# NAU RoboSub

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NORTHERN ARIZONA UNIVERSITY

AUVSI
ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS INTERNATIONAL

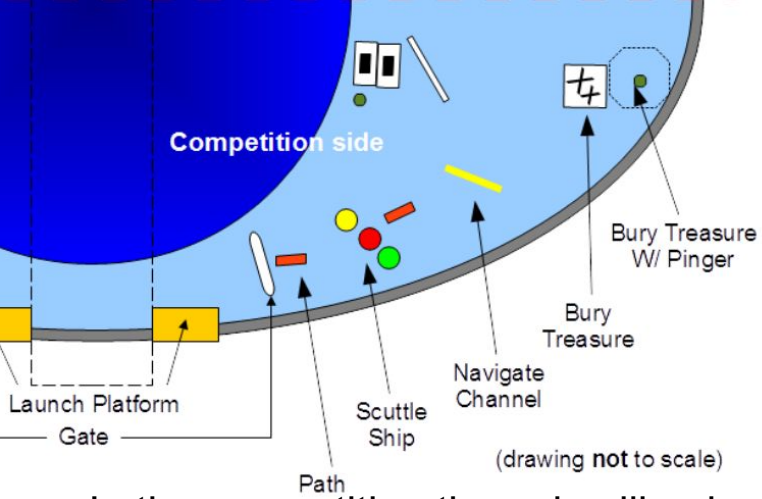
# Overview

- Introduction
- Competition tasks
- Needs/Goals
- Constraints/ Features
- Camera Box
- Endcaps
- Externals
- Internals
- Electrical
- Software
- Conclusion

# Introduction

- Robosub 2016 competition
- Client: Dr. Kosaraju
- NAU's first time participating


[1] AUVSI foundation




# AUVSI Robosub Competition

2016 competition theme: Pirates

In the competition the sub will gain points for:

- Bumping two buoys in order (red then green)
- Pulling a third yellow “buoy” downward, “scuttling” an attached boat floating on surface
- Passing through a pvc U (8’ by 4’)
- Dropping markers into 2 plastic bins
  - One bin has a cover with a PVC handle that needs to be removed
- Firing torpedoes through 12” and 7” squares
- Surfacing in a 9’ octagon marked with a pinger 16’ below the surface acoustic pinger
  - Extra points for carrying an object up from the floor then descending and placing near an X

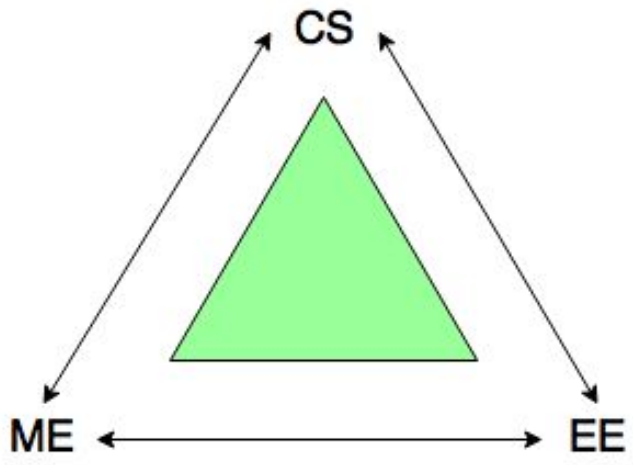
[1] AUVSI foundation, [2] Skull and Crossbones

# Robosub Needs/Goal

- Needs: NAU has no robosub for the AUVSI competition
- Goal: complete a new robosub ready for competition in July 2016

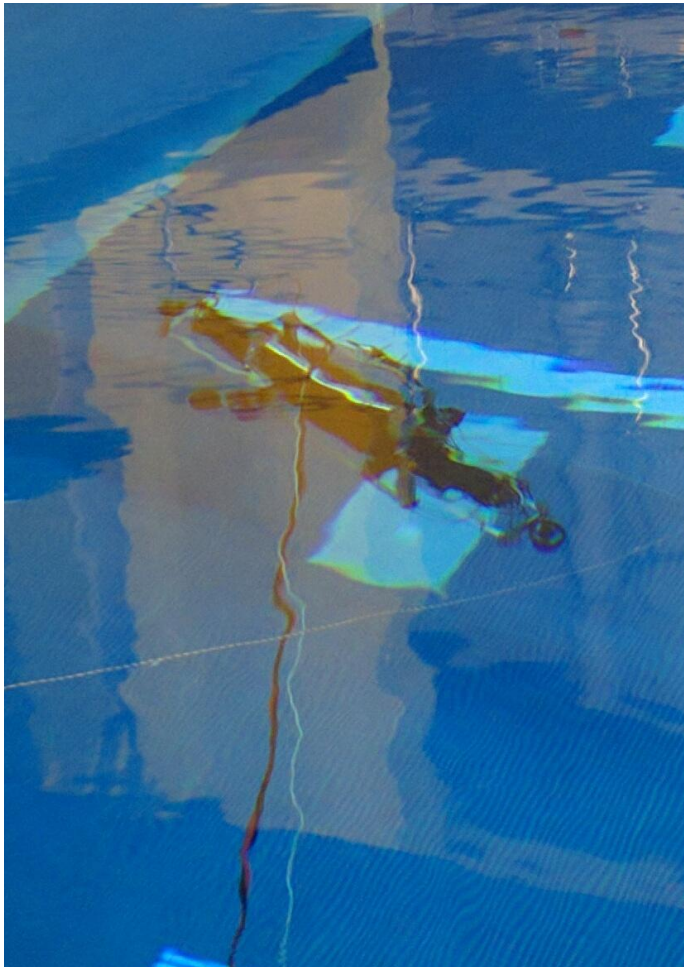
Includes aspects from :

- Mechanical
- Electrical
- Software



# Constraints

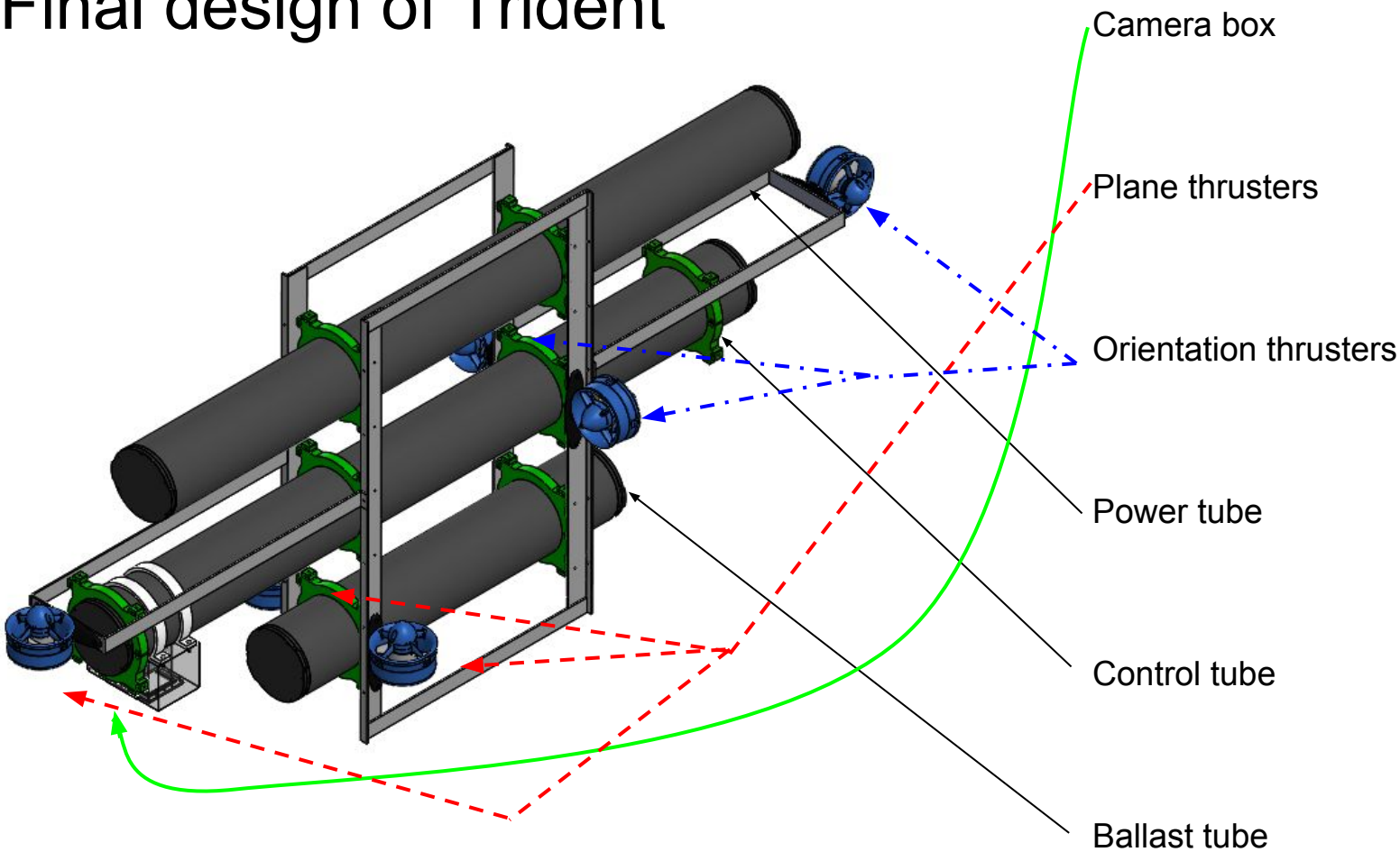
- Autonomous
- Fits in 6’ x 3’ x 3’ volume
- Has waterproof kill switch
- Must be at least 1% buoyant
- 15 minute time limit
- Weighs less than 125 lb
    - Extra points for weight < 84lb, 48.5lb, 22lb



# Required Features

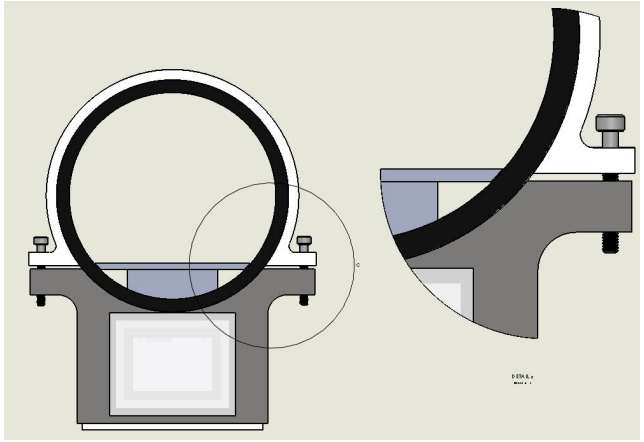
- Water tight enclosure
  - Obstacles are max 16’ deep (~22 psi)
- External frame
  - Mounts sensors and thrusters
- Electrical circuit
- Internal frame for electronics
  - Must account for heat
- Autonomy software

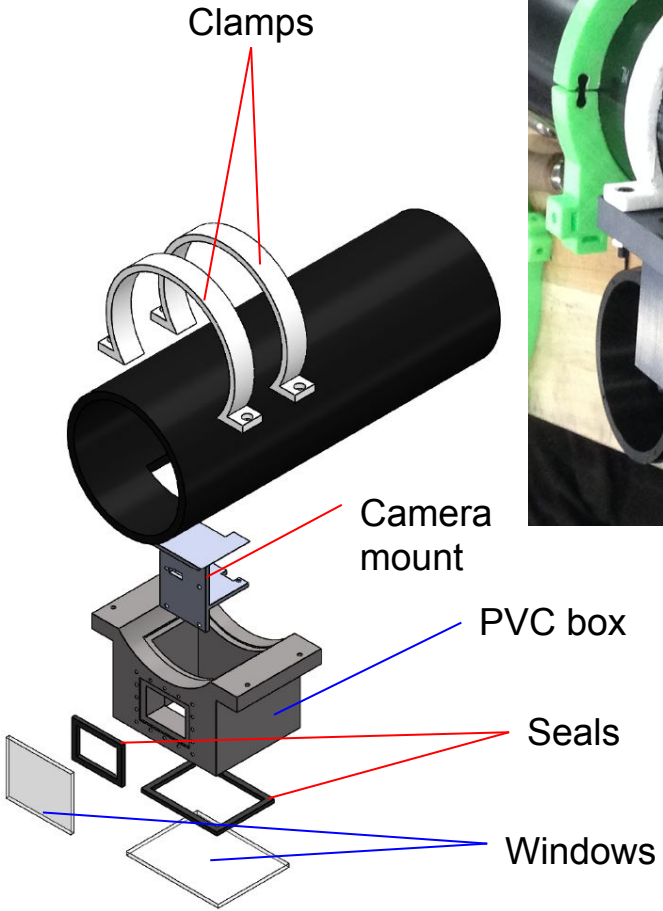
# Final design of Trident



# Camera Box

- Front and bottom facing cameras
  - 3D print mount
- Acrylic windows sealed with epoxy & silicone
- Epoxy and clamps to fasten to body
- Rubber gasket between tube
- Problems…
  - Tube not perfectly circular





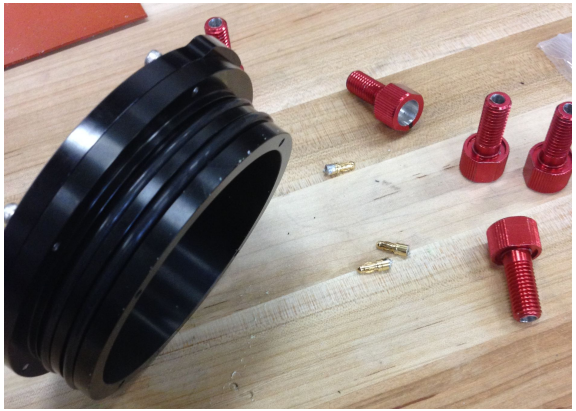

# End Caps

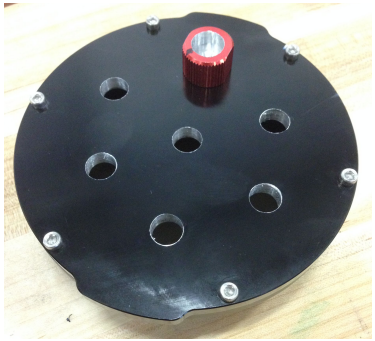
- Through ports for cables
- Water tight
  - O-rings x3 per end cap
- Aluminum end caps
  - Machinability
  - Heat release from system

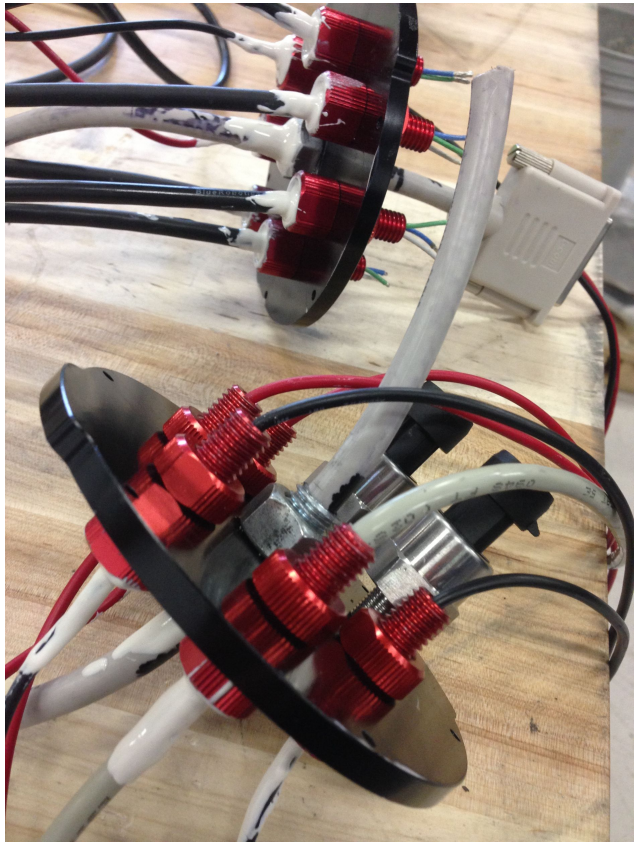

[3] Blue Robotics

# Manufacturing End Caps

- Drilled holes for cables
- Drilled holes through bolts
- O-rings/epoxy for water tightness

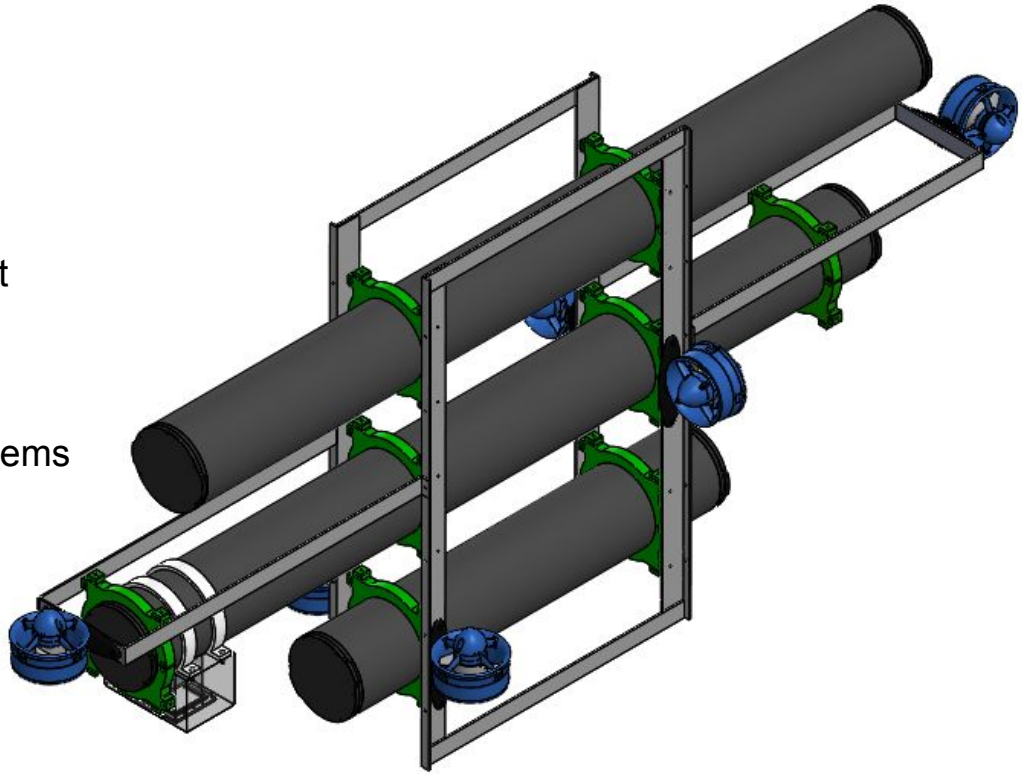






# External Design

- Metal-frame design
  - Three tubes, bottom for ballast
  - Rigid metal construction
  - Difficult to mount external systems



# External Frame

- Changed due to unexpected instabilities
  - Sheet metal strips / angle brackets
    - Angle brackets provide rigidity
    - Strips provide stability
  - Threaded rod holds construction rigidly together
- Alternatively: 3D print from ABS plastic
    - Mechanically superior to PLA
      - Stronger
      - Low risk of delamination
      - Superior finishing qualities (sanding, drilling)
    - Faster and cheaper to manufacture

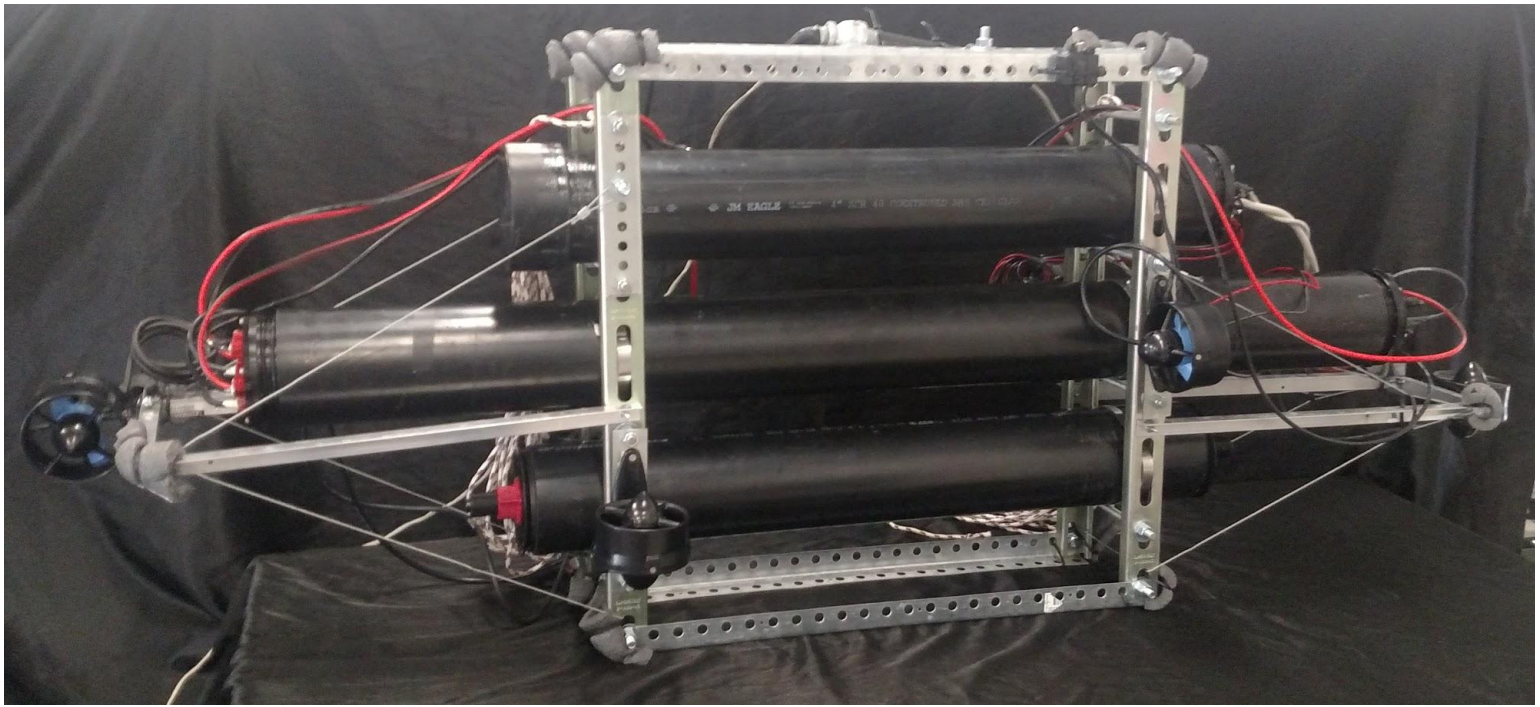
# L Channel connection for Thruster

- Increases strength on the U and X shape brackets
- Prevent torsion problem between tube and brackets
- Can be moved for relocation

Nick named, “Frankenstein”

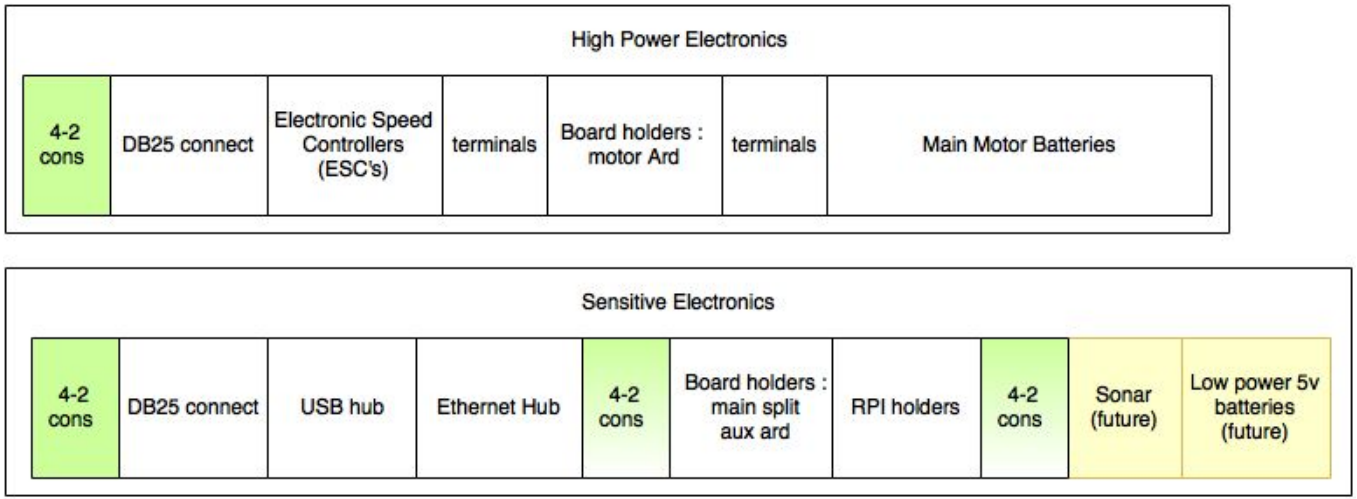
# External design: Completed prototype Trident

Nick named, “Frankenstein II”

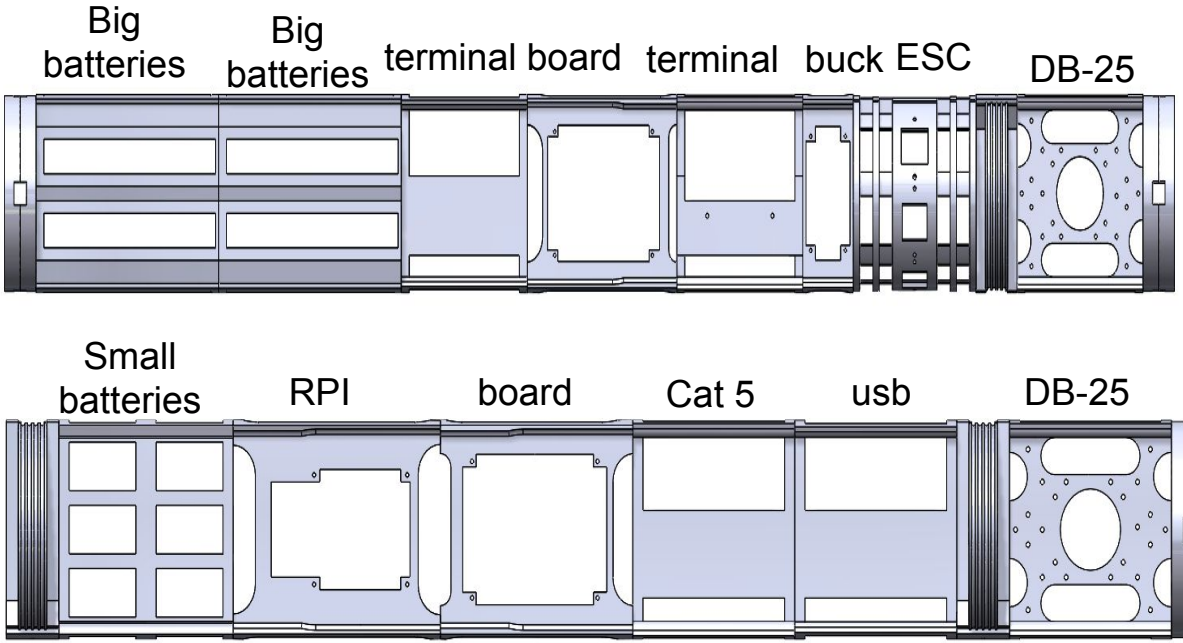


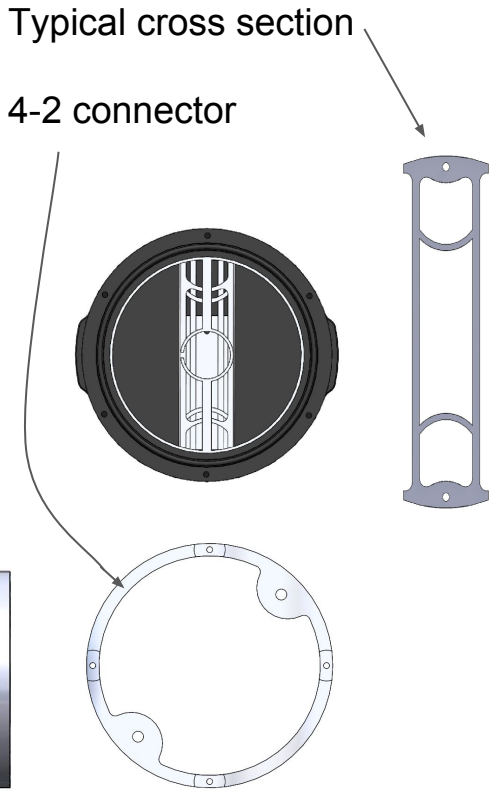
# Internals Introduction

- Modular design
  - Mix and match sections
- Repurposed misprinted sections
- Heat sinks for:
  - Electric Speed Controllers (ESCs)
  - Batteries

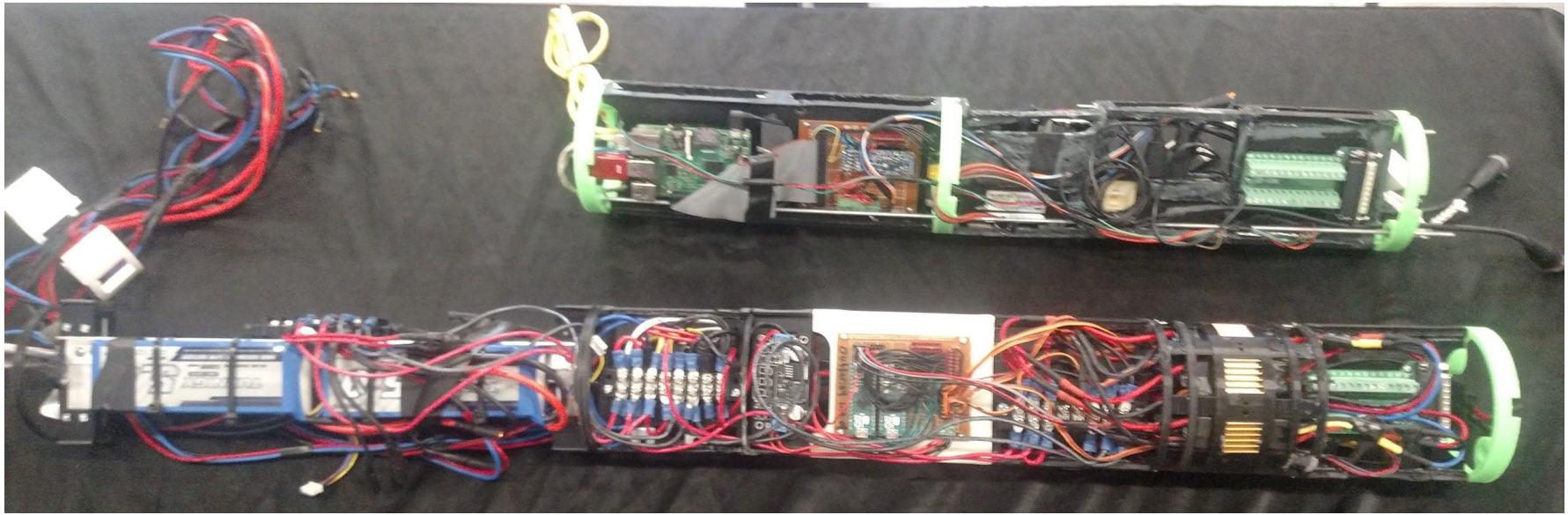


# Internal Frame Assembly



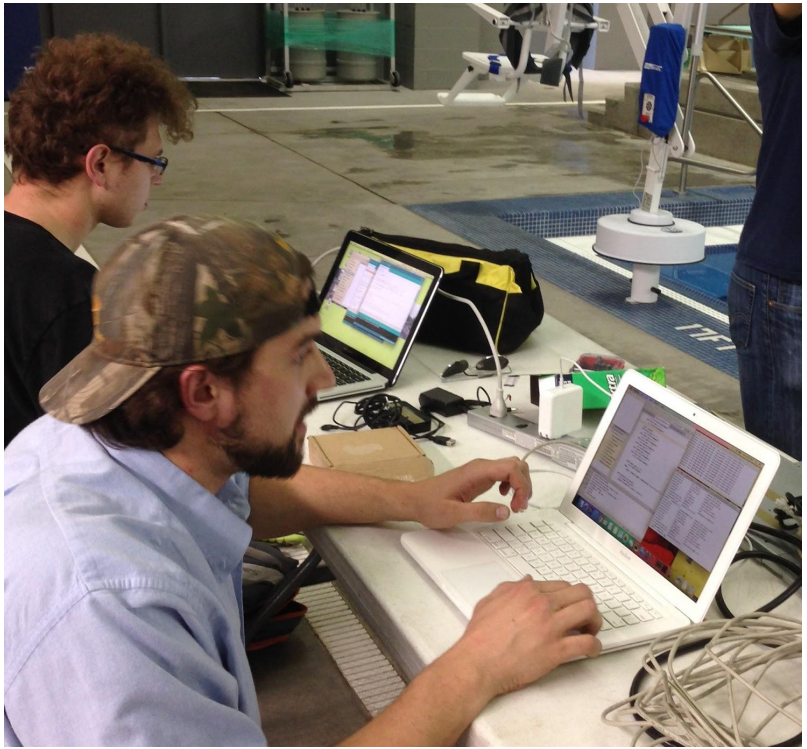



# Internal design with the hardware



# Electrical Subsystems

- Hardware
  - Power
  - Control
- Software
  - Visualization
  - Communication
  - Orientation
  - Motor feedback
  - Sonar



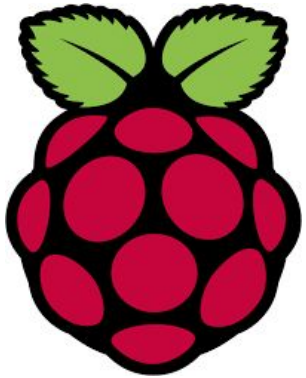
# Electrical Concept Generation

Hardware & software

- Talk to grad students and professors
- Look at competing teams
- Work with what we know
- Learn what we should know
- What components and libraries we need
- What circuits and algorithms to develop

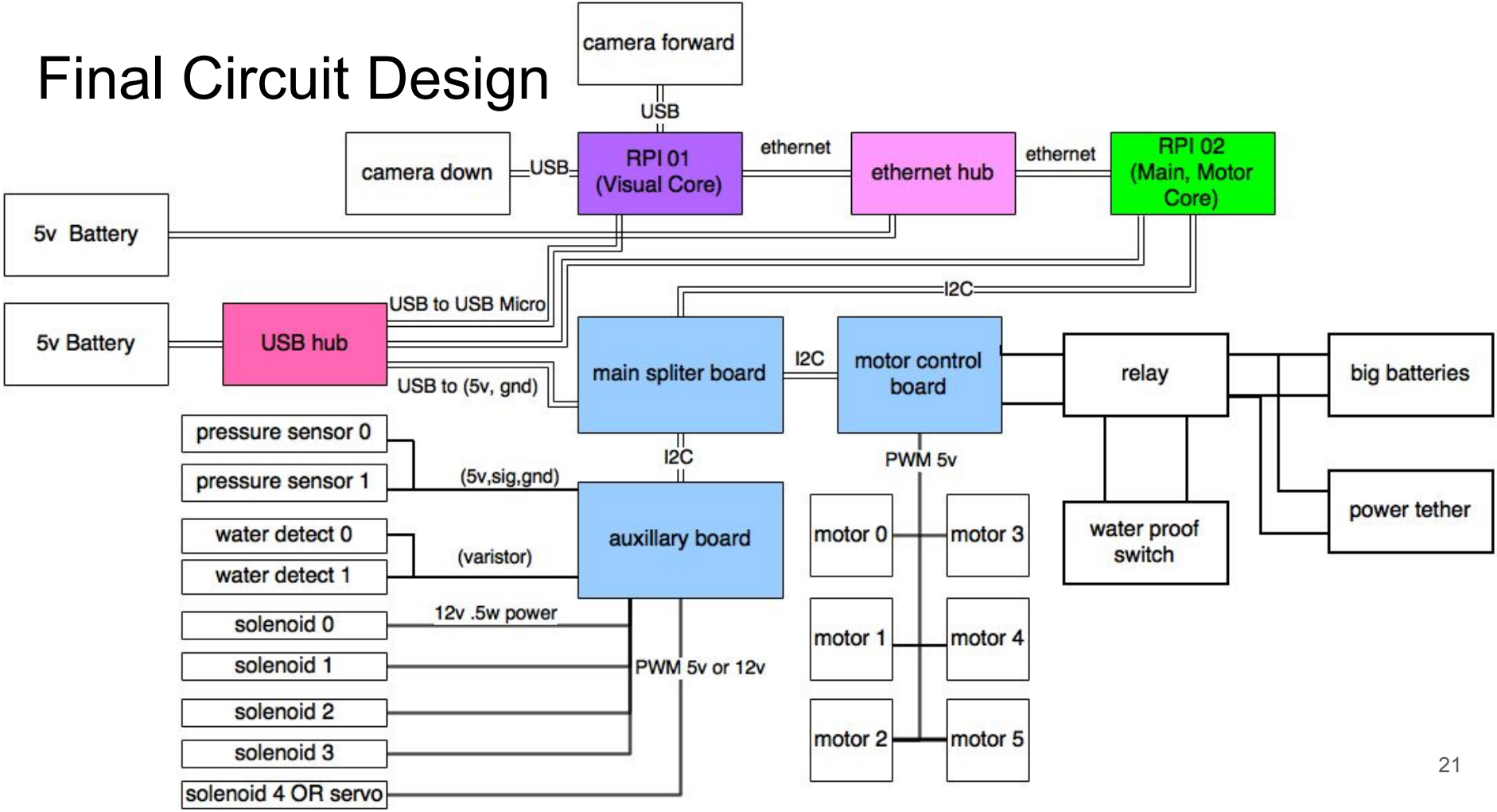


Raspberry Pi

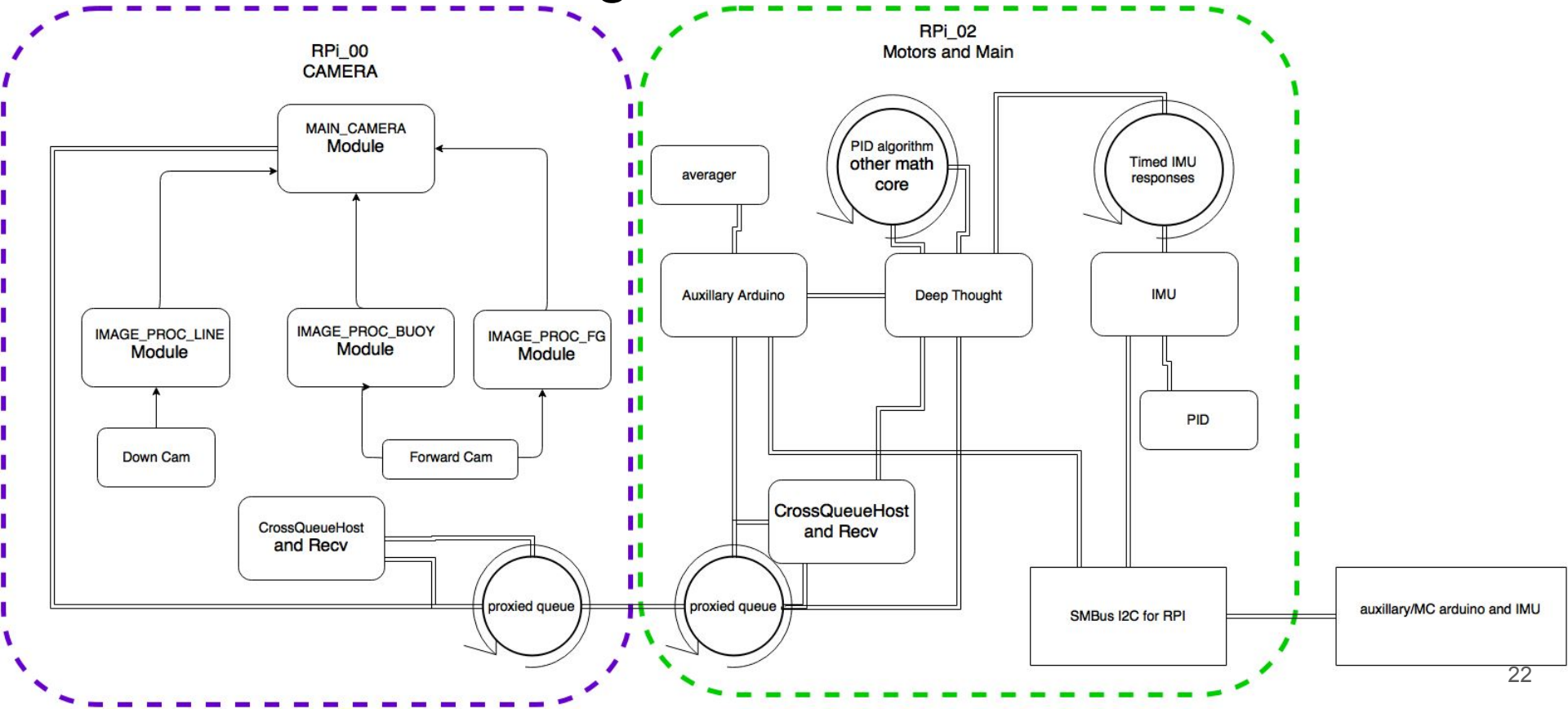


[4] Python, [5] Arduino, [6] Raspberry Pi

# Final Circuit Design

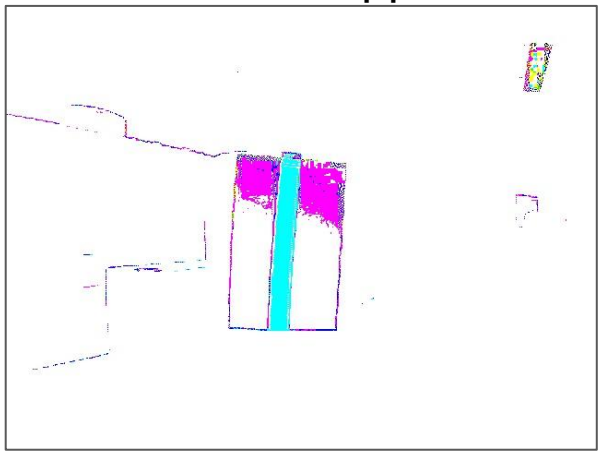


# Final Software Design



# Image Detection

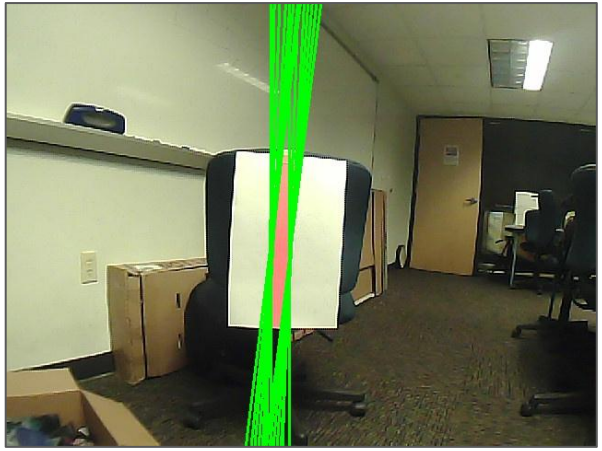
Threshold applied



Threshold applied

Green circle detected

Orange line detected

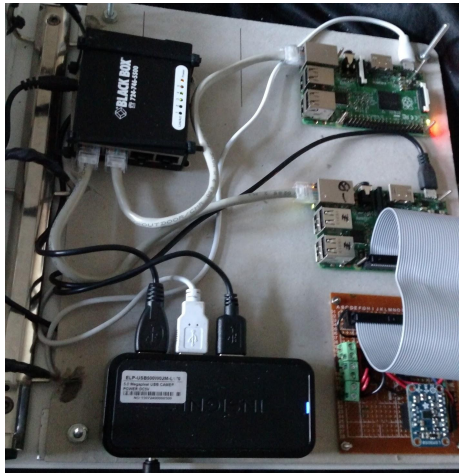


[10] OpenCV Documentation, [11] OpenCV install Tutorial

# Electrical Prototype Fabrication

Basic motor feedback of visual processing

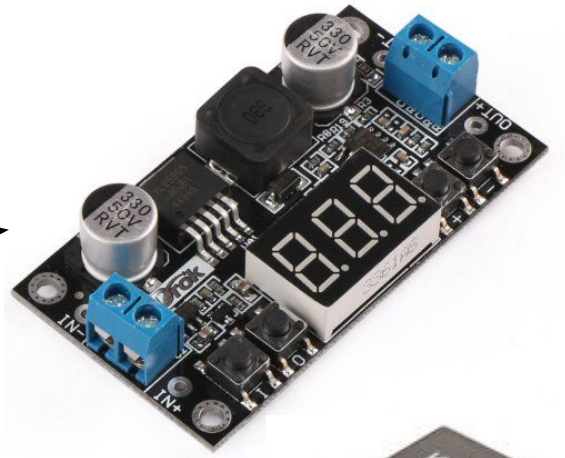
Test system set up



Assembling the internals

# EE Design Modifications

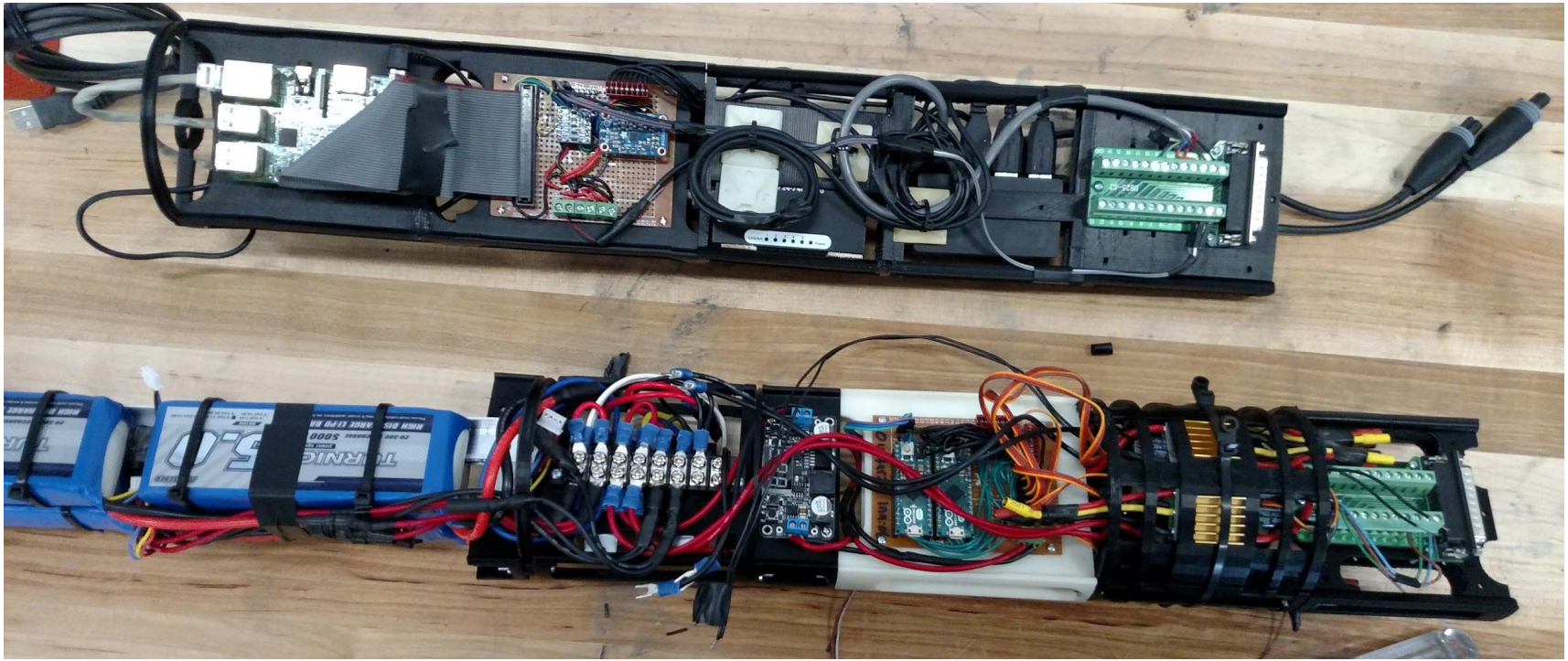
- Buck converters added
- Relay for main power On/Off
- DB communication cable
- Queued Socket Programming
- Simplified Software





[7] Amazon

# Completed Electrical Hardware Prototype



# EE Performance

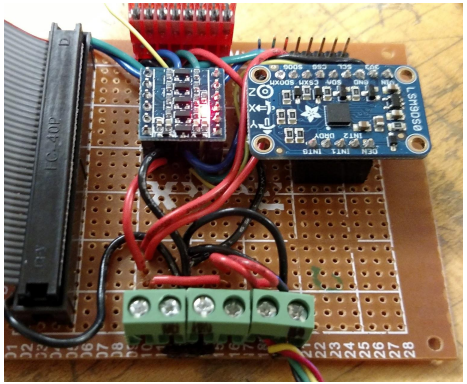
**Software**

- Find and kill ghost threads
- Computation time testing
- Find programing bugs
  - Threading issues
  - Lock passing issues
- Image detection:
  - Lighting
  - Threshold parameters
  - Image size
  - Decipher image data

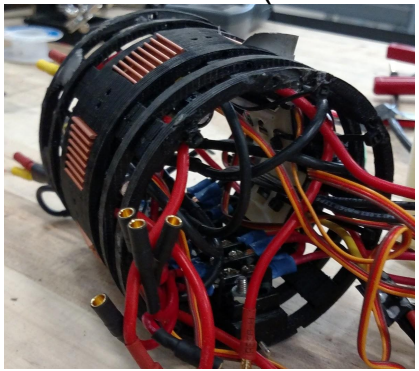
**Hardware:**

- Find and fix bad circuit elements
- Find and fix unwanted behaviour
- Eliminate motor controller heat
- EM Noise in the DB cable

Finding Board shorts



ESC heat to hull (W/ no foil)



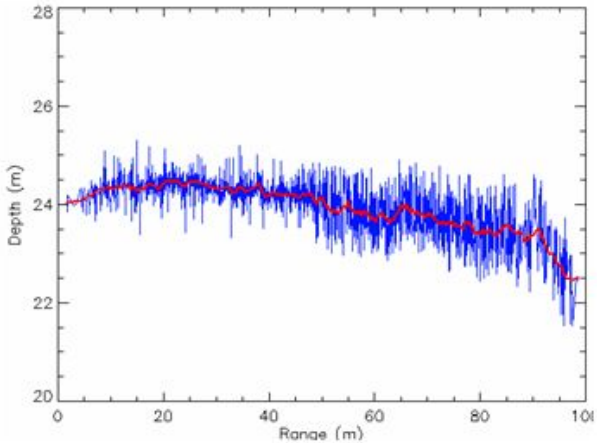
# Testing and Results

Video

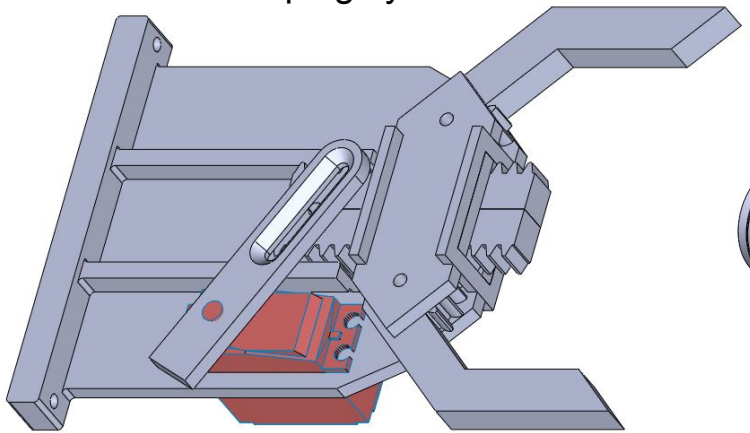
# Development for the future

- Torpedos
- Clasping
- Sonar
- Practice course construction
- Mechanical updates
- More programs

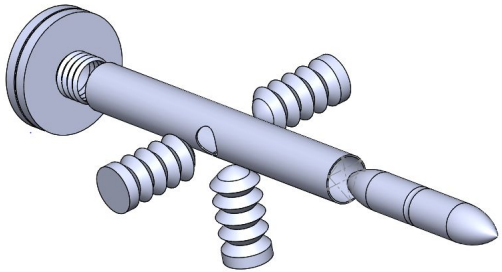
Sonar data




Clasping system



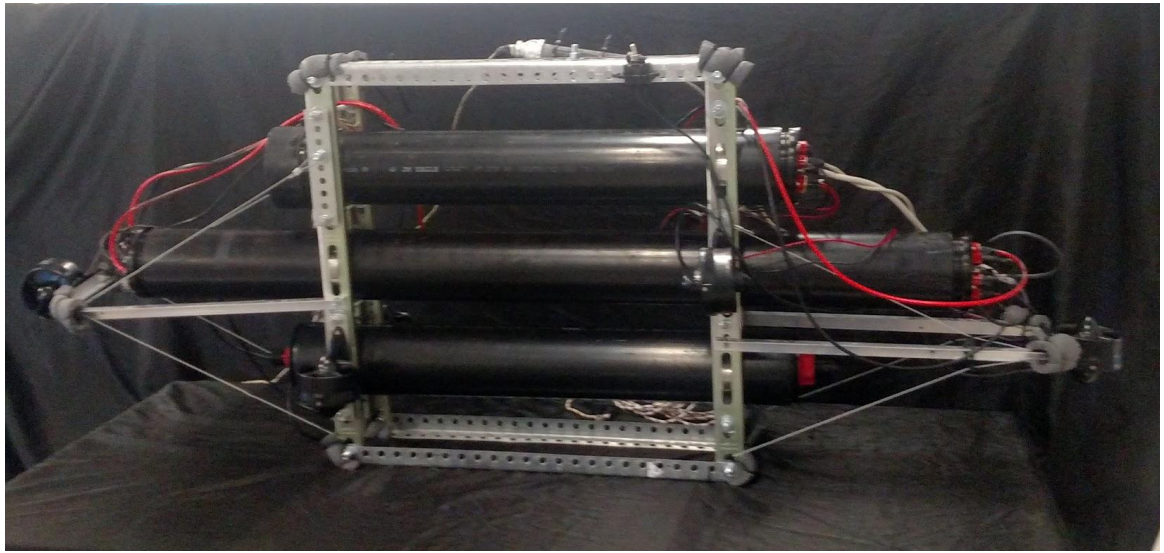
Torpedo System



[8] Sonar ping

# Conclusions

- Designed a submarine for 2016 Robosub competition
- Educational experience
- Manufactured systems
  - Camera
  - External
  - Internal
  - Electronics
  - Software



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  - Philip Mlsna
  - Dieter Otte
  - James Palmer
- The 98C shop staff:
  - Perry Wood
  - John Tester
  - Ricardo Inzunza
  - Derrick Lemons
- Dr. Kosaraju for guidance




[9] orbital ATK logo

# References


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# Questions?