NAU Robosub

Project Proposal

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NORTHERN ARIZONA UNIVERSITY

Bethany

AUVSI ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS INTERNATIONAL

Overview

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Mansour

Introduction

- Association for Unmanned Vehicle Systems International (AUVSI)
- International competition
- Includes high school and college teams
- Started in 2002

Mansour

Main Goal

- The AUVSI Robosub competition requires that we build a competitive robot meeting the design requirements that can complete all of the specified tasks autonomously.

Mansour

Tasks

- Pass through a narrow gate
- Bump a specific colored buoy while avoiding 2 others of different colors
- Remove a lid from a bin and drop a marker inside
- Shoot a torpedo at a series of targets
- Move a PVC pipe structure to a specific area
- Surface in a specific area

Constraints

- The robot is required to be Autonomous
- The weight limit of the robot is less than 57kg
- The size limit of the robot is within 1.83m x 0.91m x 0.91m
- The competition requires a Kill Switch
- The time limit is within 15 minutes
- The power source requires U.S 120V 60Hz 15A electrical for all the countries

Dan

Criteria

Thruster
- Weight
- Cost
- Thrust
- Power draw
- max Dim(mm)

Power source
- Weight
- Capacity
- Voltage
- Cost

Ballast
- Dry weight
- Cost
- Pitch control
- Water seal area
- Energy consumption

Computer/ controller
- processing
- RAM size
- bulkyness
- Weight
- Volume
- ADC pins 5V
- Dig I/O pins
- Cost

Torpedoes
- Launch force
- Weight/Volume
- Accuracy
- Range

Clasping System
- Clamping Force
- Clearance
- Carrying Load
- Cost

Camera
- Resolution
- Size
- Power
- Cost
- protocol steps

Acoustic Sensors
- Sensitivity
- Weight
- design cost
- monetary cost

Pressure Sensor
- Accuracy
- Cost

Inertial Measurement Unit
- Range
- Range
- Weight
- Cost

Software Language
- compiled
- community help
- Previous experience
- visual lib wrapping
- digital I/O lib wrapping
- corecampatablity
- threading
- ease to learn
- garbagecollection
- visual data snapshot ease

Dan

Functional Diagram

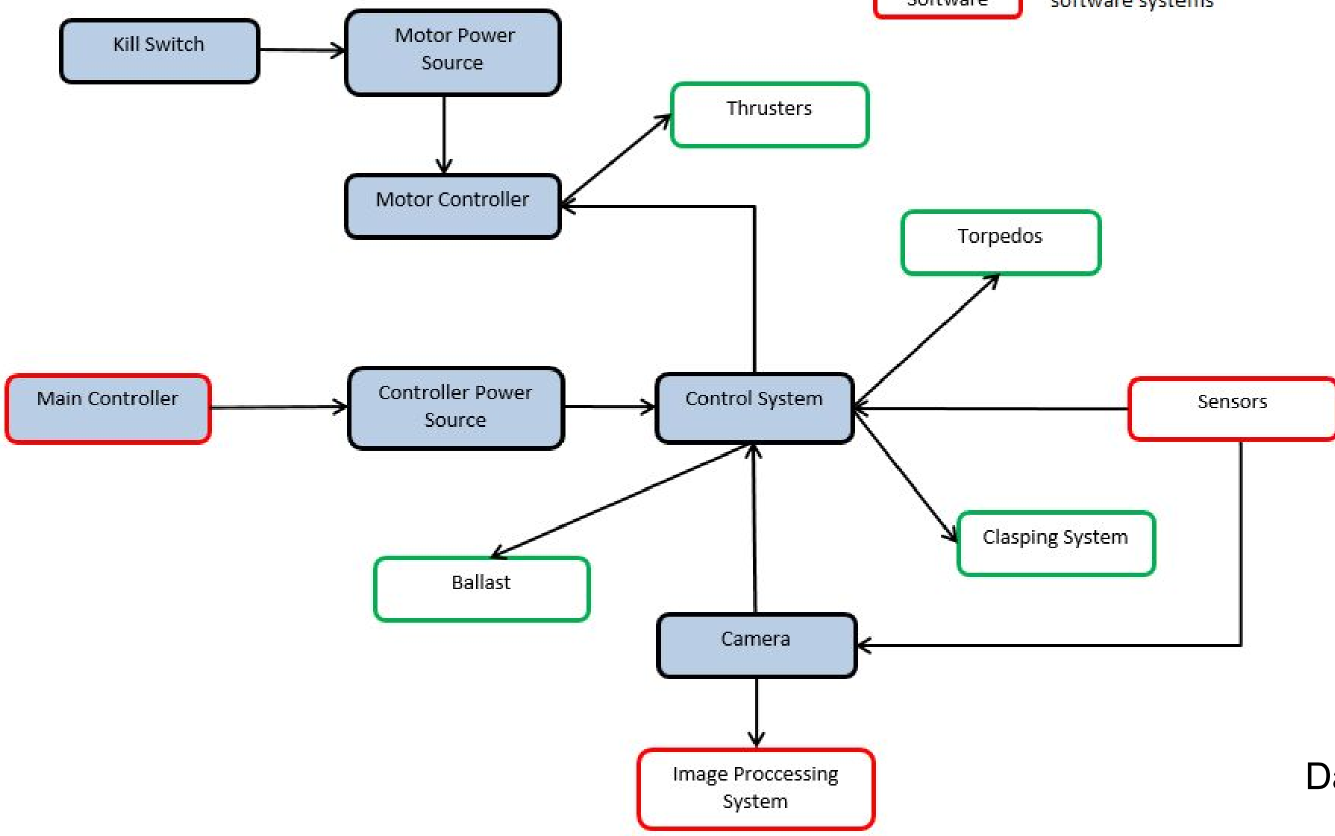
Sensors:	pressure
	feelers (switch or analog)
	pingers/sonar/acoustic
	IMU (inertia measuring unit)
	water pressure

Casing — *Everything highlighted in blue is connected to casing

mechanical — mechanical systems

electrical — electrical systesm

Software — software systems



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Design Choice:
Inertial Measurement Unit

- **Sparkfun 9-dof Razor IMU**

- Chosen for:
  - Relatively low cost
  - ease of programming
  - 9-dof including:
    - 3 accelerometers
    - 3-axis gyroscope
    - 3-axis magnetometer (compass)

Dan

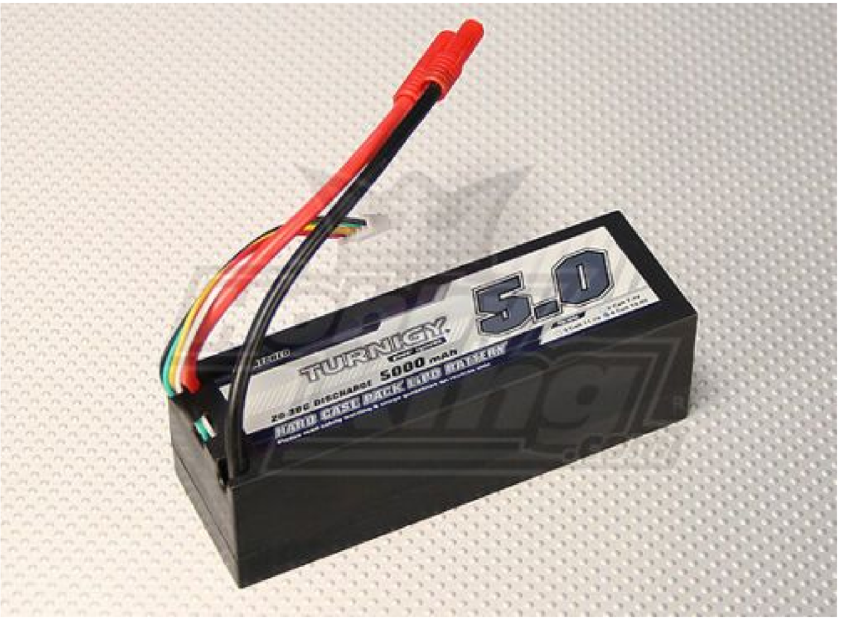
Design Choice: Pressure Sensor

- **Omega PX309 (0-30psi)**
- Chosen for:
  - Low cost
  - Good accuracy
  - Effective to ~ 30 ft
  - Must be mounted internally

Dan

Design Choice: Power source

- **Lithium Polymer**
  - Lightweight
  - High capacity (mAh)
  - Compact
  - Inexpensive

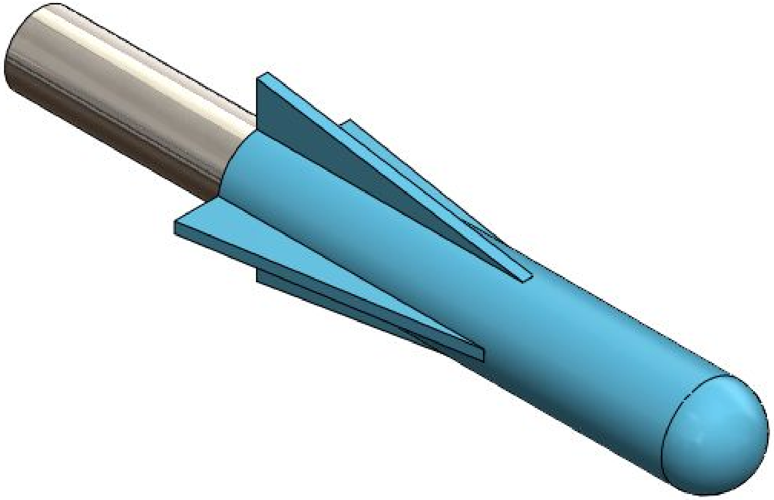


Bethany

Design Choice: Torpedoes

- **Compressed air system**

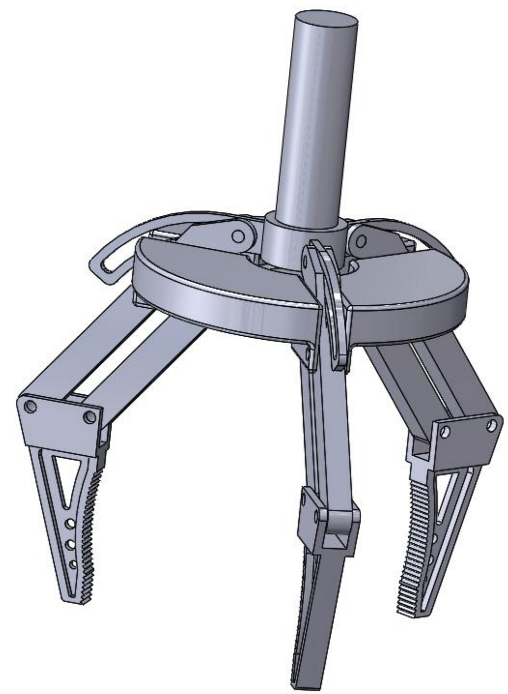
- Chosen for:
  - driving force on sub
  - ease to implement with control system
  - increased water resistivity
  - fewer moving parts



Bethany

Design Choice: Clasping system

- **Claw system**
- Chosen for:
  - three claws maintain the stability
  - easy to implement and mount
  - 180 degree range of motion
  - able to connect to the pneumatic system



Wenkai

Design Choice: Cameras

- **fish-lens 170° view 4Mp camera, pointed down**
  - large pixel count
  - Linux OS compatible
  - occurring target without moving sub

- **75° degree 8Mp camera, pointed forward**
  - large pixel count
  - Linux OS compatible
  - larger pixel per degree count
  - good for acquiring targets and their distance

Feras

Design Choice: Acoustic sensors

- **Aquarianaudio h1c hydrophone**

- Chosen for:
  - low cost
  - available specs
  - ease mounting with ¼”NPT
  - shielded cable

will

Design Choice: Software Language

- **Python**
- Chosen for:
  - ease to learn
  - Image processing libraries
  - Compatibility with other libraries
  - Socket parallel programming
  - large user community
  - can be compiled

will

Design Choice: Thrusters

- **Blue Robotics T100**

- Chosen for:
  - High thrust
  - Rugged and durable
  - Relatively low cost

Daniel

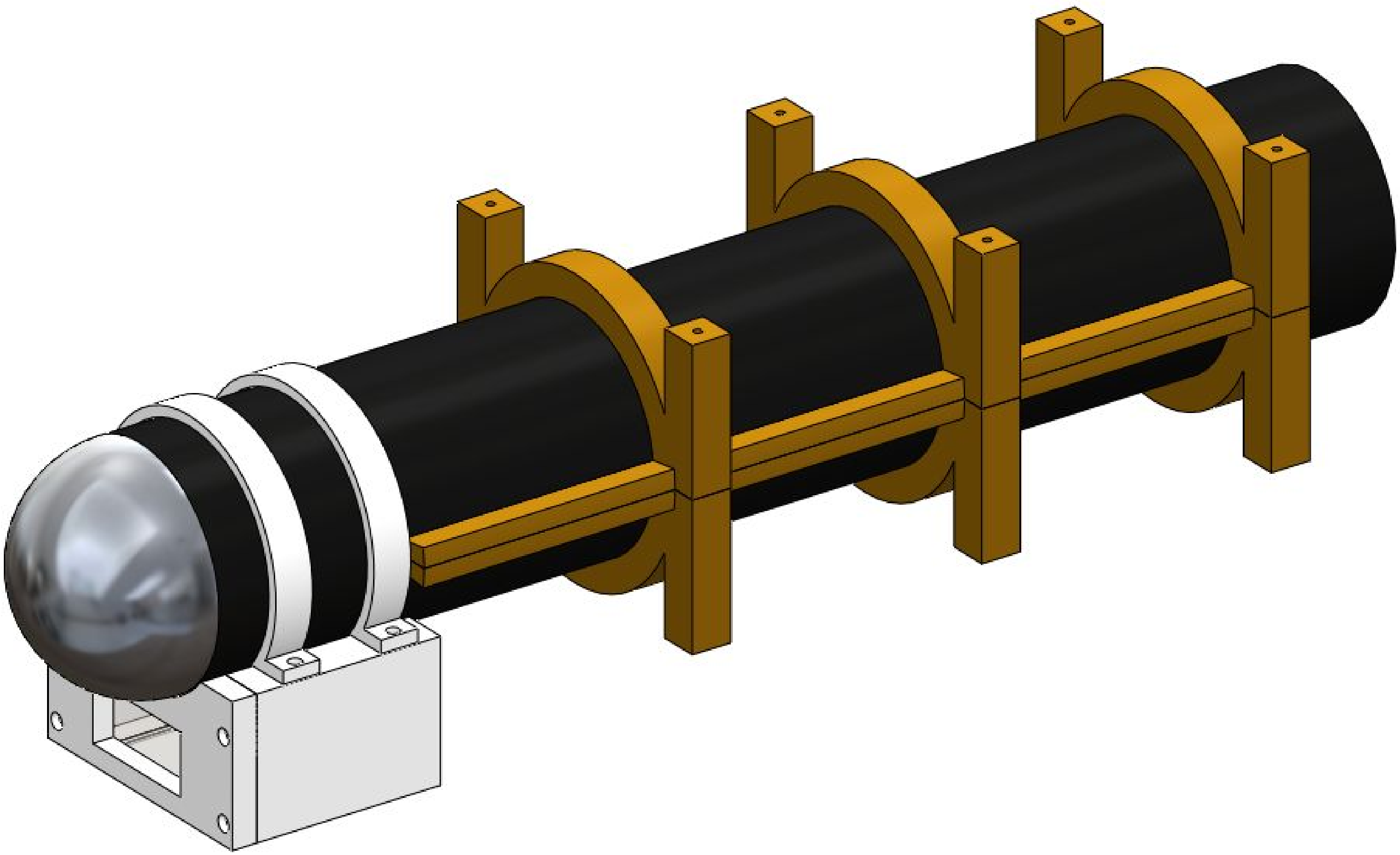
Design Choice: Frame Attachment

- Bracket pattern
- Ease of attachment
- Simple design
- Modular
- Expandable

- Affordability
- Easy to modify
- Relatively Lightweight
- Standardization
- "Skeletal"

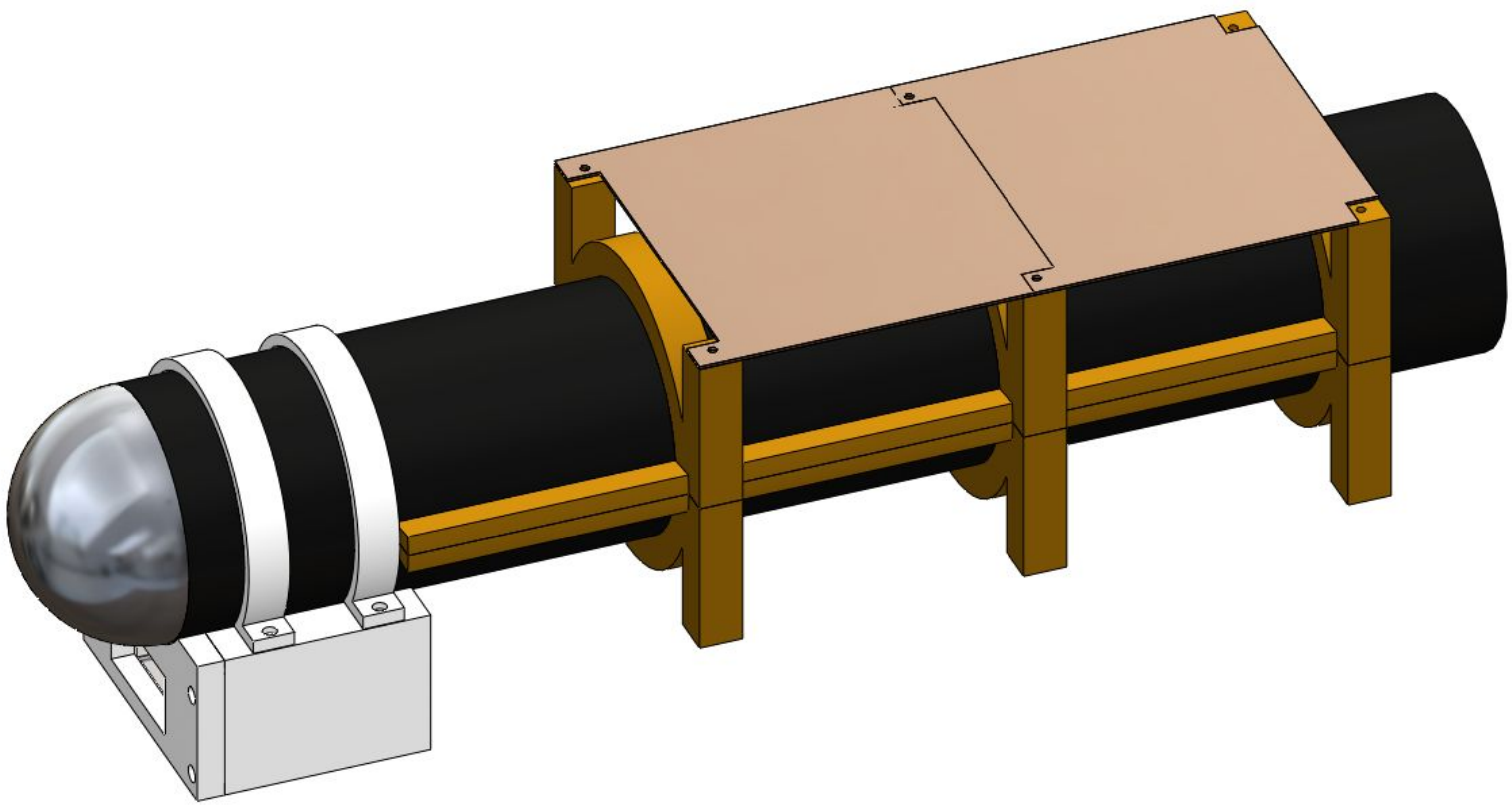
Daniel

Design choice: Frame attachment



Daniel

Design choice: Frame attachment



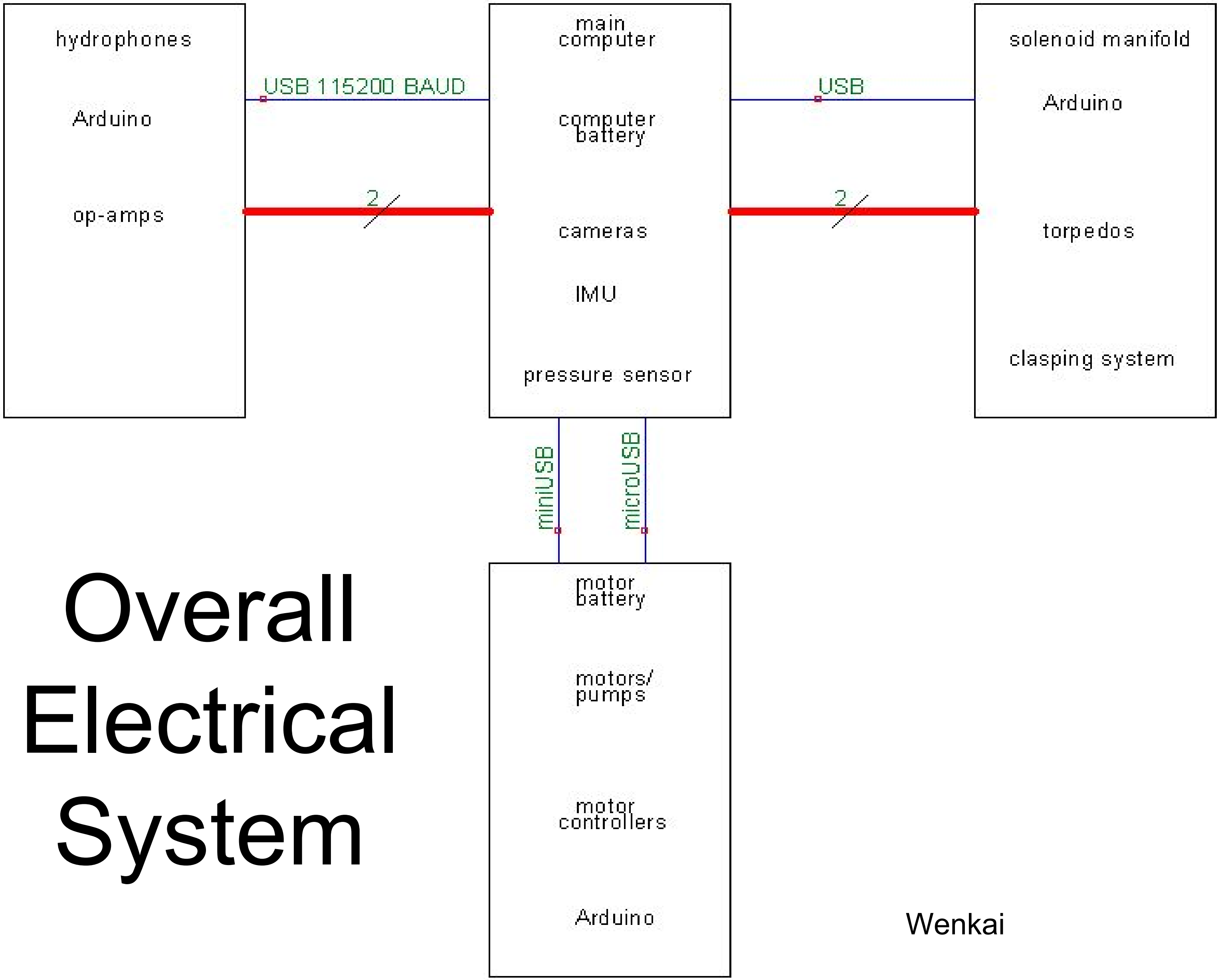
Daniel

Design Choice: Computer/controller

- **ODROID:**
  - 2 GB DDR3 RAM
  - 8 cores, 2 Gh (parallel processing)
  - 3 ADC pins
  - Chosen for:
    - High speed and ADC signal crunching
- **Raspberry Pi:**
  - 512 MB RAM
  - 1 core, 0.7 Gh
  - 0 ADC pins
  - Chosen for:
    - Low cost and ease of programming

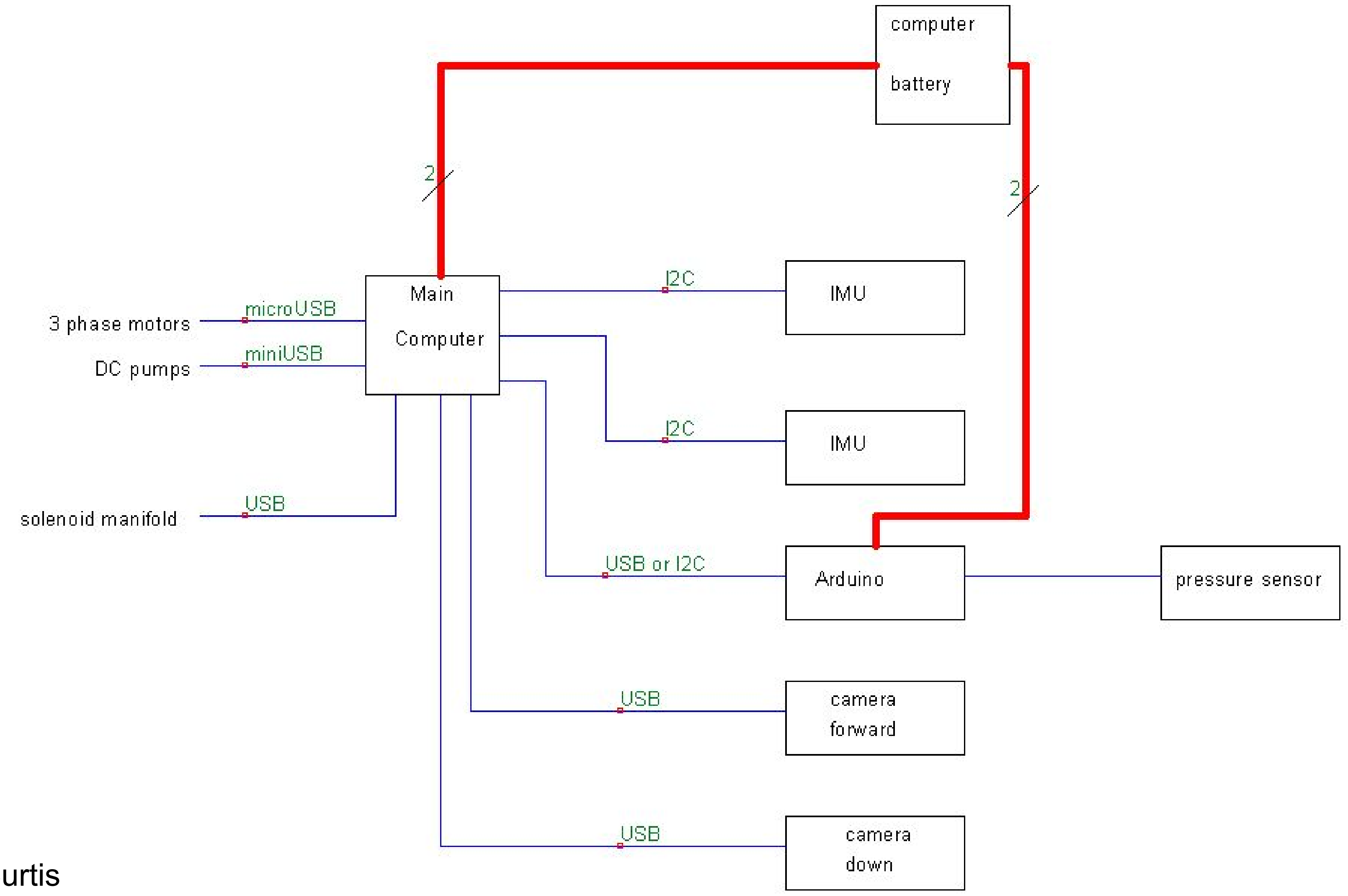
Curtis

Overall Electrical System



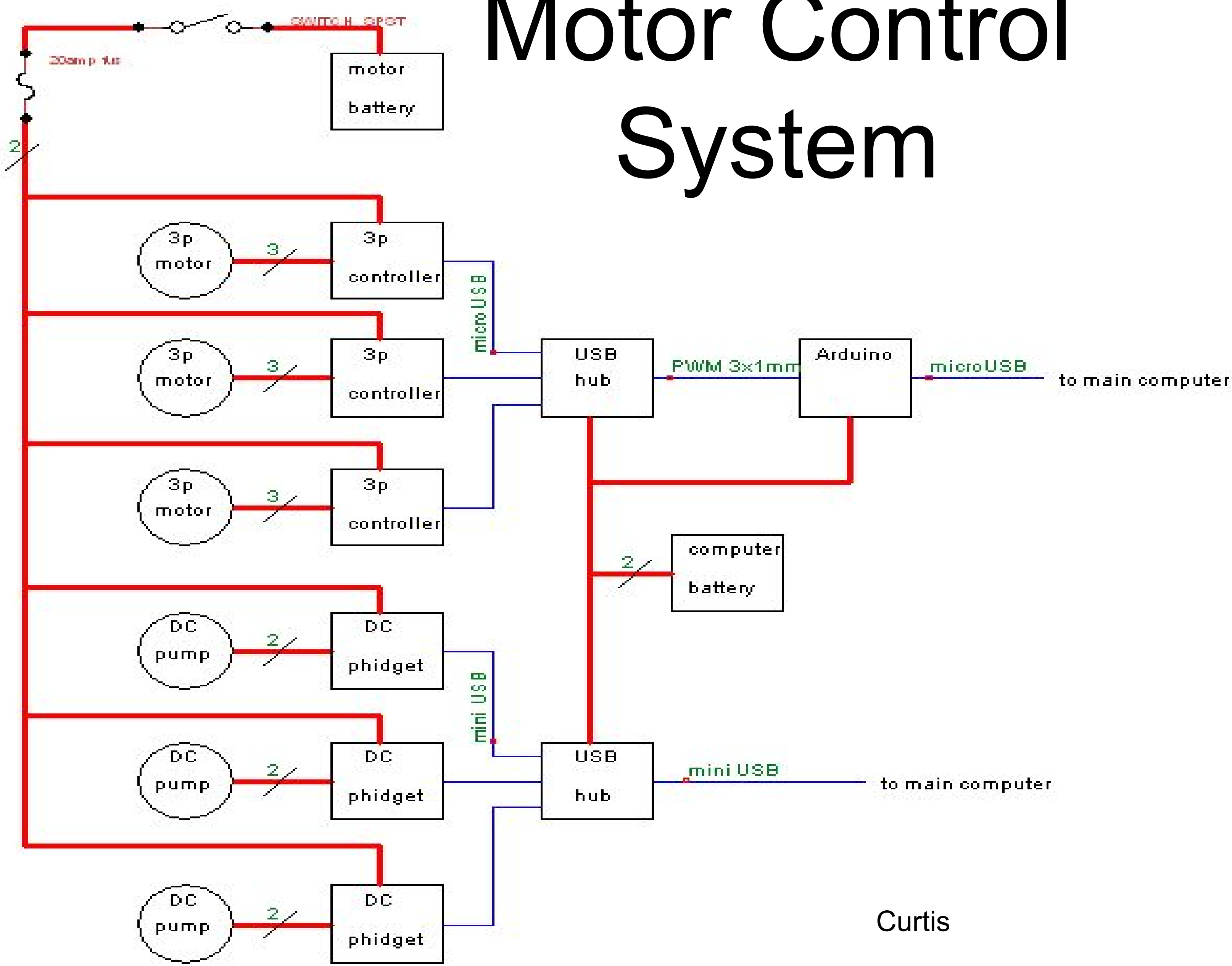
Wenkai

Main Computer

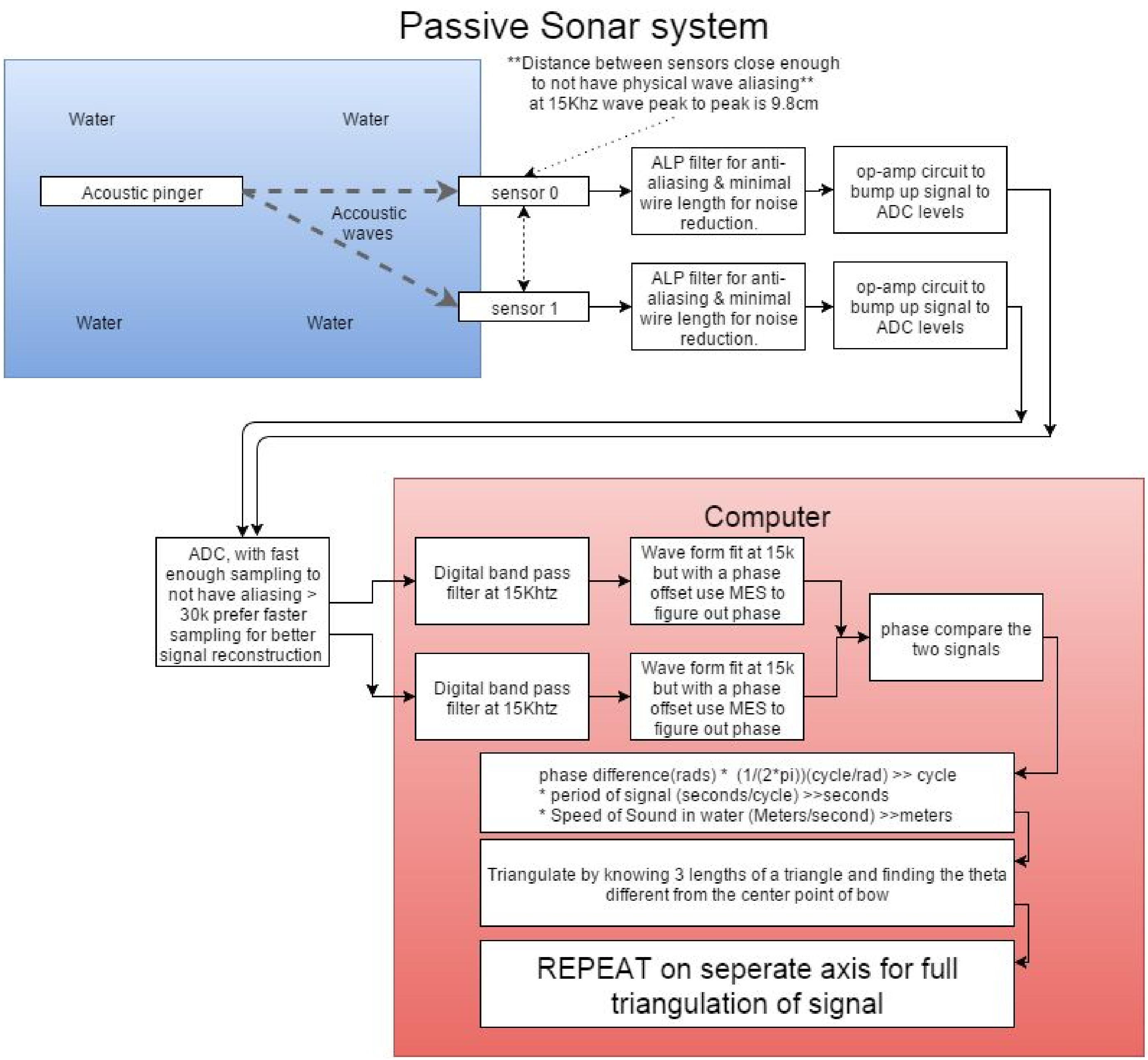


Curtis

Motor Control System

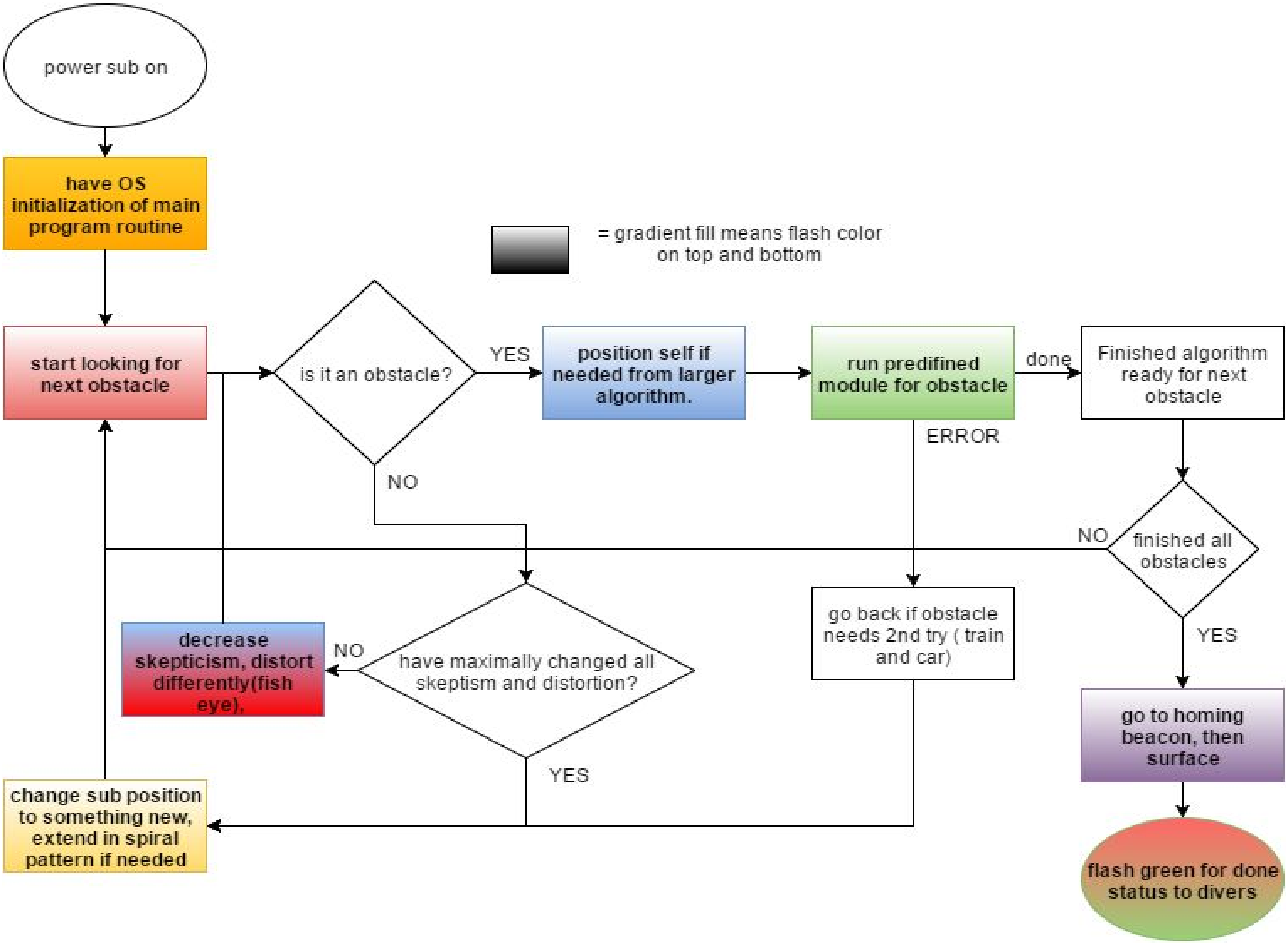


Curtis


Passive Sonar system
Distance between sensors close enough to not have physical wave aliasing at 15Khz wave peak to peak is 9.8cm
Water
Water
Acoustic pinger
Accoustic waves
sensor 0
sensor 1
Water
Water
ALP filter for anti-aliasing & minimal wire length for noise reduction.
op-amp circuit to bump up signal to ADC levels
ALP filter for anti-aliasing & minimal wire length for noise reduction.
op-amp circuit to bump up signal to ADC levels
Computer
ADC, with fast enough sampling to not have aliasing > 30k prefer faster sampling for better signal reconstruction
Digital band pass filter at 15Khtz
Wave form fit at 15k but with a phase offset use MES to figure out phase
phase compare the two signals
Digital band pass filter at 15Khtz
Wave form fit at 15k but with a phase offset use MES to figure out phase
phase difference(rads) * (1/(2*pi))(cycle/rad) >> cycle * period of signal (seconds/cycle) >>seconds * Speed of Sound in water (Meters/second) >>meters
Triangulate by knowing 3 lengths of a triangle and finding the theta different from the center point of bow
REPEAT on seperate axis for full triangulation of signal

will

Sub Main Routine



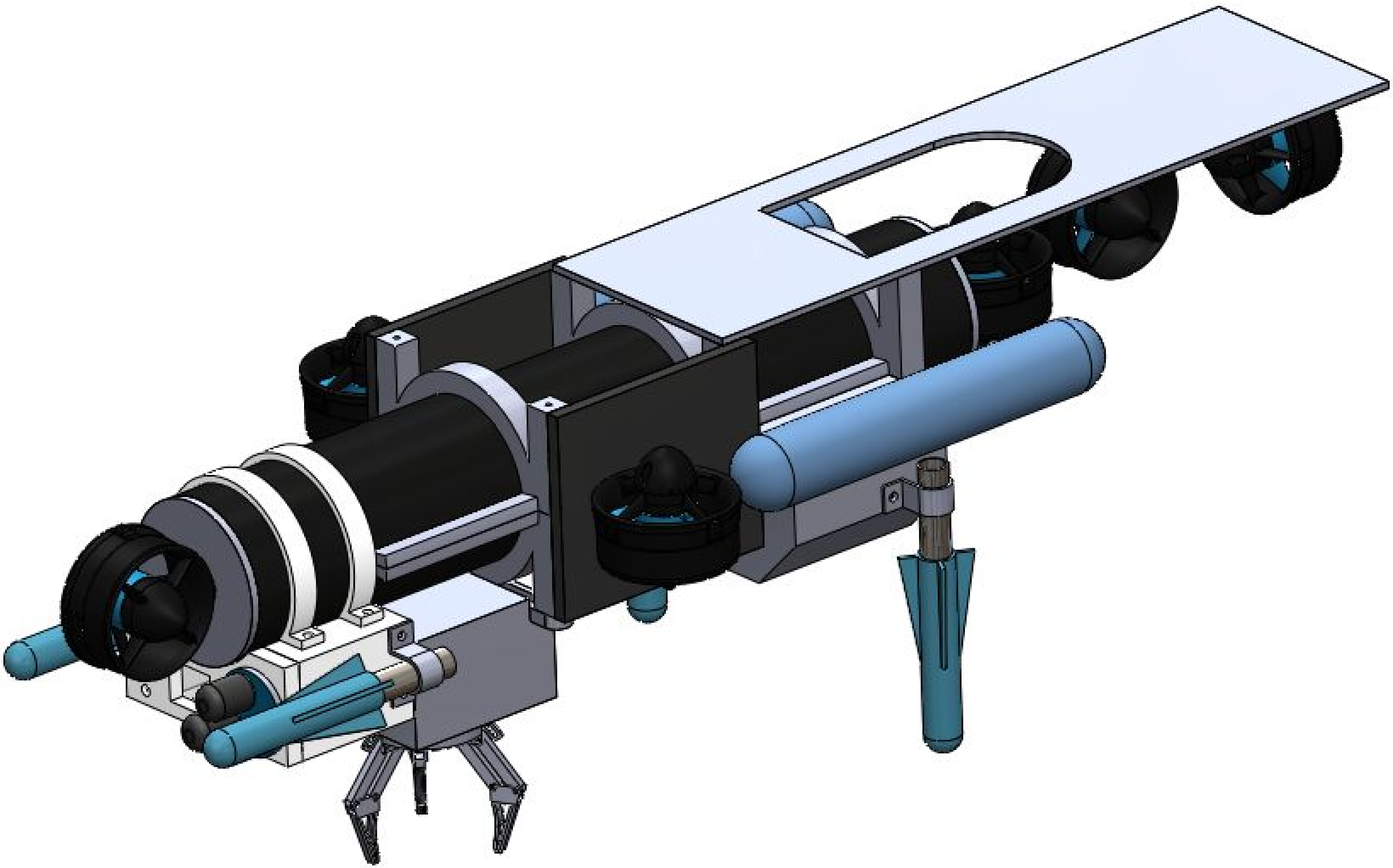
Will

Prototype

- A prototype was designed to test camera and thruster capabilities
  - This was a barebones design intended to make sure the coding systems would in fact be able to move the sub based only on camera inputs
  - shows dampened line following response
  - Video

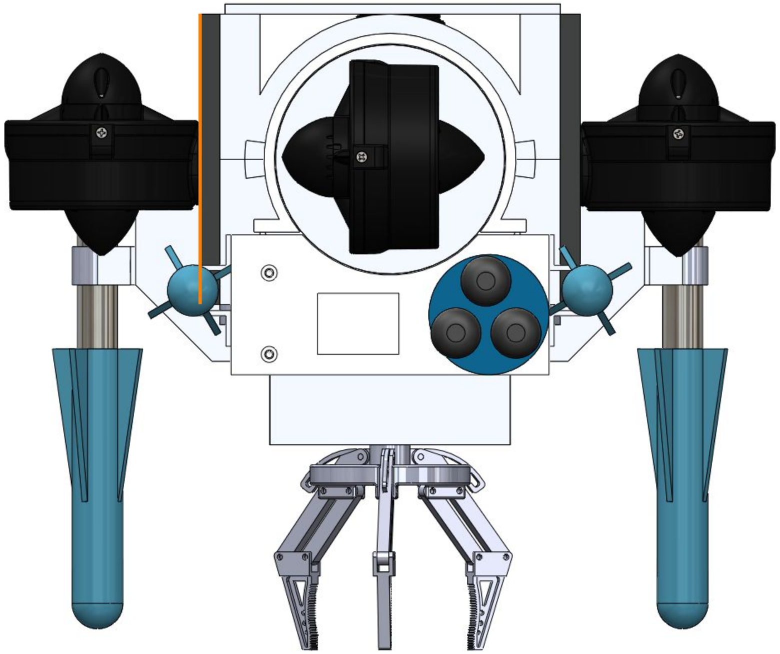
Feras

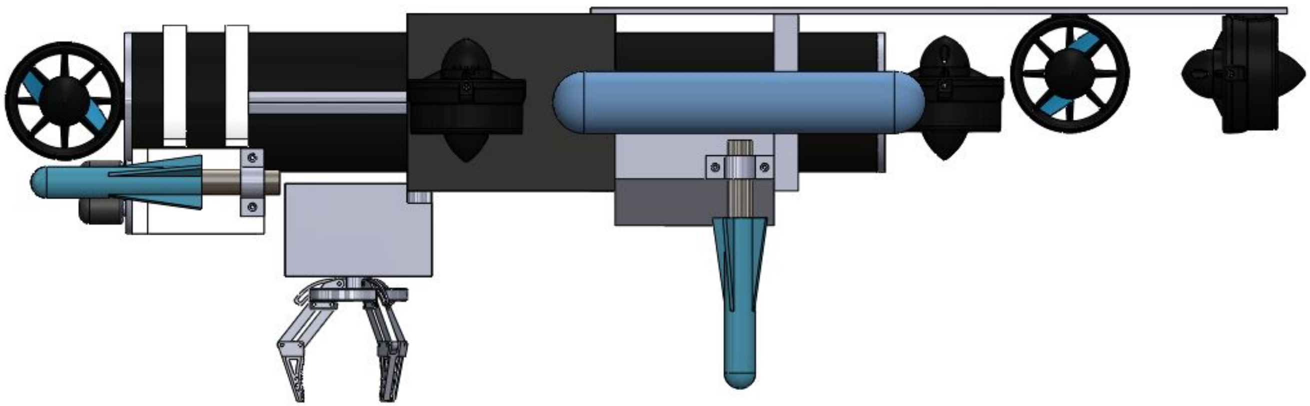
Final Design



everyone

Final Design





Total Project cost

Electrical Control	**$569.01**
Hydrophones	**$446.19**
Motors and Batteries	**$638.21**
Pneumatics	**$452.30**
Frame and other Mechanical	**$89.00**
Registration cost	**$750.00**
TOTAL PROJECT COST	**$2,944.71**

Wenkai

Cost Breakdown

- Without pneumatics
  - cost - $452
  - point loss from clamp - 1400
  - point loss from torpedoes - 1500
- Without markers
  - cost - $cheap
  - point loss - 1200
- Without audio sensors
  - cost - $446.19
  - point loss - 2000

Wenkai

Conclusions

- We have entered the AUVSI Robosub competition to build an autonomous submarine capable of completing a number of tasks
- The design process involved creating a functional diagram including all mechanical, electrical, and computational systems
- Each system on this diagram was designed
  - Python programming language
  - Blue Robotics thrusters
  - lithium polymer batteries
  - compressed air torpedoes
  - pneumatic claw clasping system
  - fish-lens 170° view 4Mp camera downward
  - 75° degree 8Mp camera forward
  - h1c acoustic sensors

Feras

Conclusions

  - Omega PX301 pressure transducer
  - Sparkfun Razor 9-dof IMU
  - ODROID computer
  - Raspberry Pi controller
- A frame was designed to facilitate mounting of all systems
- Electrical systems were designed
- Computer algorithms are being built to tackle each of the many obstacles
- A prototype was built to validate the capabilities of the camera-thruster interaction
- A final design was created including all possible systems
- A BOM was created and costs were compiled
  - projected costs are above budget without sacrificing some systems

Feras