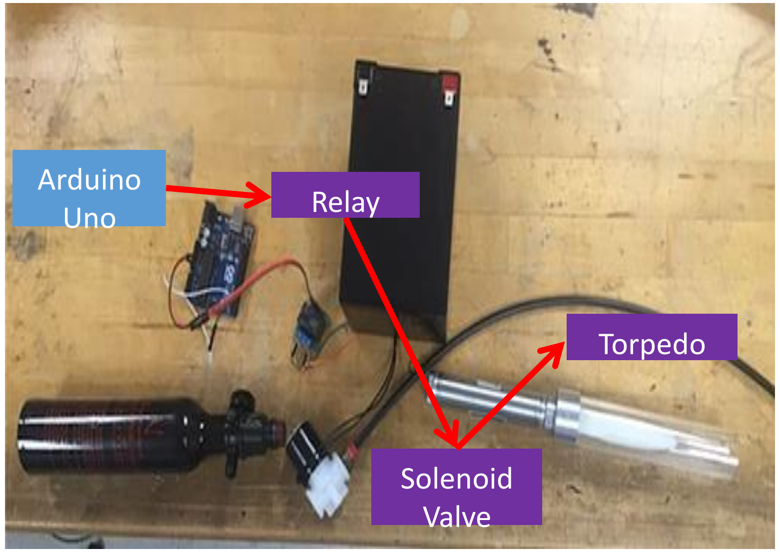
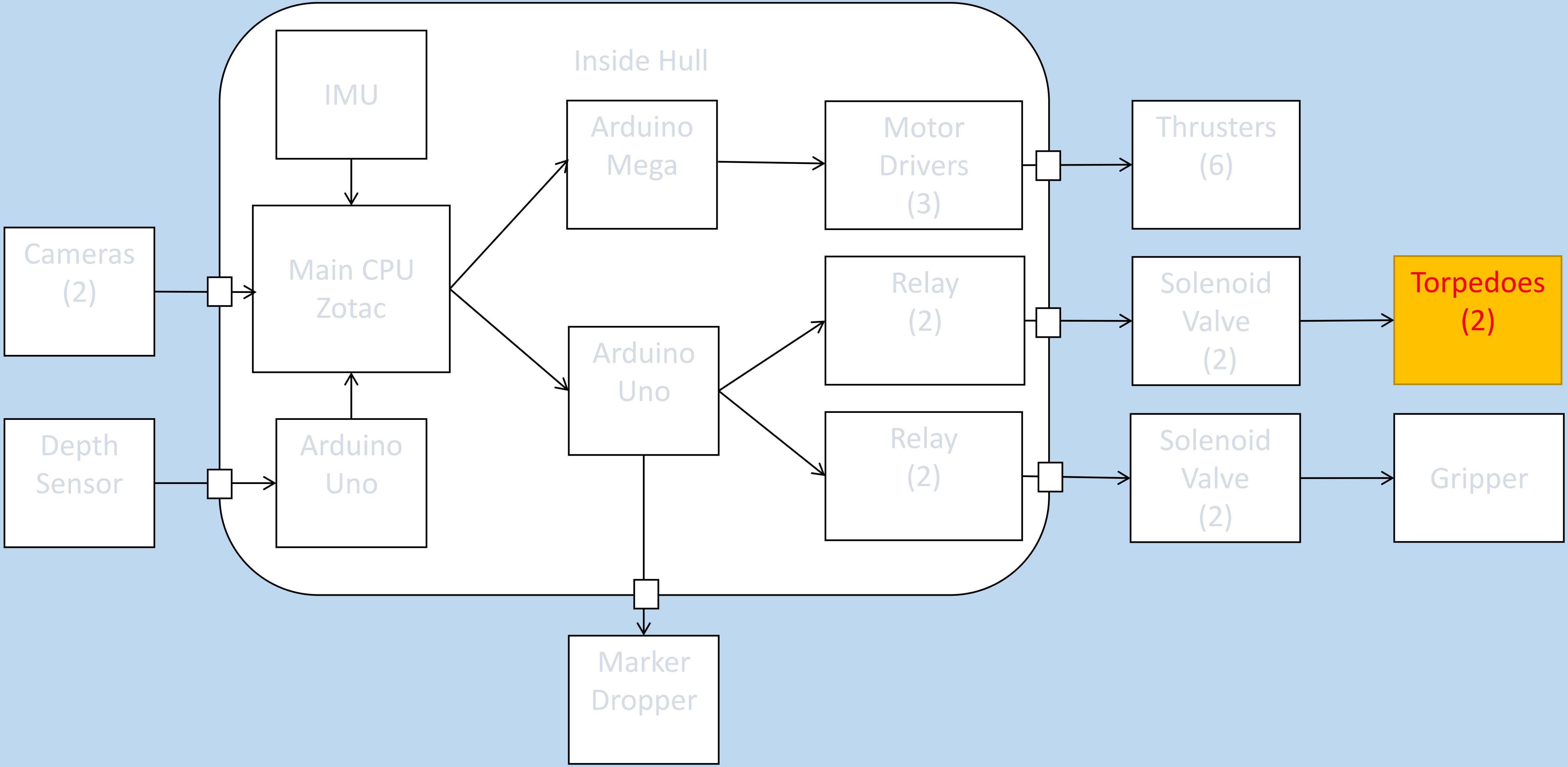


Figure 14: Air System Configuration

Torpedos



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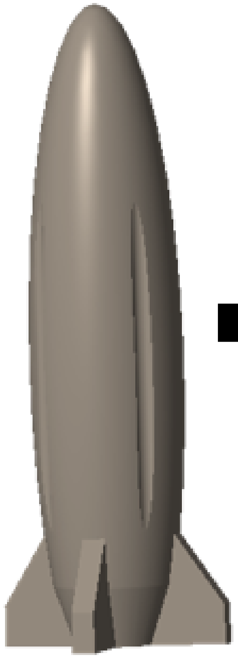
Torpedo Development



CAD design
- Small fins for easy mold release
- Small diameter to ensure piston fit

3D printed torpedo
- High buoyancy abs plastic
- Rapid prototyping

Plaster mold
- Plaster of Paris
- Mold around 3D printed torpedo
- Recoverable molds

Simpact 85A urethane rubber
- Relatively high density rubber (sinks in water)
- Easy pour but short pot life for rubber positive mold

Torpedoes Completed

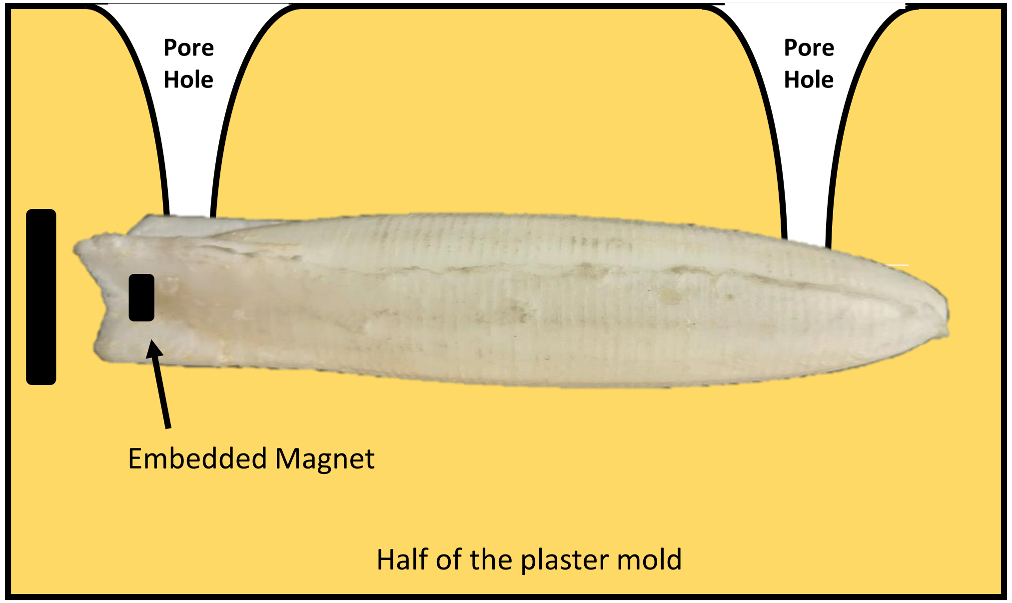
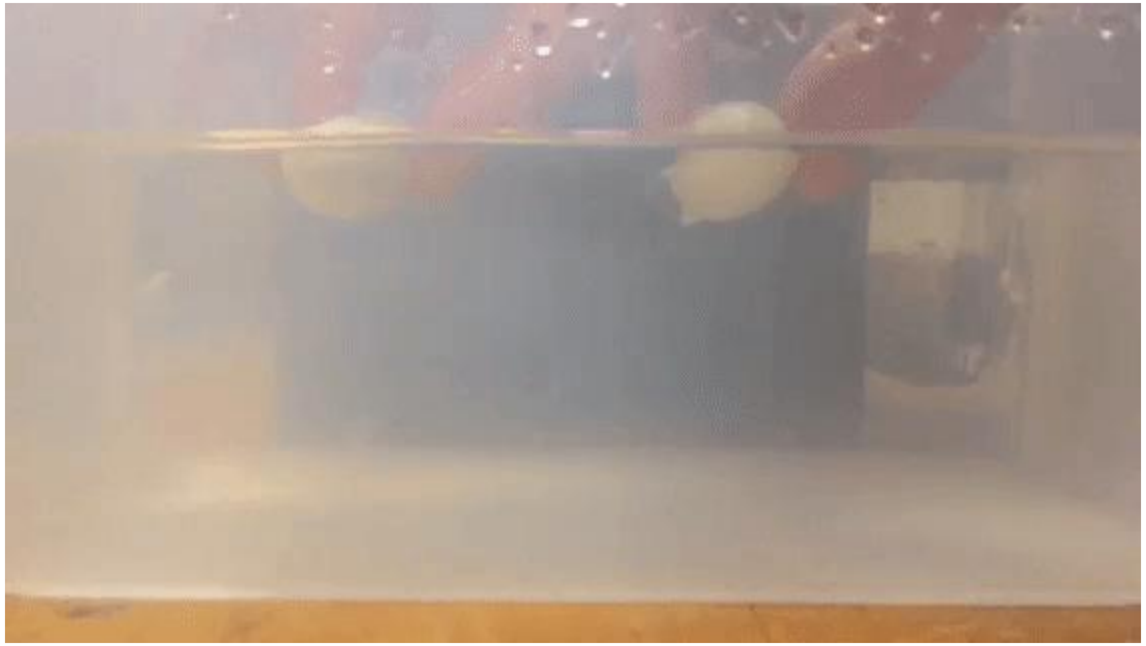


Figure 15: Magnet Embedded Torpedo Process



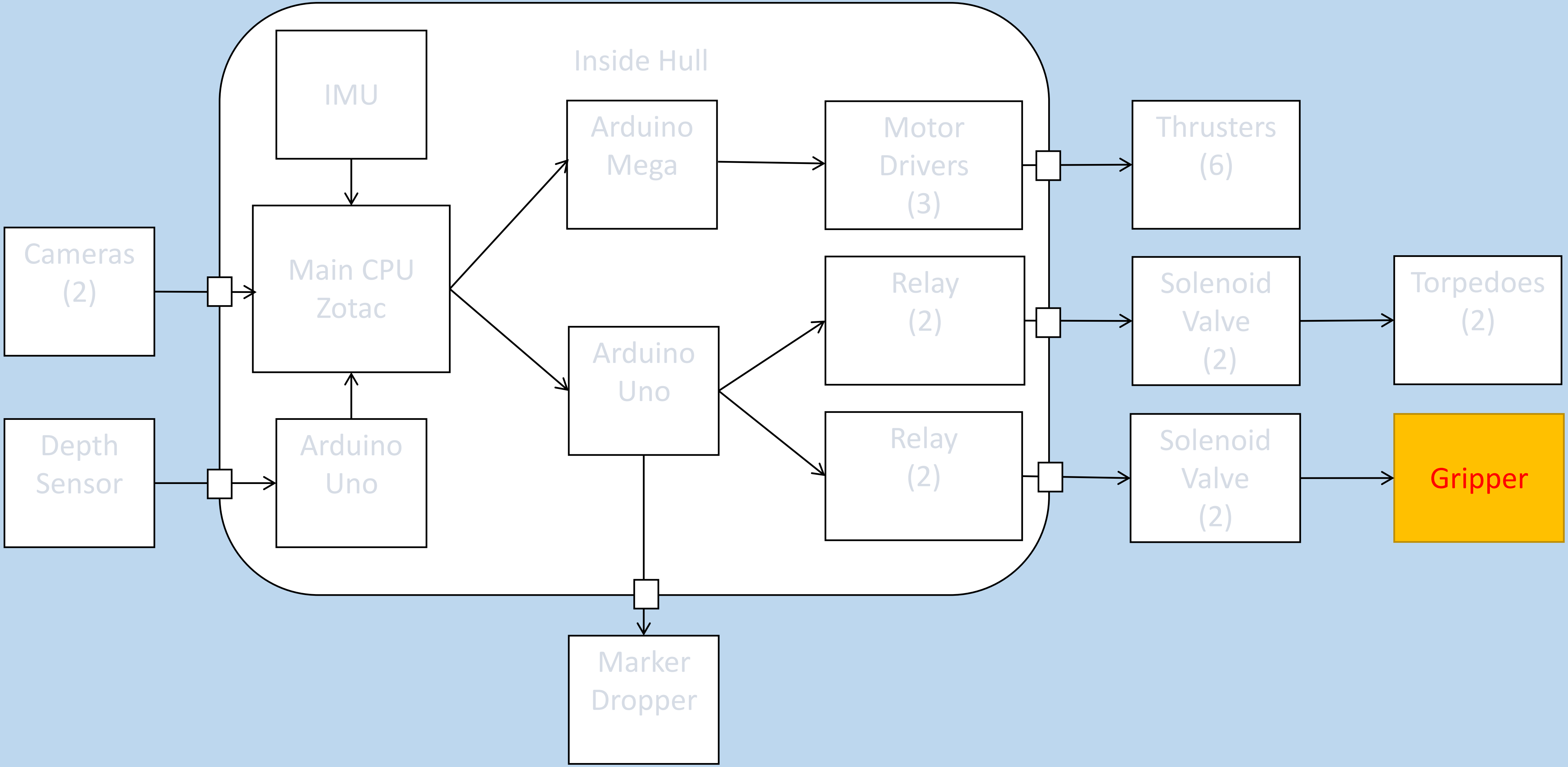
Next step

- Optimize for buoyancy (towards neutrality)
- Embed surface magnets to the torpedo back

Successful Testing

- Rubber torpedo successfully negatively buoyant
- Improvement over old design

Gripper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Marker Dropper

Gripper Development

Figure 16: Old Mechanism

- Lack of actuation mechanism
- Large ineffective claws

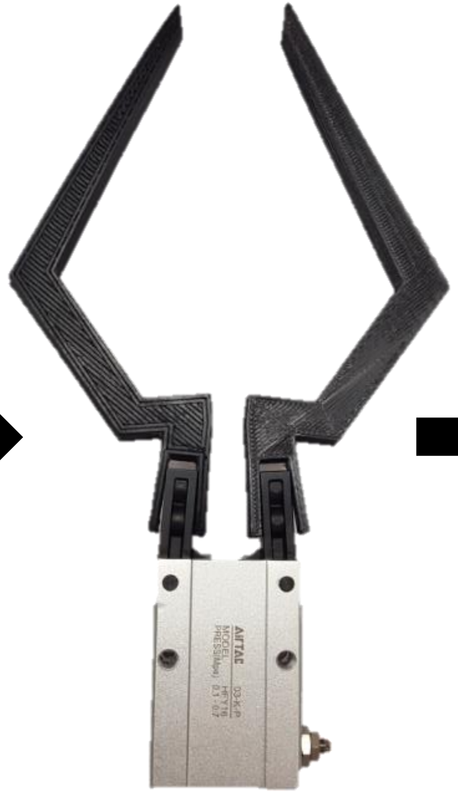


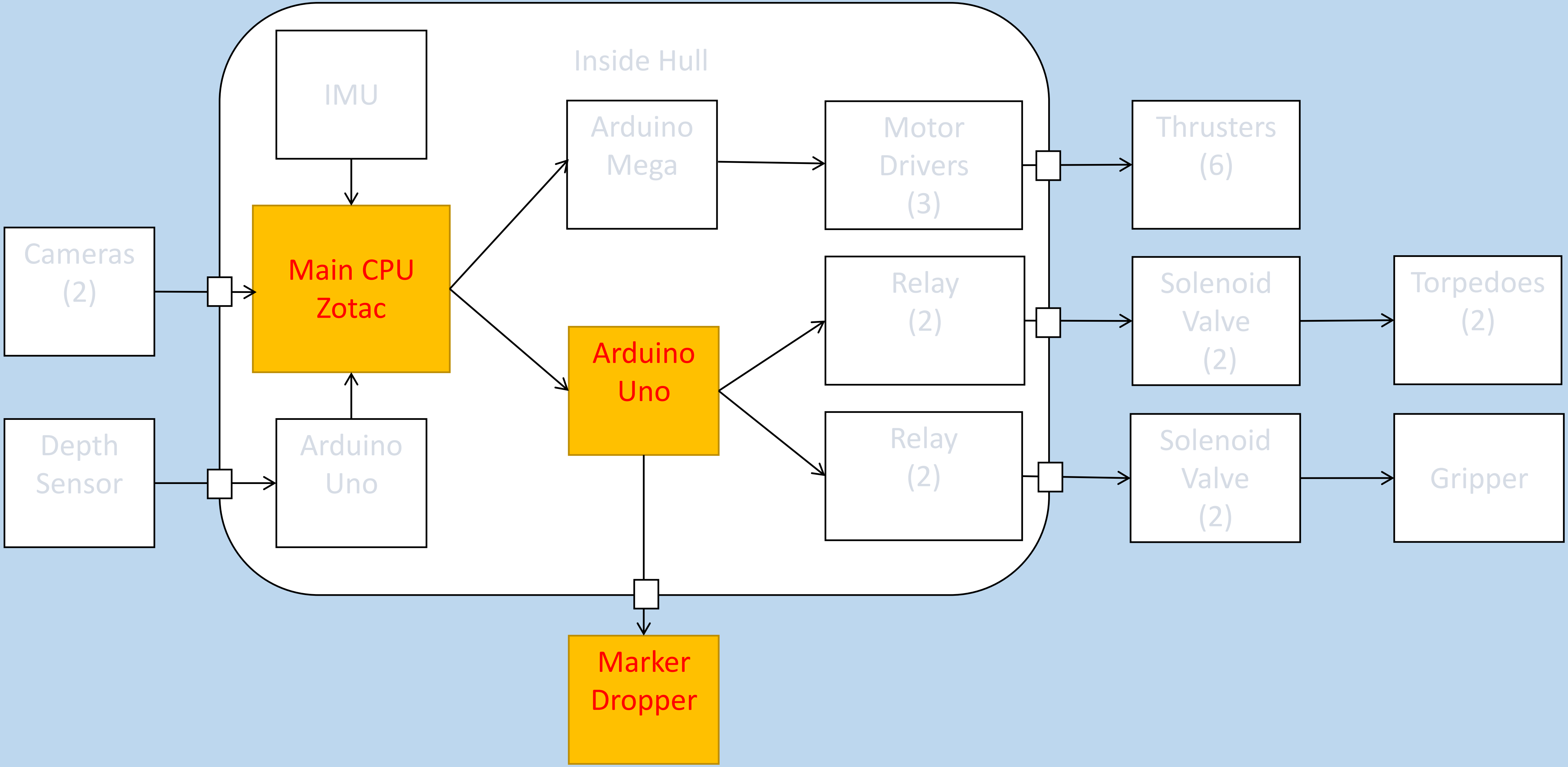
Figure 17: Gripper Prototype

- Purchased pneumatic actuator
- 3D printed gripping mechanism

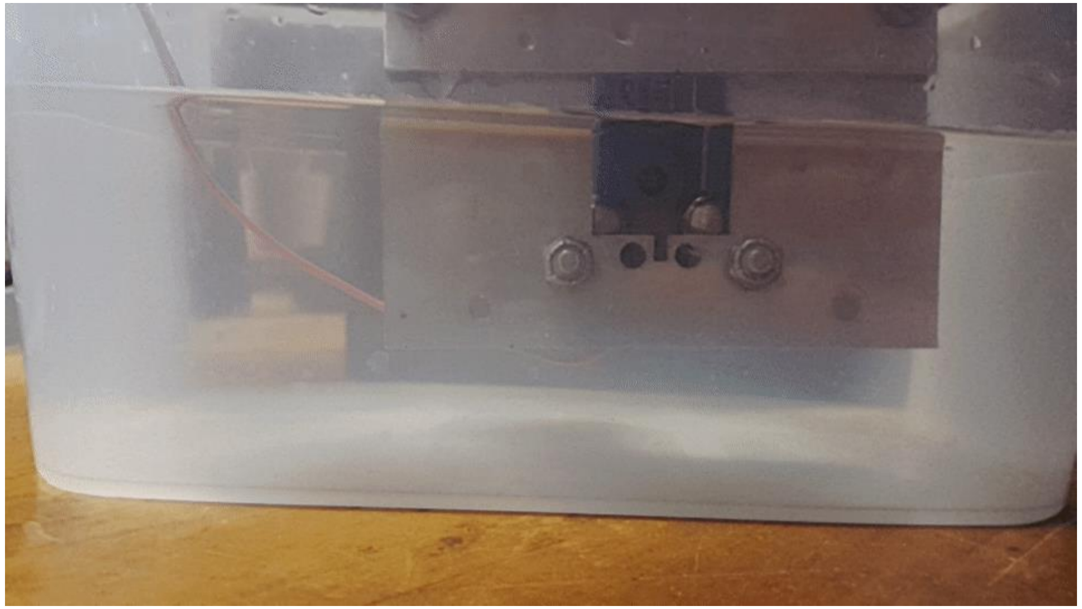
- ME team next step
  - Create appropriate mounting platform for gripper on submersible frame
  - Find and implement component for air system integration

- ECE team next step
  - Iterating design for larger gripping surface
  - Development of high friction gripping surface

Marker Dropper



Marker Dropper Development



Old System

- Normal DC motor
- Poor waterproofing
- Usable frame

New actuator

- waterproof servo
- Adjusted bracket positioning to allow the servo arm enough space to move

Tested servo underwater

- Markers successfully drop when prompted by user
- Mount to frame

Final step

- Integrate with main CPU (working with ECE Team)

Current Work

- Transfer Components from old to new hull
  - Cameras
  - Thrusters
  - Electronics
- Water Test all subsystems in pool
  - Torpedo
  - Gripper
  - Marker Dropper
- Code created to control sub remotely to test systems
  - Needed to test subsystems until image processing is finished
  - Works through serial from external computer

Figure 18: New hull with components

Gantt Chart Spring 2016

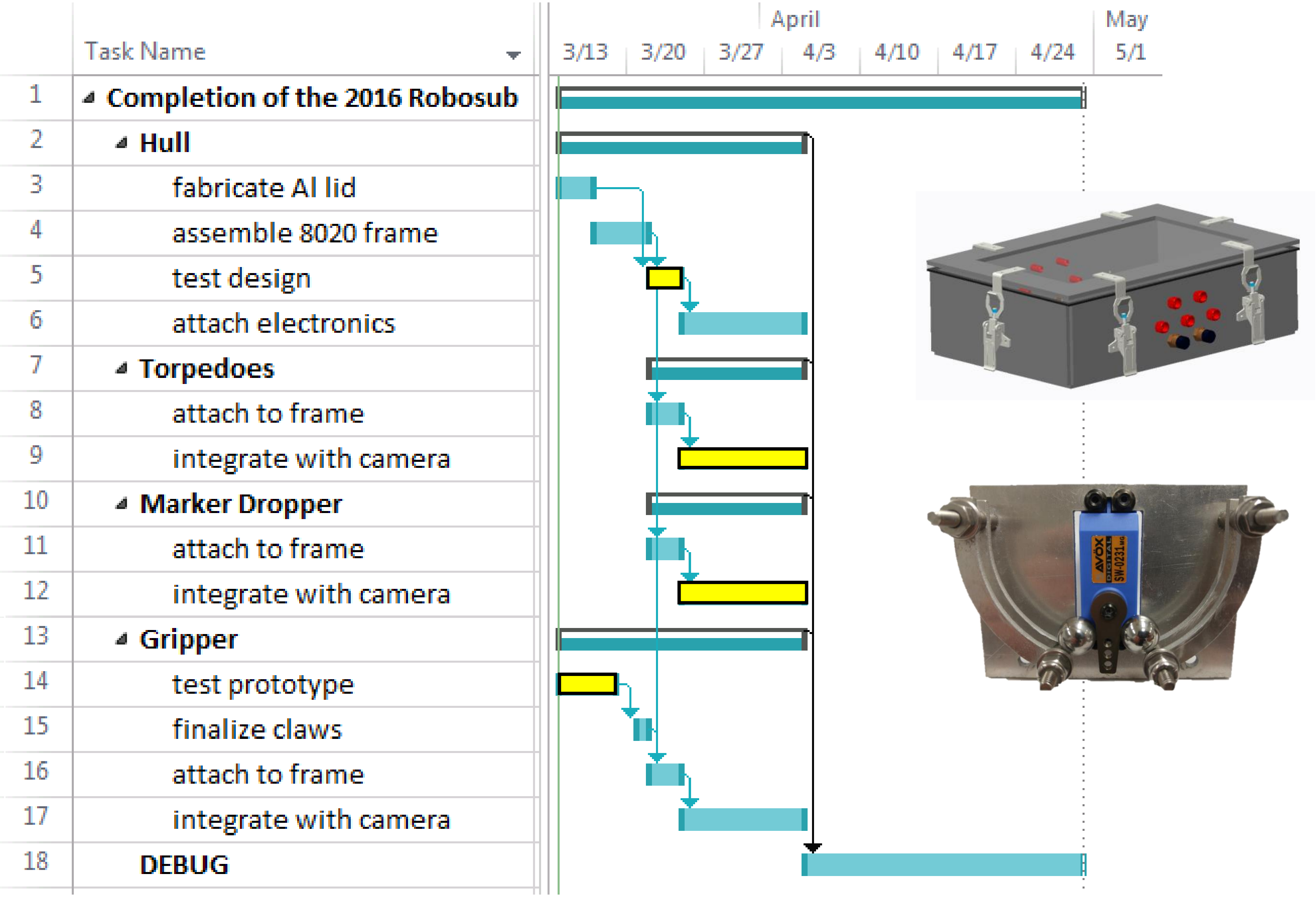


Figure 19: Time allocation and scheduling for spring 2016 semester

Testing Schedule

Test	Date	Notes
Gate Navigation	ECE Dependent	Remote control implemented
✓ Marker Dropper	January 22	Success
✓ Torpedoes	February 1	Success
✓ Gripper and Air Systems	February 1	Success
Testing of New Hull	March 25	Fabricating lid now
Systems Integration	Monthly	

Conclusion

- Fully assembled and tested torpedos and marker dropper
- Reorganized, electrically insulated, and modularized hull electronics
- Pneumatics system fully operational
- New hull fabrication completed

References

- [1] Auvsifoundation.org, "Home - Foundation", 2016. [Online]. Available: http://www.auvsifoundation.org/home. [Accessed: 16- Feb- 2016].
- [2] Onr.navy.mil, "Office of Naval Research Home Page", 2016. [Online]. Available: http://www.onr.navy.mil/. [Accessed: 16- Feb- 2016].
- [3]F. Engineering, "FAMU-FSU College of Engineering :: Welcome", *Eng.fsu.edu*, 2016. [Online]. Available: http://www.eng.fsu.edu/. [Accessed: 16- Feb- 2016].

Questions?