YELLOW Submarine TRR

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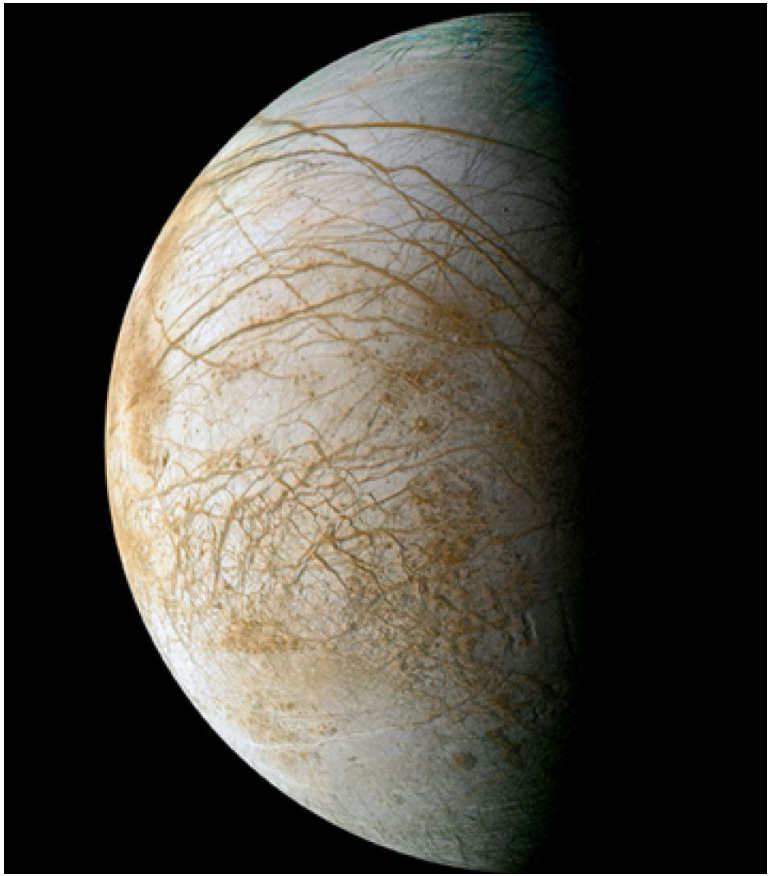
Overview

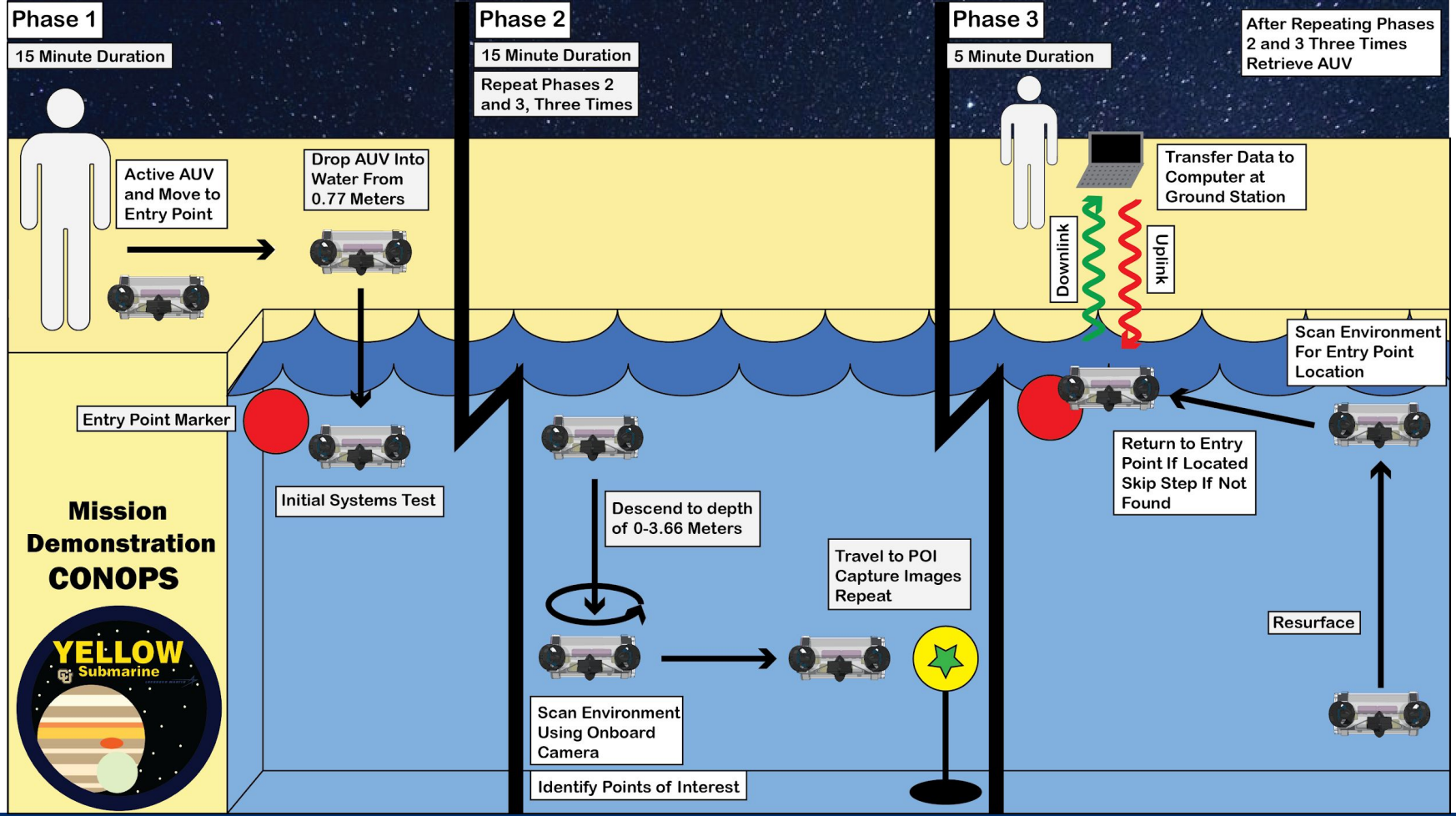
Motivation

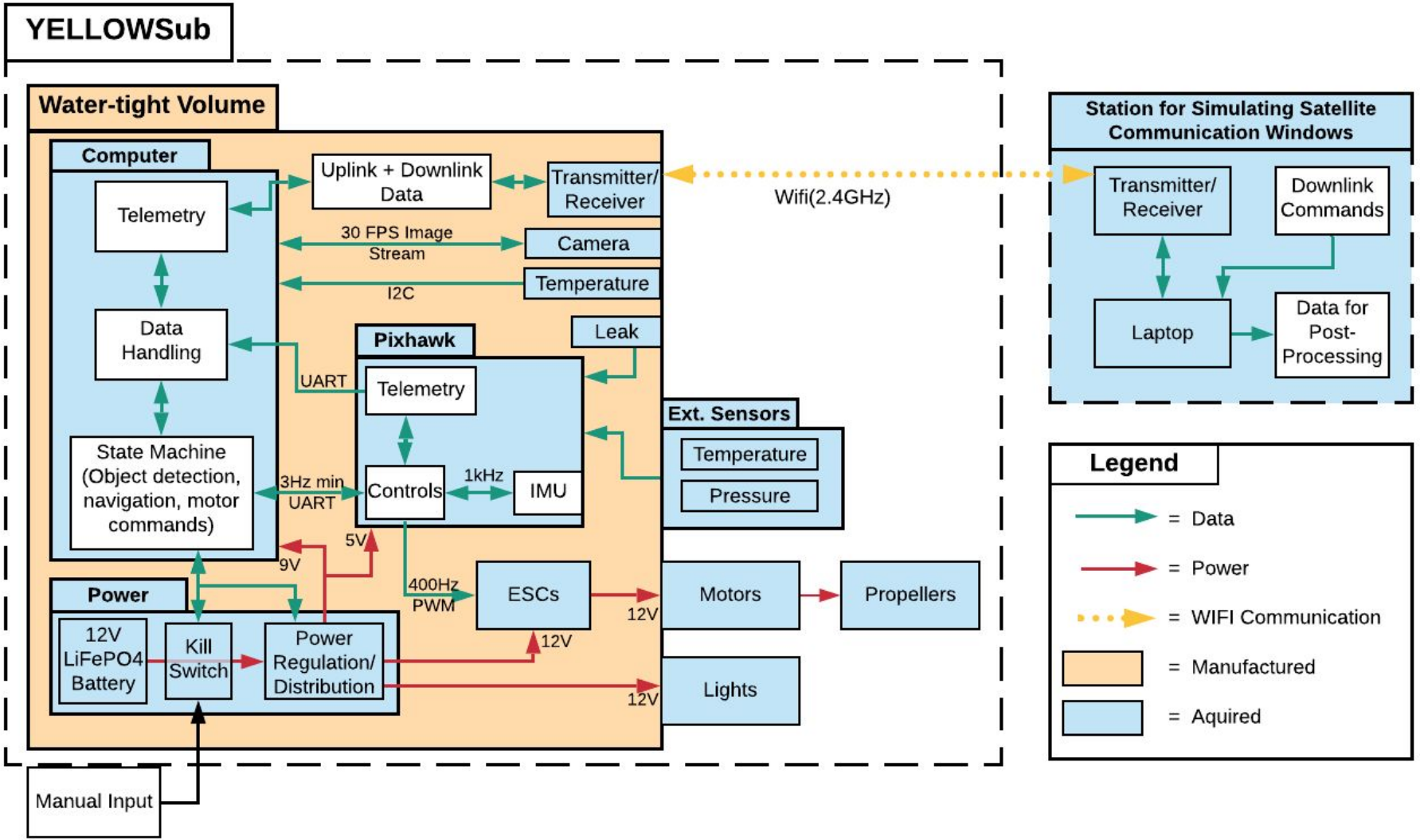
- Exploration of Europa's subsurface ocean
- Autonomous Underwater Vehicle (AUV)
  - Navigate
  - Identify points of interest (POI)
  - Downlink data to orbiter



Project Description

- Proof-of-concept
- Technology demonstrator in a pool environment
  - Autonomously explore
  - Find POIs
  - Take images of POIs
  - Resurface to communicate data
  - Repeat for an hour


Phase 1
15 Minute Duration
Active AUV and Move to Entry Point
Drop AUV Into Water From 0.77 Meters
Entry Point Marker
Initial Systems Test
Mission Demonstration CONOPS
YELLOW Submarine
Phase 2
15 Minute Duration
Repeat Phases 2 and 3, Three Times
Descend to depth of 0-3.66 Meters
Travel to POI Capture Images Repeat
Scan Environment Using Onboard Camera
Identify Points of Interest
Phase 3
5 Minute Duration
After Repeating Phases 2 and 3 Three Times Retrieve AUV
Transfer Data to Computer at Ground Station
Downlink
Uplink
Scan Environment For Entry Point Location
Return to Entry Point If Located Skip Step If Not Found
Resurface


YELLOWSub
Water-tight Volume
Computer
Telemetry
Data Handling
State Machine (Object detection, navigation, motor commands)
Uplink + Downlink Data
Transmitter/ Receiver
30 FPS Image Stream
Camera
I2C
Temperature
Leak
Pixhawk
UART
Telemetry
3Hz min UART
Controls
1kHz
IMU
Ext. Sensors
Temperature
Pressure
5V
9V
Power
12V LiFePO4 Battery
Kill Switch
Power Regulation/ Distribution
400Hz PWM
ESCs
12V
12V
Motors
Propellers
12V
Lights
Manual Input
Wifi(2.4GHz)
Station for Simulating Satellite Communication Windows
Transmitter/ Receiver
Downlink Commands
Laptop
Data for Post-Processing
Legend
= Data
= Power
= WIFI Communication
= Manufactured
= Aquired

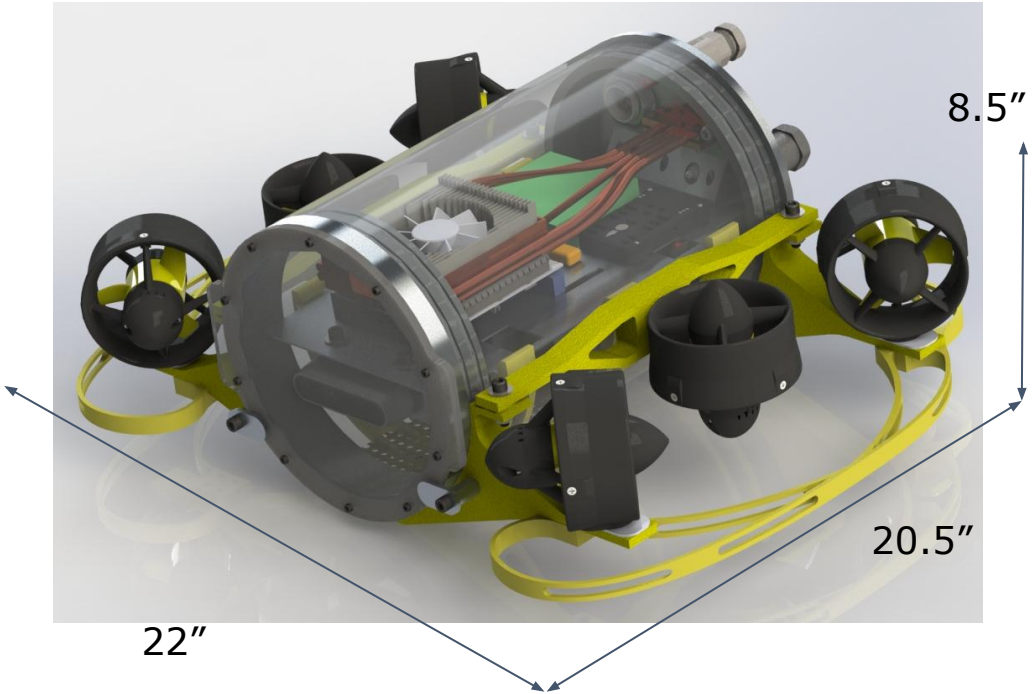
Main Metrics					
Level	1	2	3	4	5
Object Detection	-Single-class (1 color) -Stationary -Simple object (uniform dimensions)	-Multi-class (more than 1 color) -Stationary -Simple object (uniform dimensions)	-Multi-class (more than 1 color) -Stationary -Complex object (non-uniform dimensions)	-Moving objects (non-stationary) -Multi-class (more than 1 color) -Complex object (non-uniform dimensions)	-
Navigation	-Rotates in place (without explicitly commanded translation)	-Rotates in place then moves towards POI	-Rotates in place -Moves towards POI -Repeat for mulitple POIs	-Rotates in place -Moves towards POI -Repeats for multiple POIs -For each POI, orbit keeping the area of the bounding box of the POI wtihin 30-40% of the total image area	-
Collision avoidance (needs Navigation level 2)	-	-Comes to a complete stop before hitting an object (POI, wall, or junk) in view of front RGB camera -Holds position	-Navigates around "junk" object in view -Detects "junk" object in view of front RGB camera and moves to the left or right until junk is out of frame -Moves forward past obstacle	-Can navigate around multiple "junk" objects in view -Detects "junk" objects in view of front RGB camera -Moves left or right until all obstacles are out of frame or if there's sufficient space between them, then move sideways until the AUV is between the obstacles -Proceeds to move forward past obstacle	-Avoids walls even when not in view -In addition to level 4 capabilities, AUV can avoid walls that are not view of the front RGB camera
Imaging	-Capture at least 1 image of POI, where POI is at least partly in the frame	-Capture at least 1 image of POI, where POI is fully in frame	-Capture multiple images of POI, where POI is fully in frame	-Capture image of POI from multiple angles	-
Downlink	-AUV health packet reported to ground station during communication period	-Images, temperature data, and pressure data reported to ground station	-	-	-
Uplink	-Can recieve kill-switch command from ground station during communication period	-Can be commanded to return to a specific search depth	-Can be commanded to look for a specific class of object	-	-
Surfacing	-Moves straight up to surface and can remain on surface	-Rotates once to look for drop point marker -If found, returns to within 2 m of drop point before surfacing -Otherwise, resurfaces in place	-Returns to drop area using IMU data while looking for drop point marker -If marker found, returns to within 2 m of drop point before surfacing -If marker not found within 2 minutes, surface in place	-Returns to within 2 m of drop point without a marker, then surfaces	-

Mission Objectives/Levels of Success

- Detect stationary simple objects of different colors
- Rotate in place scanning environment and move toward POIs
- Avoid collision with objects within field of view
- Capture images of POIs and environmental data
- Surface and transfer data to ground station every 20 minutes 3 times

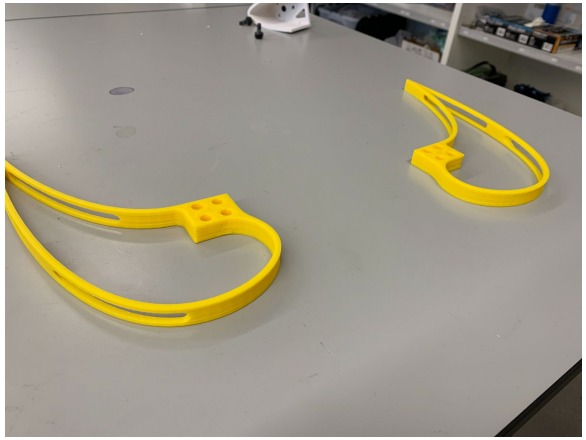
Baseline Design

- Weight: 12.6kg (27.8lbs)
- Buoyant Force: 124.6N (28.0lbs)
- 6 Thrusters (5 DOF)
- Yaw rate: 0.1028-0.7rad/s
- Max Cruise velocity: 0.48 m/s
- Intel RealSense D435 Camera
  - FOV: 50 degrees
  - Visual range: 0.61-4.27m (2-14ft)
- NVIDIA Jetson Xavier
- 12.8V 12Ah Lithium Ion Battery



Changes from MSR

- Heat pipes have been added to the thermal model
  - Transfers heat quicker during the beginning stages of the mission, but steady state will remain at its optimized 306K
- Strengthened original bumper design
- Considering a different material for the gasket between the acrylic and aluminum



Critical Project Elements

- Structural Integrity
  - 1.5.1: Water Pressure, 5.3.1: Drop Survival, 1.6.1: Thermal Testing
- Power
  - 1.1.1: Onboard Batteries, 1.4.1: Electrically Driven
- C&DH
  - 3.2.1: Image and Data Packets, 3.3.1: Onboard Data Storage, 4.1.1: Complete Data Transmittal
- Autonomous Navigation
  - 1.5.2: Depth Control, 2.1.1: Underwater Movement
- Image Processing
  - 2.1.1.4: Collision Avoidance, 5.2.1: POI Data

Critical Issues

- Leak Test 1 & 2 found water intrusion in front gasket
- 6 motor test turned up some unexpected autopilot responses: only half of our motors were utilized for control channel actuation
- Drill bit broke in one of the holes of our front end-cap
- Electronics (PCB, battery) can’t be tested/verified without electronics load
- Image processing being confused by ripples and reflections on surface of water

Schedule

Mechanical Schedule

	TASK NAME	START DATE	END DATE	DURATION (WORK DAYS)	TEAM MEMBER	PERCENT COMPLETE
Spring	Purchase Materials	-	-	-	Jake	90
	Laser cut acrylic front panel and gasket	1/24/2020	2/1/2020	6	Danny	100
	Machine Al end-cap	2/1/2020	2/14/2020	10	Danny	80
	Machine front ring seal	2/1/2020	2/14/2020	10	Danny	95
	3D Print elec tray mounts	2/14/2020	2/18/2020	3	Danny	90
	Leak test	**2/14/2020**	**3/18/2020**	**24**	**Sam**	**20**
	Machine AL bottom clamps	2/14/2020	3/3/2020	13	Danny	100
	Machine AL Vertical Motor Mounts	2/14/2020	3/3/2020	13	Danny	100
	Pressure test	**2/21/2020**	**3/6/2020**	**5**	**Sam**	**100**
	Test motors underwater	**2/21/2020**	**3/6/2020**	**11**	**Caleb**	**10**
	3D Print bumpers	2/21/2020	3/20/2020	21	Danny	45
	3D Print water baffle	2/22/2020	3/5/2020	9	Danny	100
	Role and Bend AL top clamps	3/1/2020	3/4/2020	3	Danny	0
	Water jet AL motor shims and clips	3/4/2020	3/11/2020	6	Danny	0
	Water jet AL electronics tray	3/4/2020	3/11/2020	6	Danny	0
	Mount motors and structure to tube	3/5/2020	3/8/2020	2	Danny	0
	Thermal test	**3/5/2020**	**4/2/2020**	**4**	**Sam**	**0**
	Drop test	**3/6/2020**	**3/8/2020**	**3**	**Caleb**	**0**
	Machine elec tray-endcap interface	3/9/2020	3/13/2020	5	Danny	0
	Manufacture thermal strap	3/13/2020	3/20/2020	6	Sam	0
	Buoyancy test	**3/18/2020**	**4/2/2020**	**7**	**Sam**	**0**
	Dynamics test	**3/30/2020**	**4/2/2020**	**4**	**Caleb**	**0**

Electrical Schedule

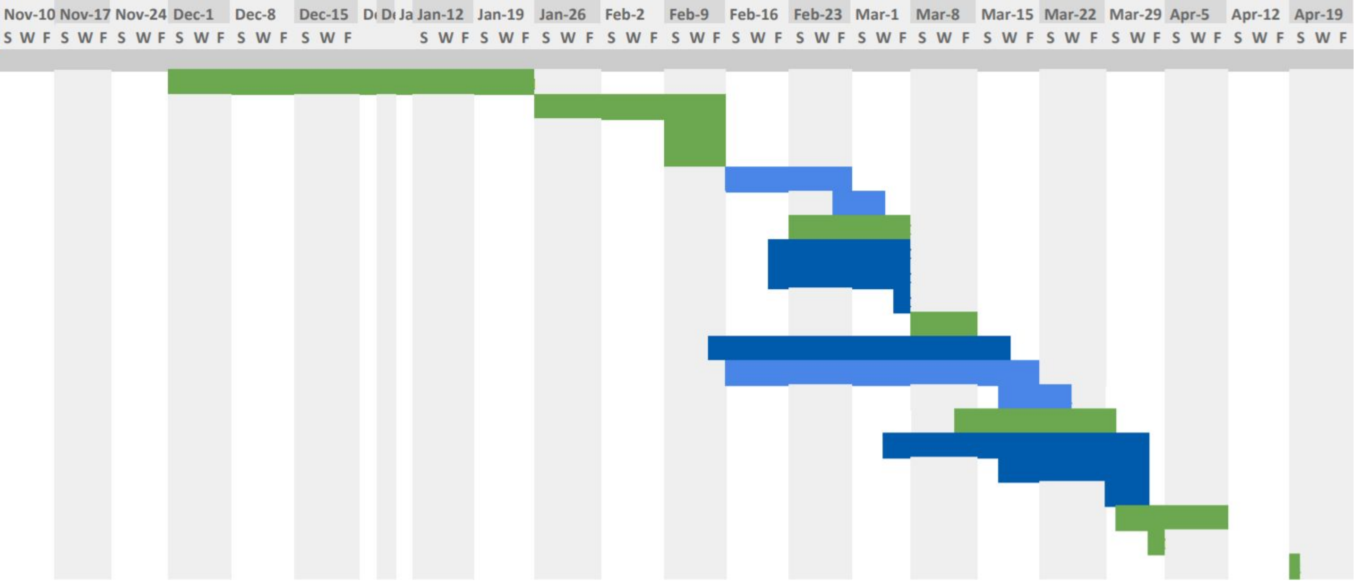
	TASK NAME	START DATE	END DATE	DURATION (WORK DAYS)	TEAM MEMBER	PERCENT COMPLETE
Spring	**Electronics tray assembly**	**2/17/2020**	**3/20/2020**	**25**	**Hardware**	**10**
	Battery testing	2/10/2020	3/6/2020	20	Matt	15
	ESC + Motor testing	**2/17/2020**	**2/28/2020**	**10**	**Christian**	**90**
	PCB v1 order + assembly	2/17/2020	2/26/2020	8	Matt	100
	Power system v1 testing w/ stable power supply	2/26/2020	2/28/2020	3	Christian	20
	Power system v1 testing w/ battery	**2/28/2020**	**3/4/2020**	**4**	**Christian**	**0**
	Calibrate and test temperature sensor	2/26/2020	3/4/2020	6	Griff	0
	Calibrate and test pressure sensor	2/26/2020	3/4/2020	6	Griff	0
	PCB v2 design buffer	3/4/2020	3/6/2020	3	Christian	0
	PCB v2 order + assembly buffer	3/6/2020	3/11/2020	4	Griff	0
	PCB v2 + converters testing buffer	3/11/2020	3/13/2020	3	Christian	0
	PCB v2 + converters + battery testing buffer	3/11/2020	3/13/2020	3	Griff	0
	Out of water communications testing	2/17/2020	2/28/2020	10	Matt	100
	Surfaced AUV communications test	**3/18/2020**	**3/25/2020**	**6**	**Matt**	**0**

Software Schedule

	TASK NAME	START DATE	END DATE	DURATION (WORK DAYS)	TEAM MEMBER	PERCENT COMPLETE
Spring	**Full Image Processing Stack Test**	**12/2/2019**	**1/24/2020**	**40**	**Software**	**100**
	Gazebo Controls Test	1/20/2020	2/13/2020	19	Software	100
	Integrate D435 w/ Jetson TX2	1/24/2020	2/1/2020	6	Software	100
	Benchmark TX2	1/26/2020	2/1/2020	5	Micah	100
	Complete State Machine	**1/26/2020**	**2/14/2020**	**15**	**Alex**	**100**
	Integrate Python with ArduSub	1/26/2020	2/1/2020	5	Forrest	100
	Import AUV model into Gazebo	1/29/2020	2/8/2020	8	Forrest/Ale	100
	Integrate camera into Gazebo	2/8/2020	2/22/2020	10	Alex	80
	Resolve Depth data issues	**2/9/2020**	**2/15/2020**	**5**	**Software**	**100**
	Test YOLACT live in water	**2/9/2020**	**2/15/2020**	**5**	**Software**	**100**
	Create ground station software	2/16/2020	3/4/2020	13	Benjamin	85
	Optimize YOLACT	2/16/2020	3/13/2020	20	Micah	20
	Single Motor Integration Test	2/17/2020	2/21/2020	5	Forrest	100
	WIFI Transfer Test	2/17/2020	2/24/2020	6	Benjamin	100
	Integrate YOLACT with State Machine	2/16/2020	3/6/2020	15	Software	50
	Test Full Stack in Gazebo	**2/23/2020**	**3/6/2020**	**10**	**Software**	**20**
	6 Motor Integration Test	2/24/2020	3/6/2020	10	Forrest	50
	Integrate other sensors	3/7/2020	3/15/2020	5	Software	0
	Controls Test	**3/7/2020**	**3/13/2020**	**5**	**Software**	**0**
	Collision avoidance test in water	3/13/2020	3/20/2020	6	Software	0
	Fully autonomous operation	**3/13/2020**	**3/30/2020**	**12**	**Software**	**0**
	Extra control operations	3/30/2020	4/14/2020	12	Software	0
	Full Systems Test	**3/31/2020**	**4/10/2020**	**9**	**Software**	**0**

Schedule - Gantt Chart

TASK NAME	START DATE	END DATE	TEAM
Full Image Processing Stack Test	12/2/2019	1/24/2020	Software
Complete State Machine	1/26/2020	2/14/2020	Software
Resolve Depth data issues	2/9/2020	2/15/2020	Software
Test YOLACT live in water	2/9/2020	2/15/2020	Software
ESC + Motor testing	2/17/2020	2/28/2020	Hardware
Power system v1 testing w/ battery	2/28/2020	3/4/2020	Hardware
Test Full Stack in Gazebo	2/23/2020	3/6/2020	Software
Pressure test	2/21/2020	3/6/2020	Mechanical
Test motors underwater	2/21/2020	3/6/2020	Mechanical
Drop test	3/6/2020	3/8/2020	Mechanical
Controls test	3/7/2020	3/13/2020	Software
Leak test	2/14/2020	3/18/2020	Mechanical
Electronics tray assembly	2/17/2020	3/20/2020	Hardware
Surfaced AUV communications test	3/18/2020	3/25/2020	Hardware
Fully autonomous operation	3/13/2020	3/30/2020	Software
Thermal test	3/5/2020	4/2/2020	Mechanical
Buoyancy test	3/18/2020	4/2/2020	Mechanical
Dynamics test	3/30/2020	4/2/2020	Mechanical
Full Systems Test	3/31/2020	4/10/2020	Software
Sea Trials	4/3/2020	4/5/2020	All
FInal Demonstration	4/19/2020	4/20/2020	All



Key:

Mechanical

Software

Hardware

Test Readiness

Mechanical Testing

Completed/In progress:

- Leak test
- Pressure test

To be completed:

- Drop test
- Buoyancy test
- Thermal test
- Dynamics test

Leak Test

- Scheduled: 2/14 - 3/18 (Multiple leak tests will take place)
- Completion Status: In progress (Leak tests 1 & 2 completed)
- Test Readiness
  - Rationale: Testing whether end caps provide waterproof seal
  - Location: Rec center pool
- Risk Reduction
  - Water Intrusion, Corrosion Damage
- Requirement Verification
  - Requirement 1.5.3: Vehicle shall be waterproof

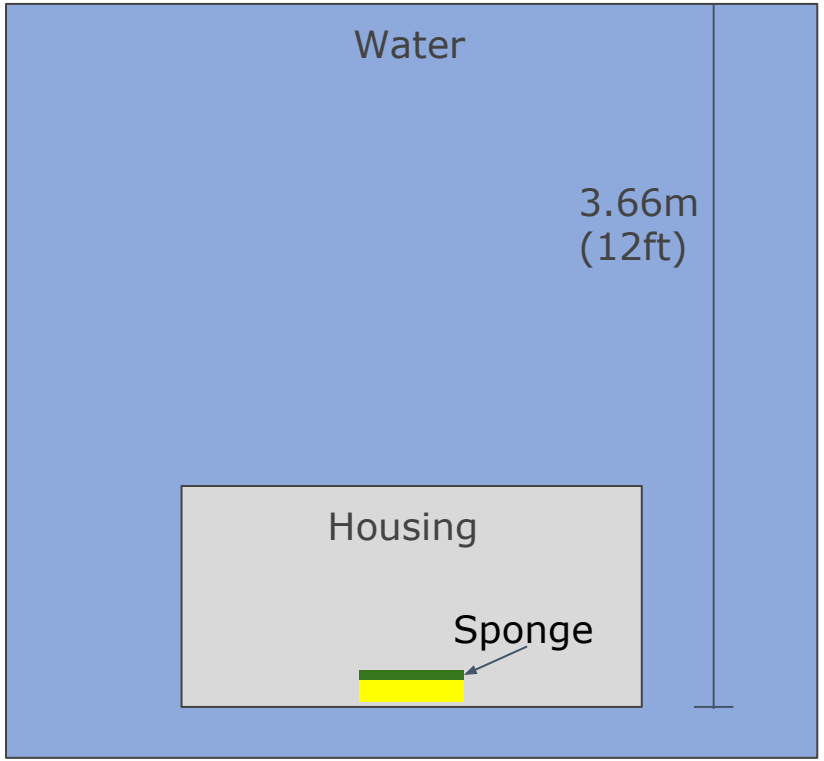
Pressure Test

- Scheduled: 2/21 - 3/6
- Completion Status: Completed on 3/1
- Test Readiness
  - Rationale: Testing whether housing can withstand pressure at maximum operating depth
  - Location: Rec center pool
- Risk Reduction
  - Buckling
- Requirement Verification
  - Requirement 1.5.1: Vehicle shall withstand water pressure at its mission depth

Leak/Pressure Test - Procedure

- Weigh sponge pre-test
- Submerge housing for at least 15 minutes (ideally 1 hour)
- Weigh sponge post-test

- Success: Sponge's change in weight is less than 0.1kg and housing doesn't buckle



Leak Test 1 - Results

- First leak test consisted of main housing (tube and endcaps) floating in a sink
- This determined if there were any high level leaks while floating

- Completed: 2/29
- Result: Minimal leakage found along the gasket
- Time Elapsed: 1 hour
- Solution: Try a softer rubber gasket, add silicone grease

Leak Test 2 - Results

- Second leak test consisting of main housing (tube and endcaps) located at 3.66m depth in the rec center pool
- This determined if there are any high level leaks at operational depth

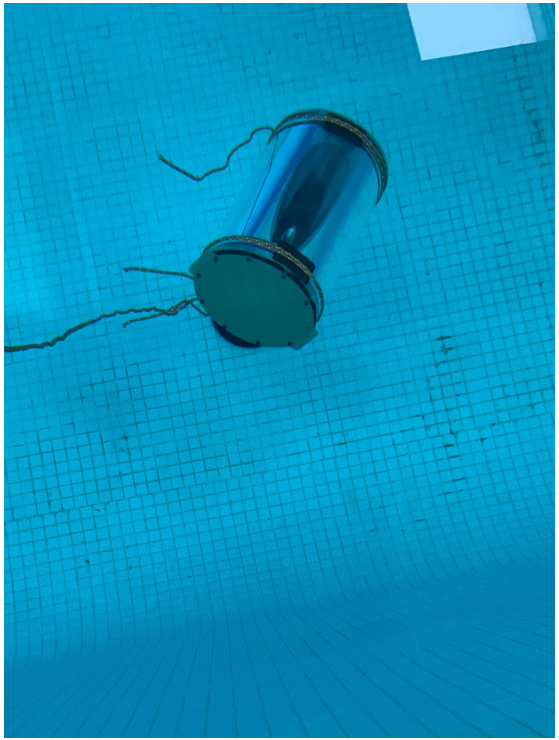
- Completed: 3/1
- Result: Small leakage found along the gasket and acrylic bowed between bolts
- Time Elapsed: 15 minutes
- Solution: Increase number of bolts along acrylic plate, try a harder rubber gasket, and add silicone grease

Pressure Test - Results

- AUV housing submerged at 3.66m in rec center pool
- This will determine if the housing will buckle at deepest operational depth

- Result: Housing did not buckle and there were no signs of structural damage
- Time Elapsed: 15 minutes

Test successful



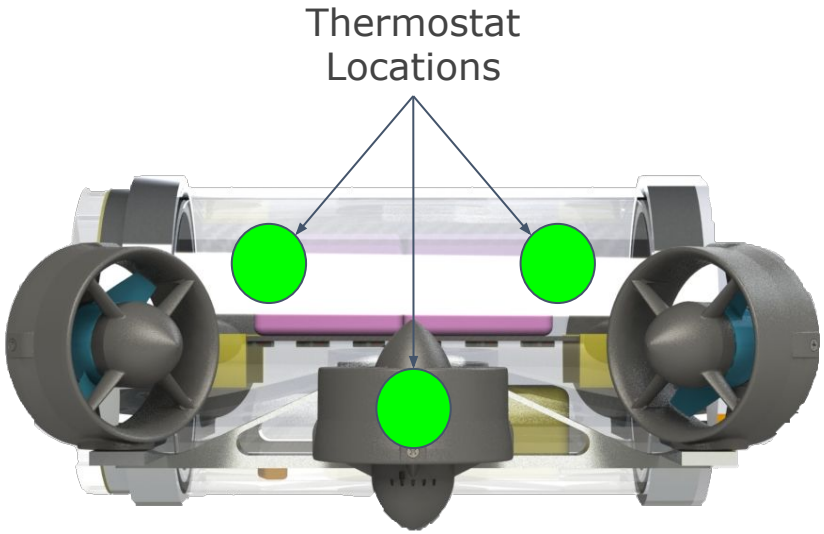
Thermal Test

- Scheduled: 3/5 - 4/2
- Completion Status: To be completed
- Test Readiness
  - Rationale: Determine whether steady state temperature is low enough such that all electronics stay operational
  - Location: Rec center pool
- Risk Reduction
  - Compartment Temperature
- Requirement Verification
  - Requirement 1.6.1: The vehicle shall be thermally tested in an aquatic environment

Thermal Test - Procedure

- Run AUV under steady operation for 10 minutes
- Record internal temperature of all thermostats
- Repeat two additional times with longer durations

- Success: Internal temperature values stay under 333K(60°C)

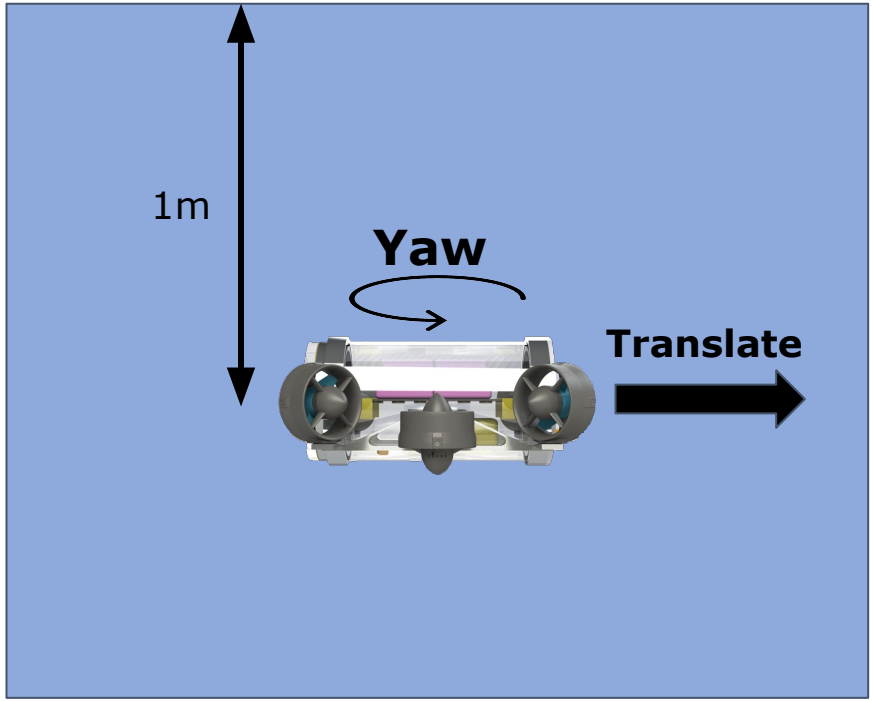


Dynamics Test

- Scheduled: 3/30 - 4/2
- Completion Status: To be completed
- Test Readiness
  - Rationale: Testing whether AUV is statically and dynamically stable
  - Location: Rec center pool
- Risk Reduction
  - Natural instability of AUV
  - Instability of controls system
- Requirement Validation
  - Requirement 2.1.1: The vehicle shall autonomously navigate underwater

Dynamics Test - Procedure

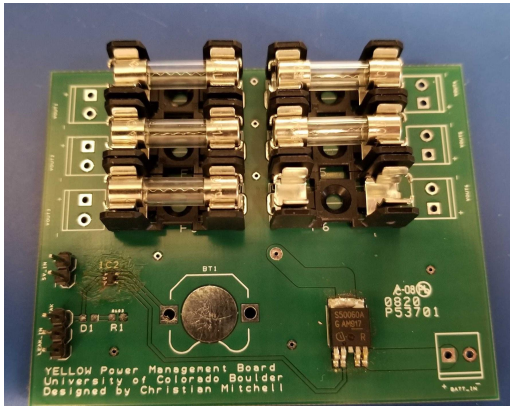
- Start filming with GoPro
- Make AUV descend to 1m depth and hold
- Disturb AUV to test static stability
- Make AUV yaw in place for 1 minute
- Make AUV translate forward for 15 seconds



Electronics Testing

Completed/In progress:

- Motor + ESC initial test
- Regulators under no load
- Basic communications



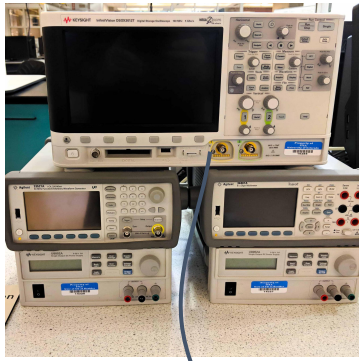
PCB v1

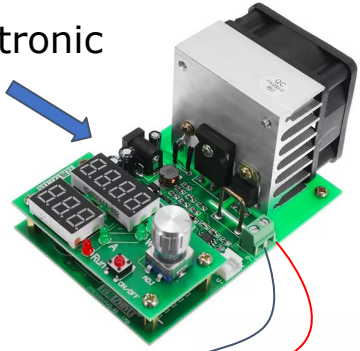
To be completed:

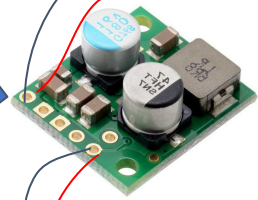
- Battery under load
- Regulators under load
- PCB test
- Leak sensor test
- Full power system

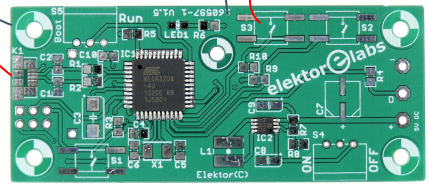
Power System Test

- Test Readiness
  - Rationale: Ensure power system can power electronics for entire mission duration
- Risk Reduction
  - Power budget (008-a)
  - Power regulation (009-a)
- Requirements Validation
  - 1.1.1: The vehicle shall store all electrical energy required to complete the mission in onboard batteries

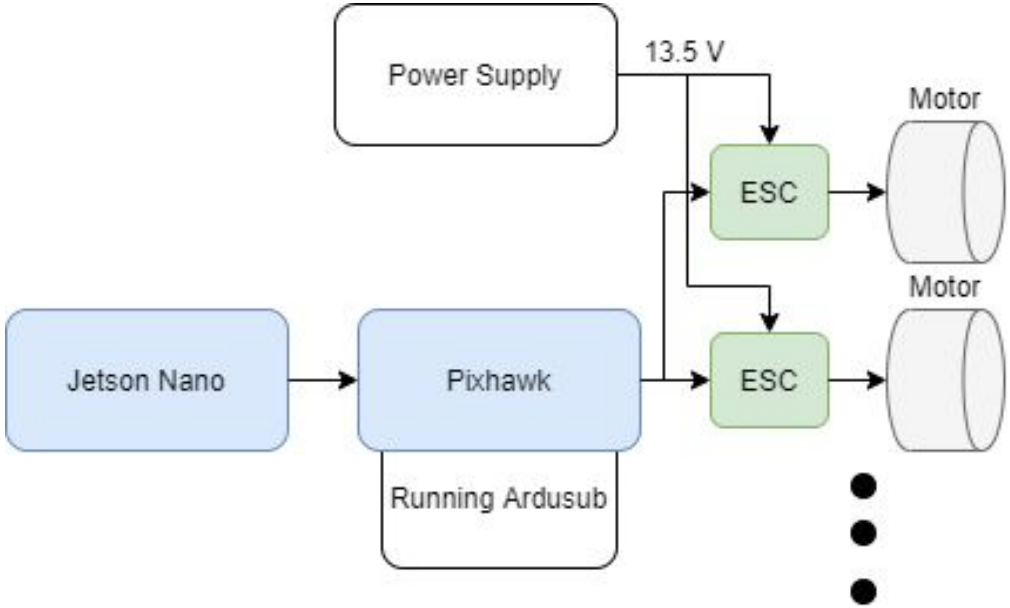








6 Motor and Ardusub Test Results



- Test 1: Manual Controls Test
  - Result: Half of motors fired when sent command
- Test 2: Ardusub/IMU Stabilization Control
  - Result: Success, All motors operated as expected

Software Testing

Completed/In progress:

- Gazebo controls test
- Live in-water YOLACT/Xavier test
- Ground Station WiFi transfer test
- 6-motor integration test

To be completed:

- 6-motor integration test
- Full-stack Gazebo integration test
- Controls test
- Collision avoidance test
- Full systems test

Live in-water YOLACT and Xavier Integration Test

- Scheduled: 2/15
- Completion Status: Complete
- Test Readiness
  - Rationale: Prove and evaluate YOLACT in live testing environment
  - Location: Rec center pool
- Risk Reduction
  - Lack of capability to conduct mission, unproven test set-up, poor integration
- Requirement Verification
  - Requirement 5.2: The vehicle shall mark points of interest

Live in-water YOLACT and Xavier Integration Test - Procedure and Results

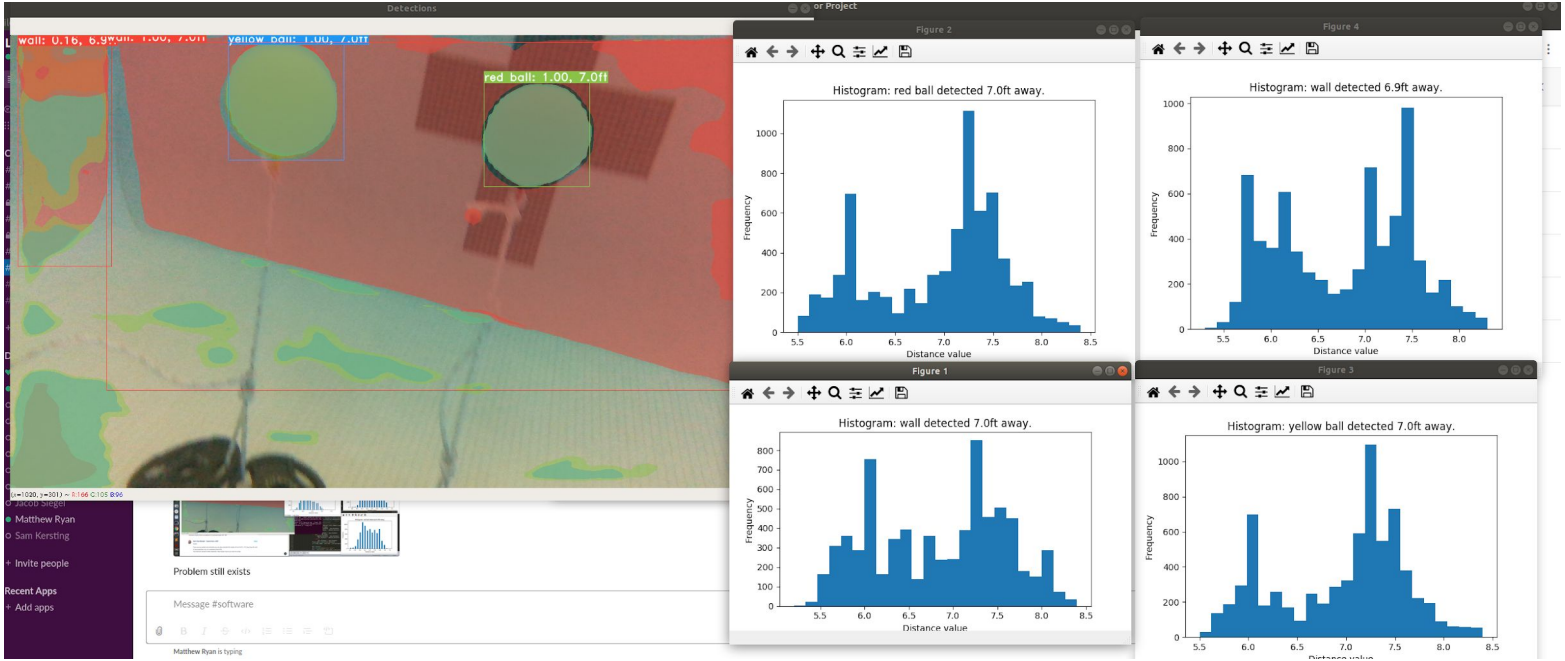
- Connect Xavier to depth camera and external monitor
- Place POI 5 ft away from depth camera
- Place depth camera in acrylic box and submerge it underwater
- Power on Xavier and run live image processing script
- Confirm measured distance with actual distance

Success: Verified that distances estimates are accurate within 0.5ft tolerance

Distance Estimate Troubleshooting

Starting Point

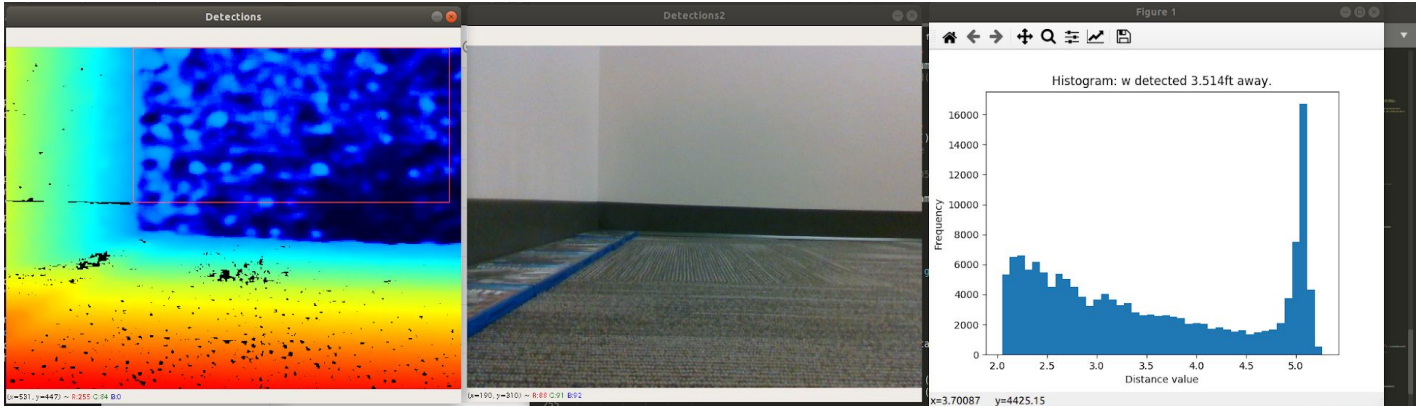
- Distance estimates are off
- Lots of noise in each mask



Distance Estimate Troubleshooting

Experimentation

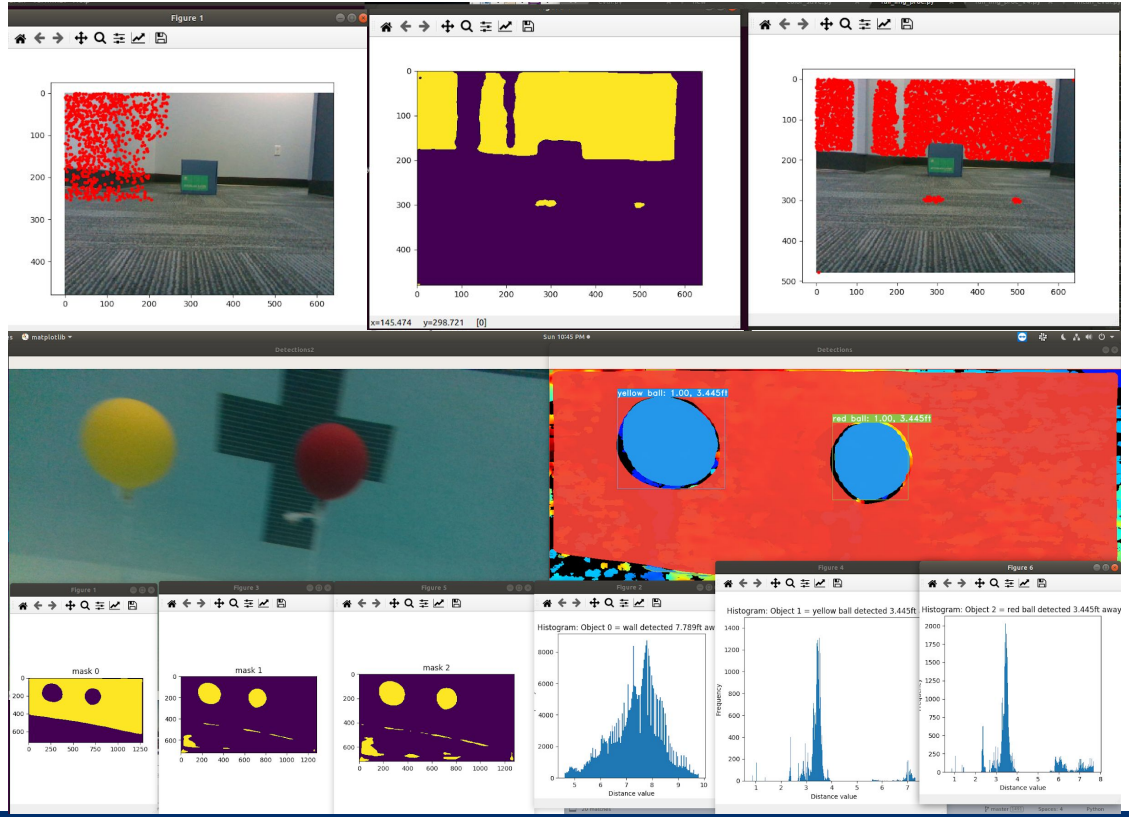
- Discovered that mode is better than mean
- Problem remains



Distance Estimate Troubleshooting

Additional Experimentation

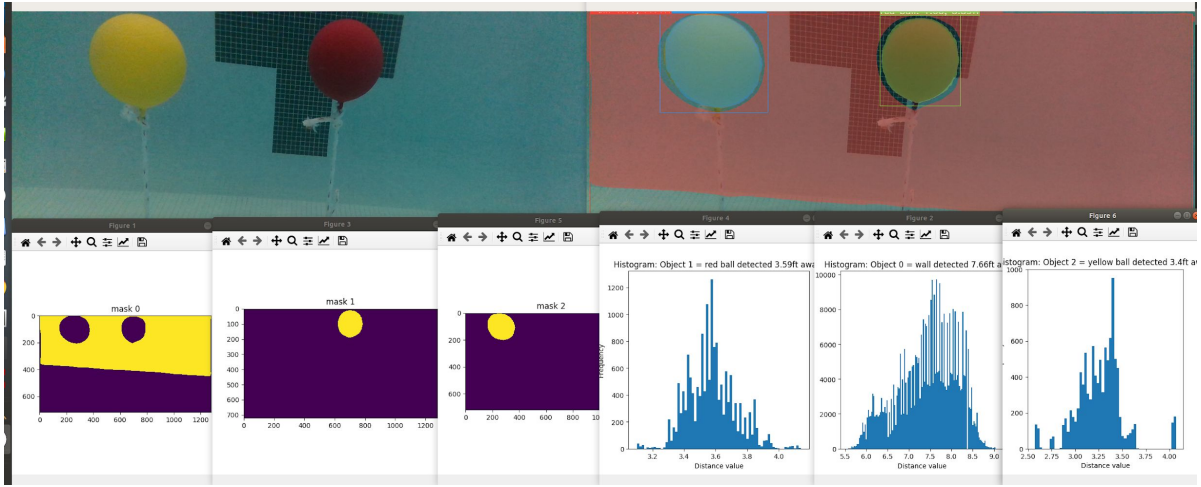
- Discovered that each mask samples same points on top-left corner
- Fixing mask sampling and alignment results in accurate distance estimates
- However, POIs have identical masks

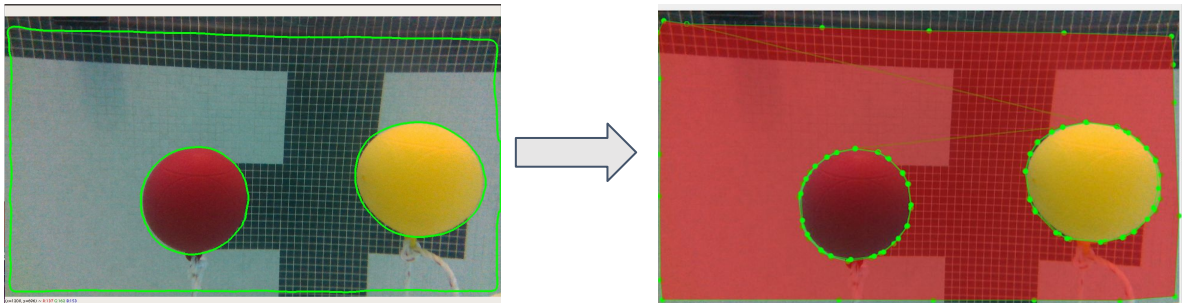


Distance Estimate Troubleshooting

Success!

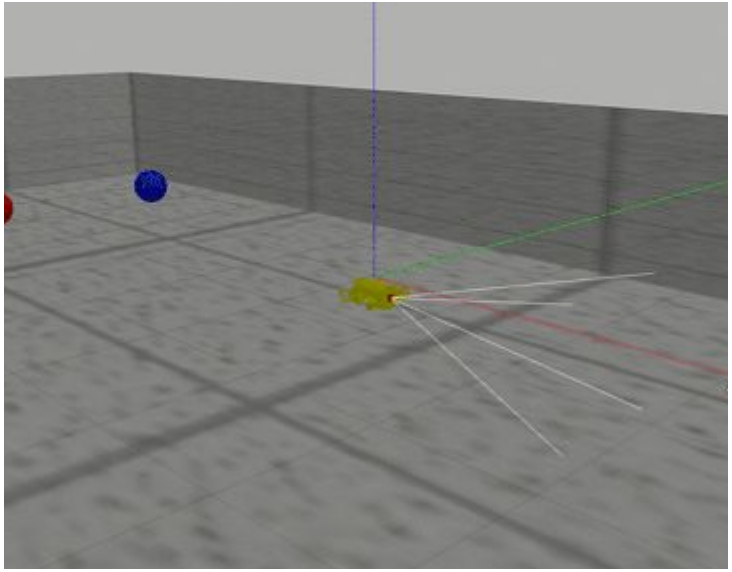
- Cropping allows each POI to have a unique mask
- Distance estimates are finally accurate
- Enabled creation of custom auto-labeler that can label 500 images in 4 minutes





Controls Test

- Scheduled: 3/7 - 3/15
- Completion: In Progress
- Test Readiness
  - Rationale: Compare real controls behavior to simulation
  - Location: Rec center pool
- Risk Reduction
  - Motor Failure, Controls Failure, Unexpected Behavior
- Requirement Verification
  - Requirement 2.1.1: Vehicle shall autonomously navigate underwater



Controls Test - Procedure

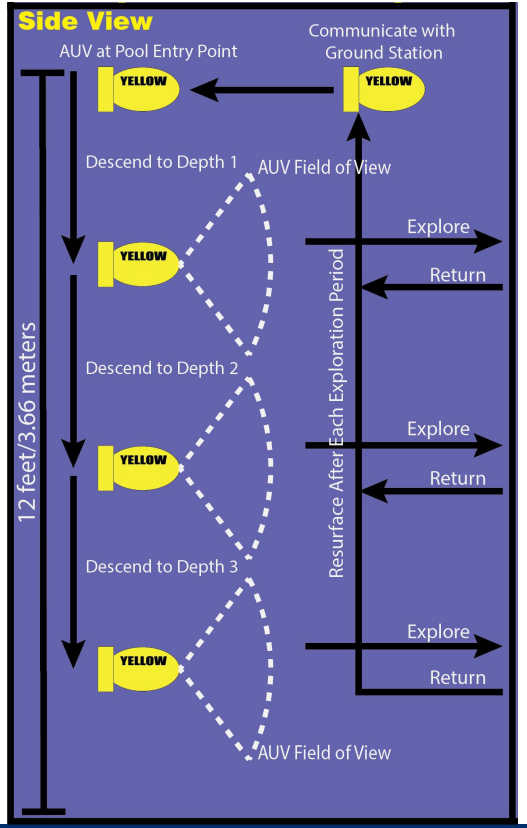
- Activate AUV
- Place in water
- Test all 5 degrees of freedom and stability control using preset script
- Observe AUV behavior
- Deactivate AUV and remove from pool

Full Systems Test

- "Sea Trials" will be conducted April 3-5
  - Entire system integrated, POIs laid out in obstacle course
  - Will be used to debug the system and verify requirements
  - Only our team present
- Demonstration planned for April 18-19
  - AUV run through its paces for Lockheed Martin advisors, faculty members
  - Purpose is to validate requirements
  - In process of reserving the Dive Well at the Rec Center

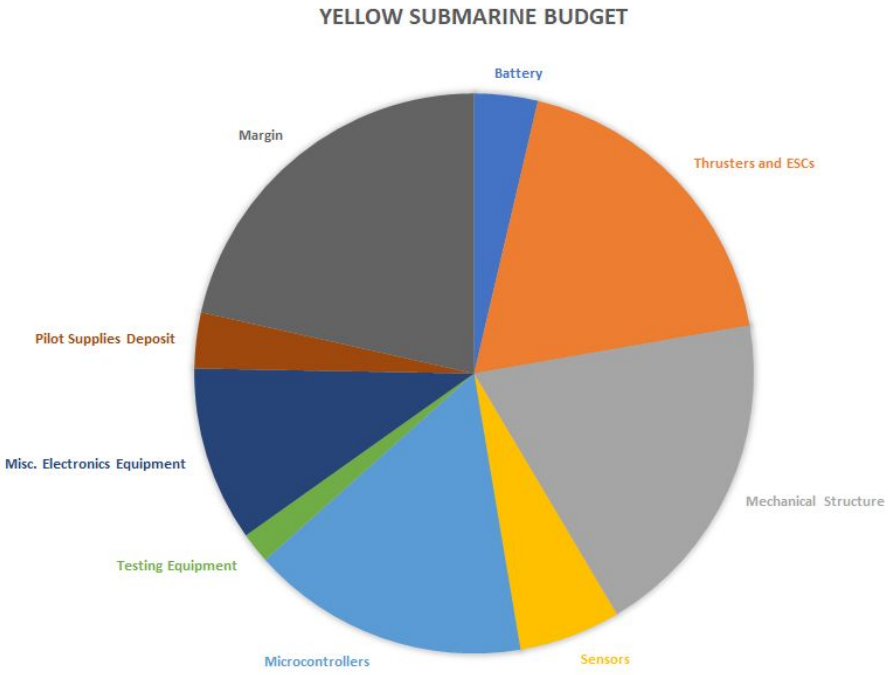
Full Systems Test - Procedure

- Lay out course
- Activate AUV
- Gently set it in pool - Lockheed suggestion after testing drop separately
- Monitor during operations
- Receive data during surface intervals
- Retrieve upon surfacing



Budget

Project Element	Cost	Percentage of Budget
Battery	$227.68	3.67%
Thrusters and ESCs	$1,152.36	18.58%
Mechanical Structure	$1,192.25	19.22%
Sensors	$364.10	5.87%
Microcontrollers	$996.60	16.07%
Testing Equipment	$110.00	1.77%
Misc. Electronics Equipment	$626.53	10.10%
Pilot Supplies Deposit	$200.00	3.22%
Total	$4,869.52	78.51%
Margin	$1,332.84	21.49%
Budget	$6,202.36	100.00%



ENGINEERING EXCELLENCE FUND

Thank You

Backup

- Mechanical
- Electrical
- Software

Mechanical

Leak Mitigations

- Use a different kind of rubber for the gaskets
- Use Silicon Grease or similar product to improve seal
- Investigate the use of a different material for our front plate to avoid cracking
- Implement a plate between the front of the plate and the screws to distribute the load.

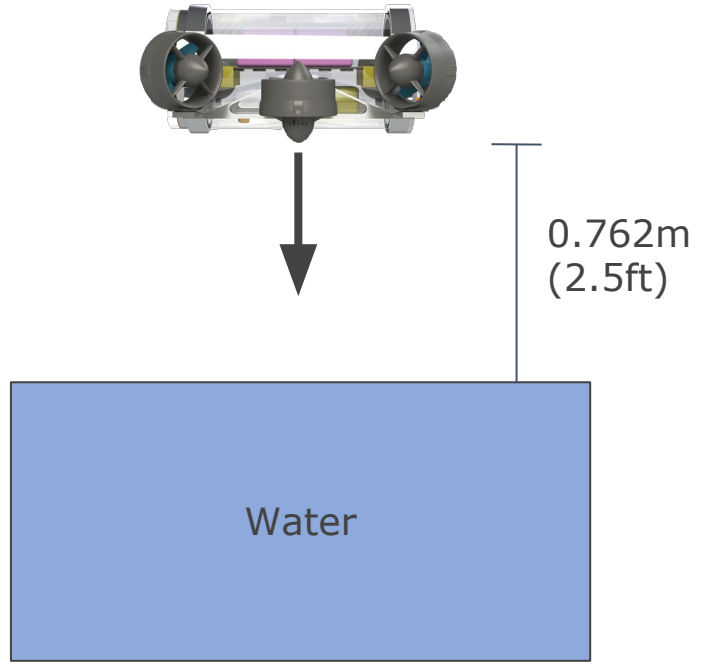
Drop Test

- Scheduled: 3/6 - 3/8
- Completion Status: To be completed
- Test Readiness
  - Rationale: Determine if the AUV can survive the 2.5 ft drop requirement
  - Location: Rec center pool
- Risk Reduction
  - Impact damage
- Requirement Validation
  - Requirement 5.3: The vehicle shall withstand impact to surface of body of water from 2.5 ft above the surface

Drop Test - Procedure

- Line inside of tube with paper
- Load electronics tray with weight
- Film impact site
- Drop AUV
- Inspect structure for damage and inspect paper for wetness

- Success: Structure is undamaged and paper has no wet spots



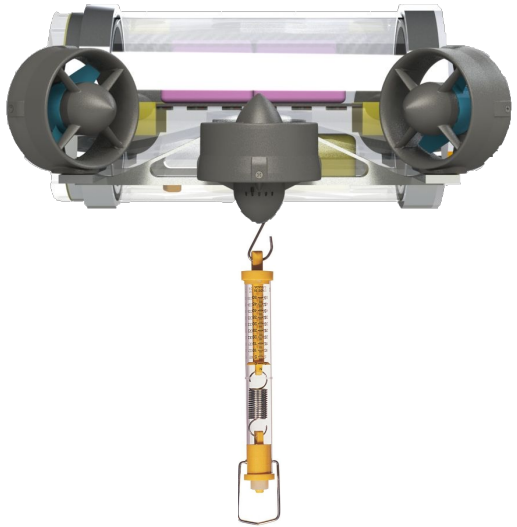
Buoyancy Test

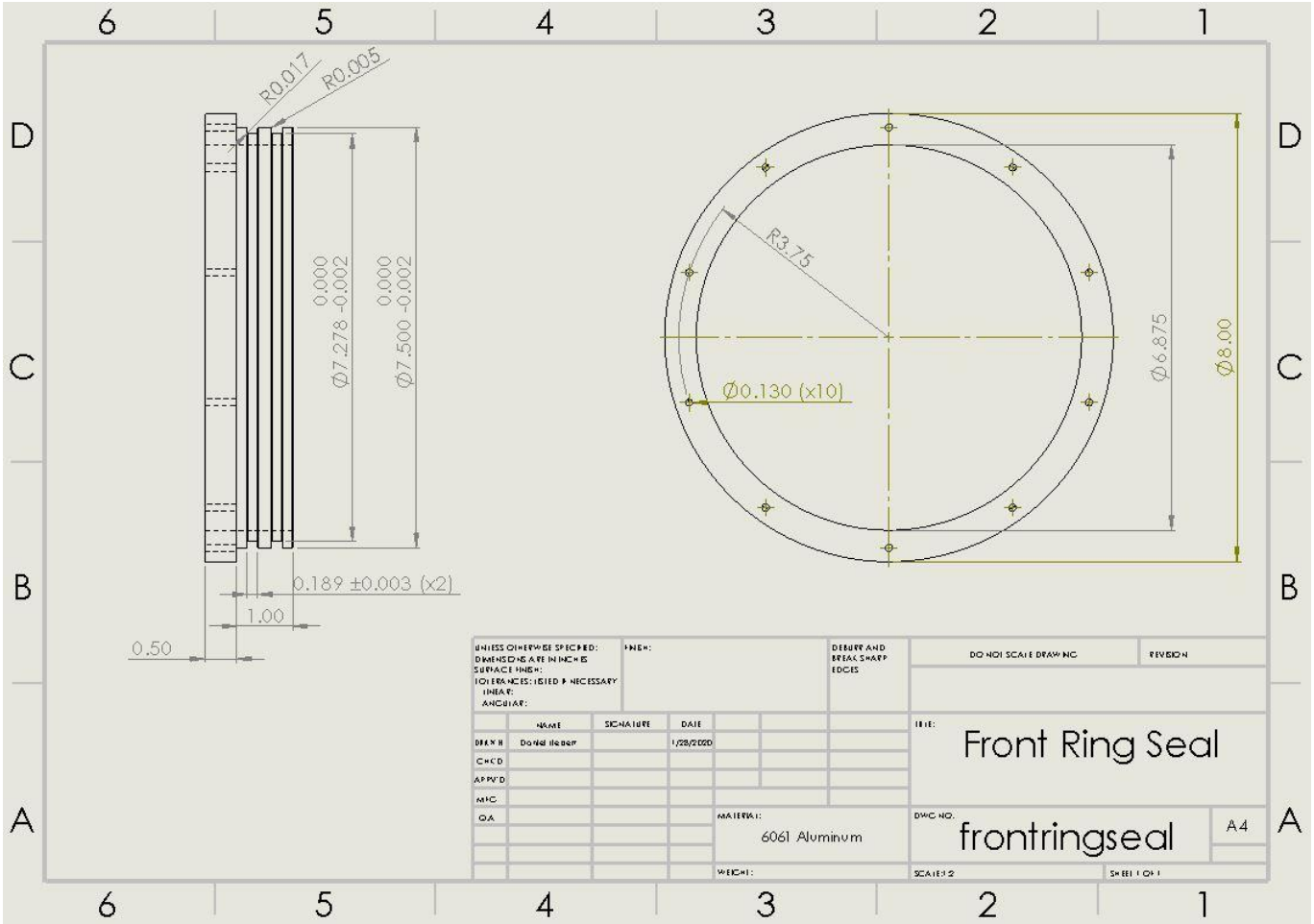
- Scheduled: 3/18 - 4/2
- Completion Status: To be completed
- Test Readiness
  - Rationale: Testing whether positive buoyancy is 1N
  - Location: Rec center pool
- Risk Reduction
  - Battery Usage
- Requirement Verification
  - Requirement 6.5: The vehicle shall weigh no more than 20kg

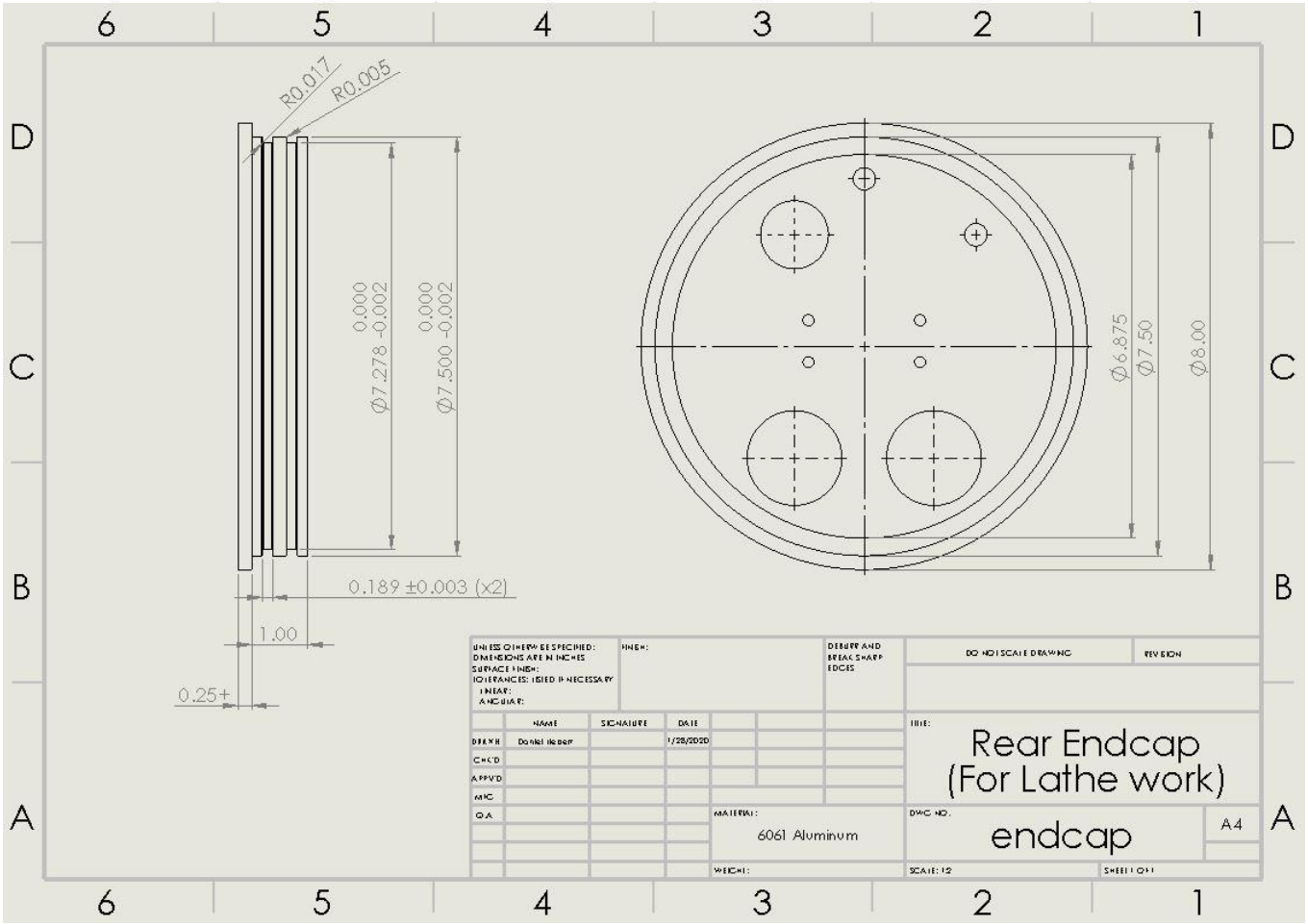
Buoyancy Test - Procedure

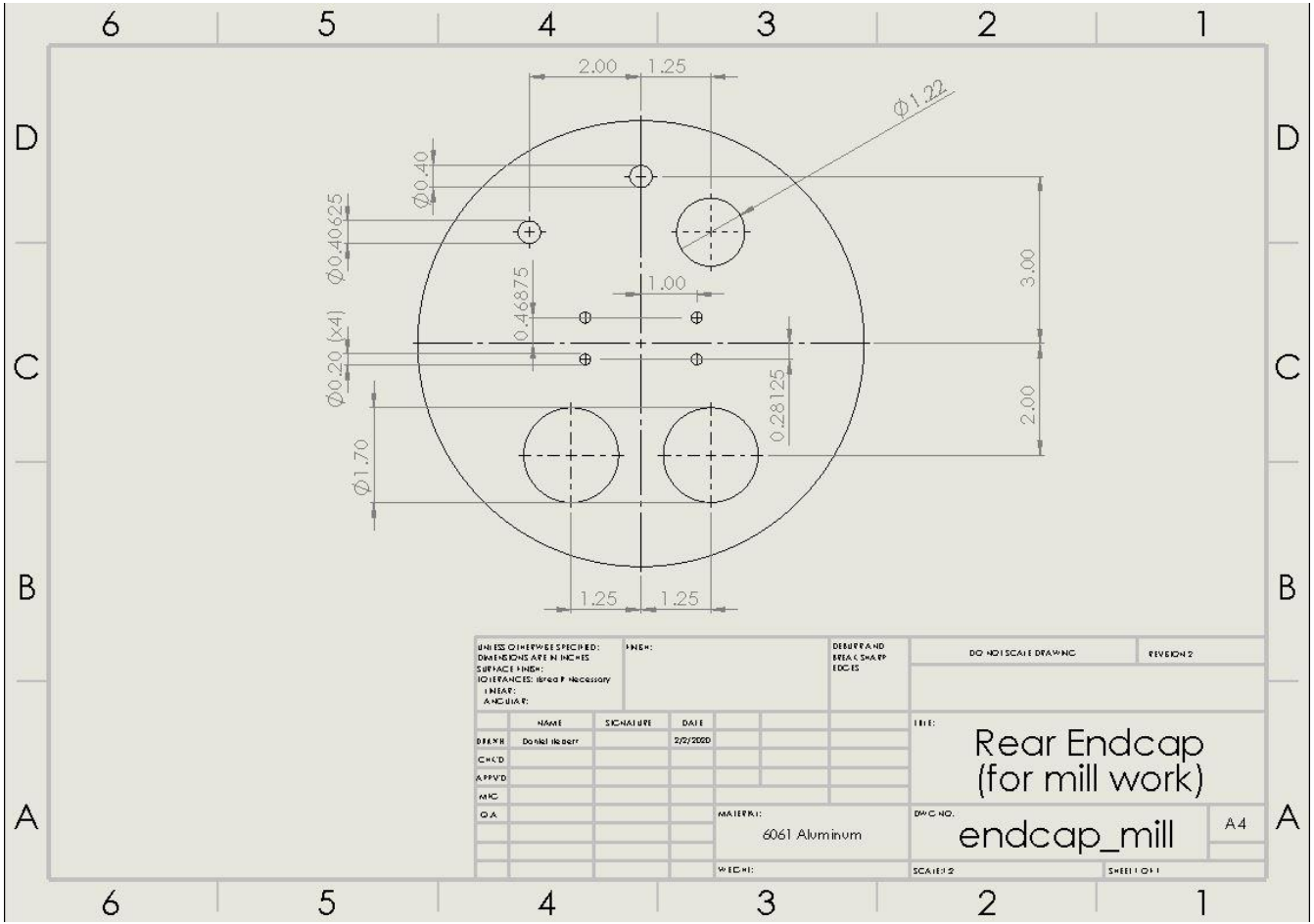
- Weigh fully assembled AUV before placing in water
- Attach a spring scale to the bottom of the AUV and submerge to at least 1m
- Record spring scale value

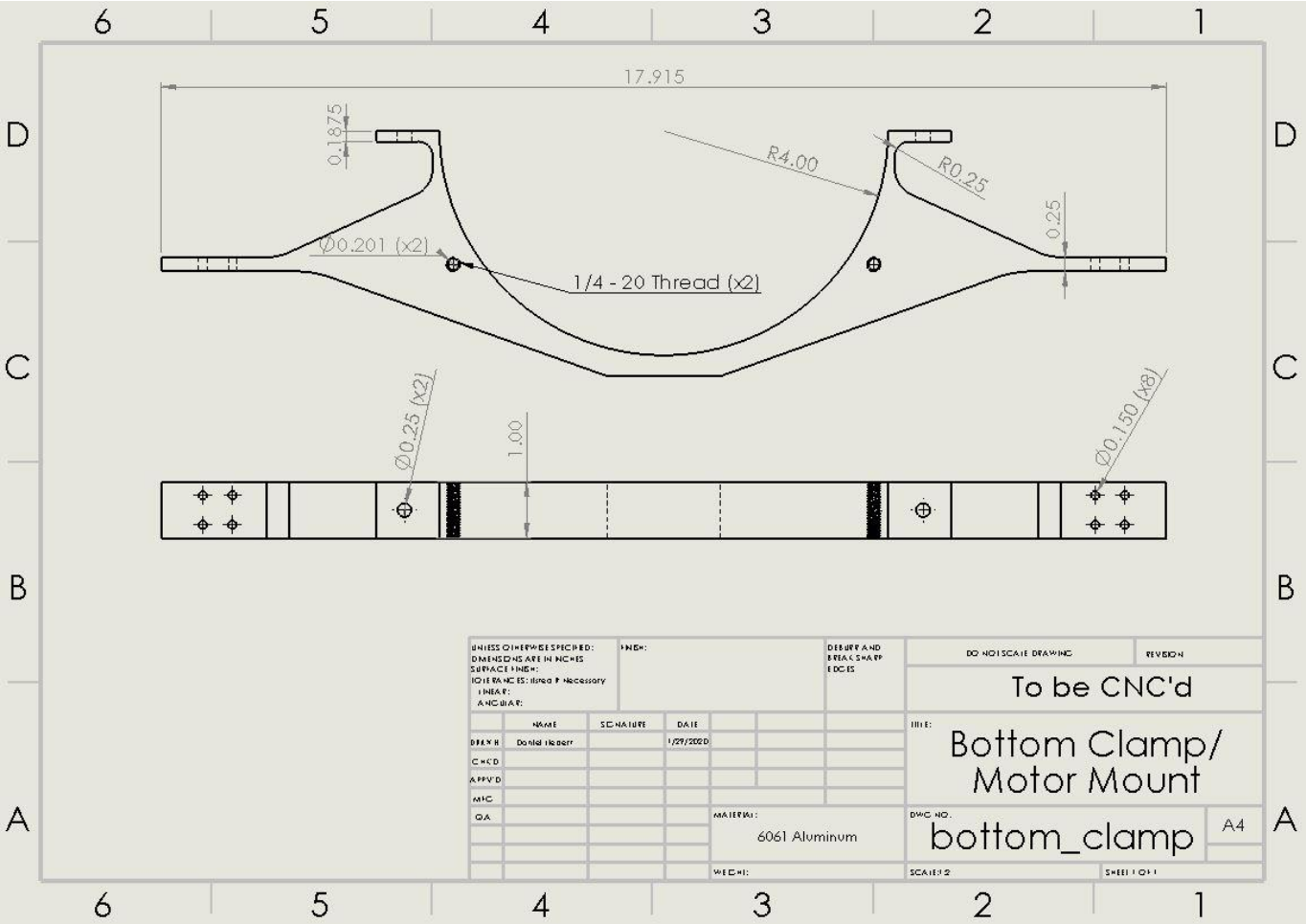
- Success: Spring scale reads 1N±0.5N

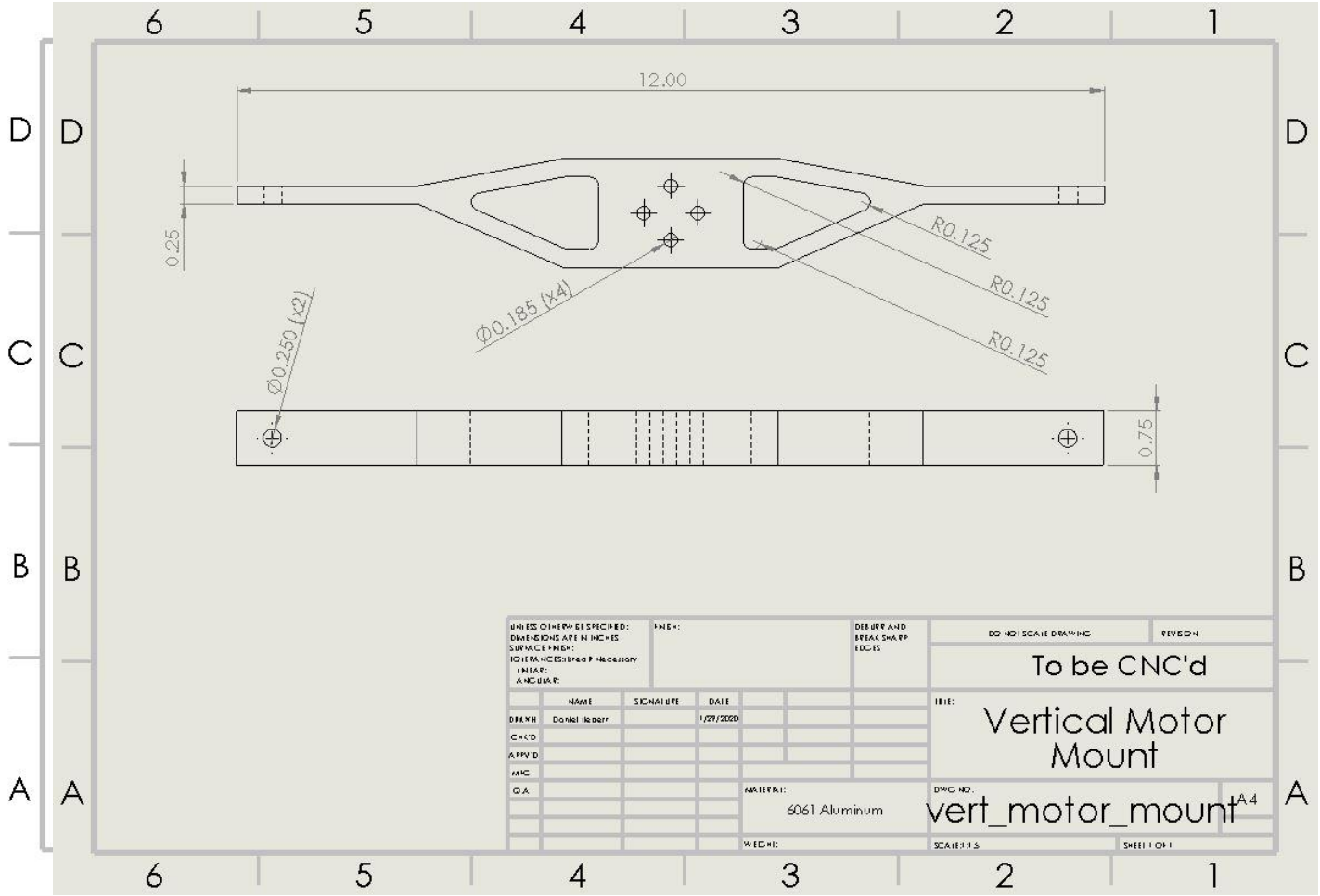



R0.017
R0.005
0.000
Ø7.278 -0.002
0.000
Ø7.500 -0.002
0.189 ±0.003 (x2)
1.00
0.50
R3.75
Ø0.130 (x10)
Ø6.875
Ø8.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
Daniel Weber
1/28/2020
CHKD
APP'D
MFG
QA
TITLE:
Front Ring Seal
MATERIAL:
6061 Aluminum
DWG NO.
frontringseal
A4
WEIGHT:
SCALE: 1:2
SHEET 1 OF 1


R0.017
R0.005
Ø7.278 0.000 -0.002
Ø7.500 0.000 -0.002
0.189 ±0.003 (x2)
1.00
0.25+
Ø6.875
Ø7.50
Ø8.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES: ISED IF NECESSARY
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
Daniel Heber
1/28/2020
CHK'D
APPV'D
MFG
Q.A
TITLE:
Rear Endcap
(For Lathe work)
MATERIAL:
6061 Aluminum
DWG NO.
endcap
A4
WEIGHT:
SCALE: 1:2
SHEET 1 OF 1


2.00
1.25
Φ1.22
Φ0.40
Φ0.40625
0.46875
1.00
3.00
Φ0.20 (X4)
0.28125
2.00
Φ1.70
1.25
1.25
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES: Break if Necessary
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION 2
NAME
SIGNATURE
DATE
DRAWN
Daniel Heberr
2/2/2020
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
6061 Aluminum
WEIGHT:
TITLE:
Rear Endcap
(for mill work)
DWG NO.
endcap_mill
A4
SCALE: 2
SHEET 1 OF 1

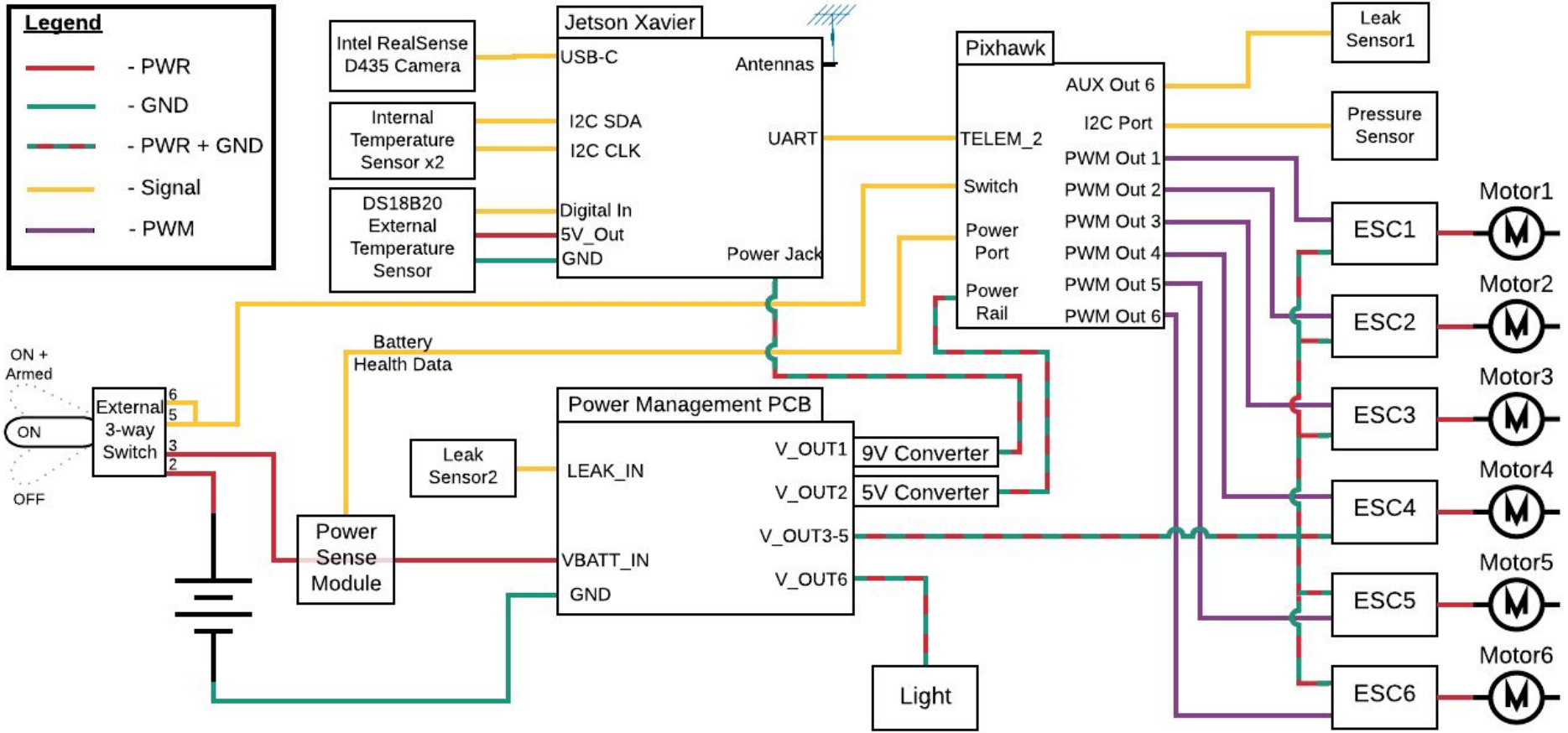

17.915
0.1875
R4.00
R0.25
0.25
Ø0.201 (x2)
1/4 - 20 Thread (x2)
Ø0.25 (x2)
1.00
Ø0.150 (x8)
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES: Hand If Necessary
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
To be CNC'd
NAME
SIGNATURE
DATE
DRAWN
Daniel Haberr
1/29/2020
CHK'D
APPV'D
MFG
QA
MATERIAL:
6061 Aluminum
TITLE:
Bottom Clamp/ Motor Mount
DWG NO.
bottom_clamp
A4
WEIGHT:
SCALE:2
SHEET 1 OF 1


12.00
0.25
R0.125
R0.125
R0.125
Ø0.185 (x4)
Ø0.250 (x2)
0.75
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:Break P Necessary
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
To be CNC'd
NAME
SIGNATURE
DATE
DRAWN
Daniel Hebert
1/29/2020
CHK'D
APPV'D
MFG
Q.A
TITLE:
Vertical Motor Mount
MATERIAL:
6061 Aluminum
DWG NO.
vert_motor_mount
A4
WEIGHT:
SCALE:1:5
SHEET 1 OF 1

Electrical

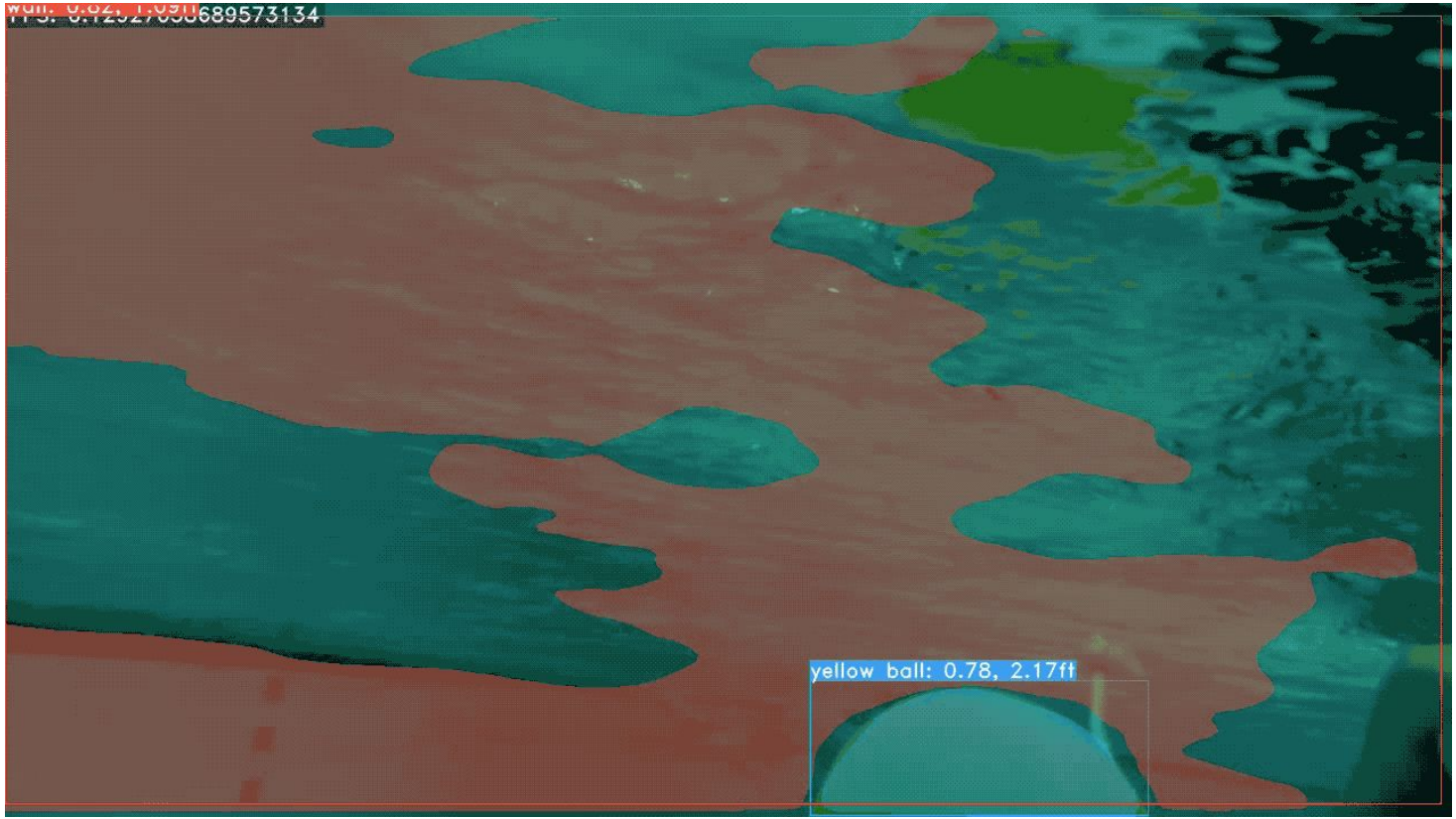
Xavier Power

- Computer power increases from 15W to 30W (worst case)
- Required battery capacity increases from 8.9Ah to 10.2Ah
- Need to change design to include a higher capacity battery
  - 9 Ah -> 12 Ah
  - 1.2 kg -> 1.3 kg

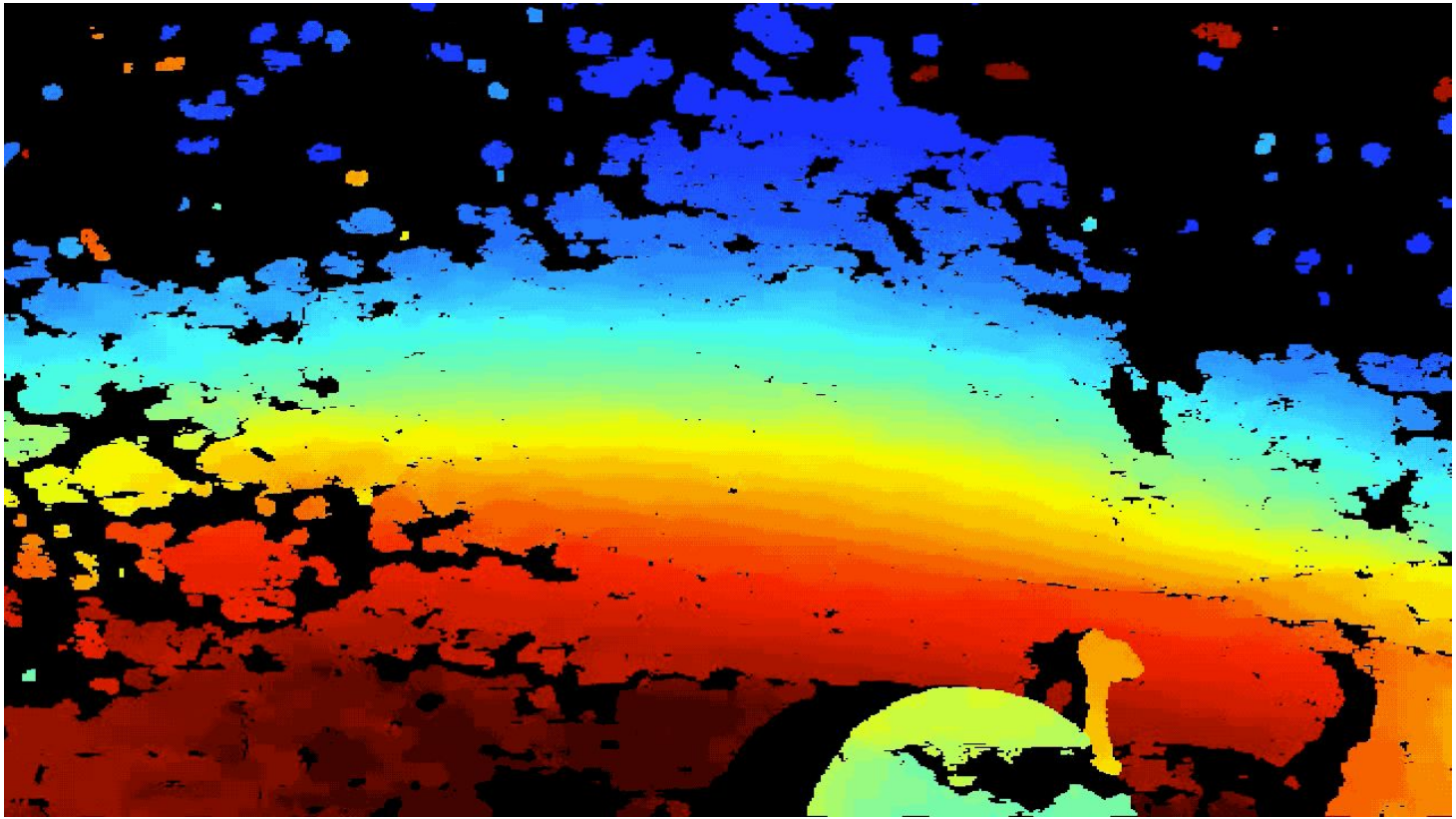

Legend
- PWR
- GND
- PWR + GND
- Signal
- PWM
Intel RealSense D435 Camera
Internal Temperature Sensor x2
DS18B20 External Temperature Sensor
Jetson Xavier
USB-C
I2C SDA
I2C CLK
Digital In
5V_Out
GND
Antennas
UART
Power Jack
Pixhawk
TELEM_2
Switch
Power Port
Power Rail
AUX Out 6
I2C Port
PWM Out 1
PWM Out 2
PWM Out 3
PWM Out 4
PWM Out 5
PWM Out 6
Leak Sensor1
Pressure Sensor
ESC1
ESC2
ESC3
ESC4
ESC5
ESC6
Motor1
Motor2
Motor3
Motor4
Motor5
Motor6
ON + Armed
ON
OFF
External 3-way Switch
6
5
3
2
Battery Health Data
Power Sense Module
Leak Sensor2
Power Management PCB
LEAK_IN
VBATT_IN
GND
V_OUT1
V_OUT2
V_OUT3-5
V_OUT6
9V Converter
5V Converter
Light

Software

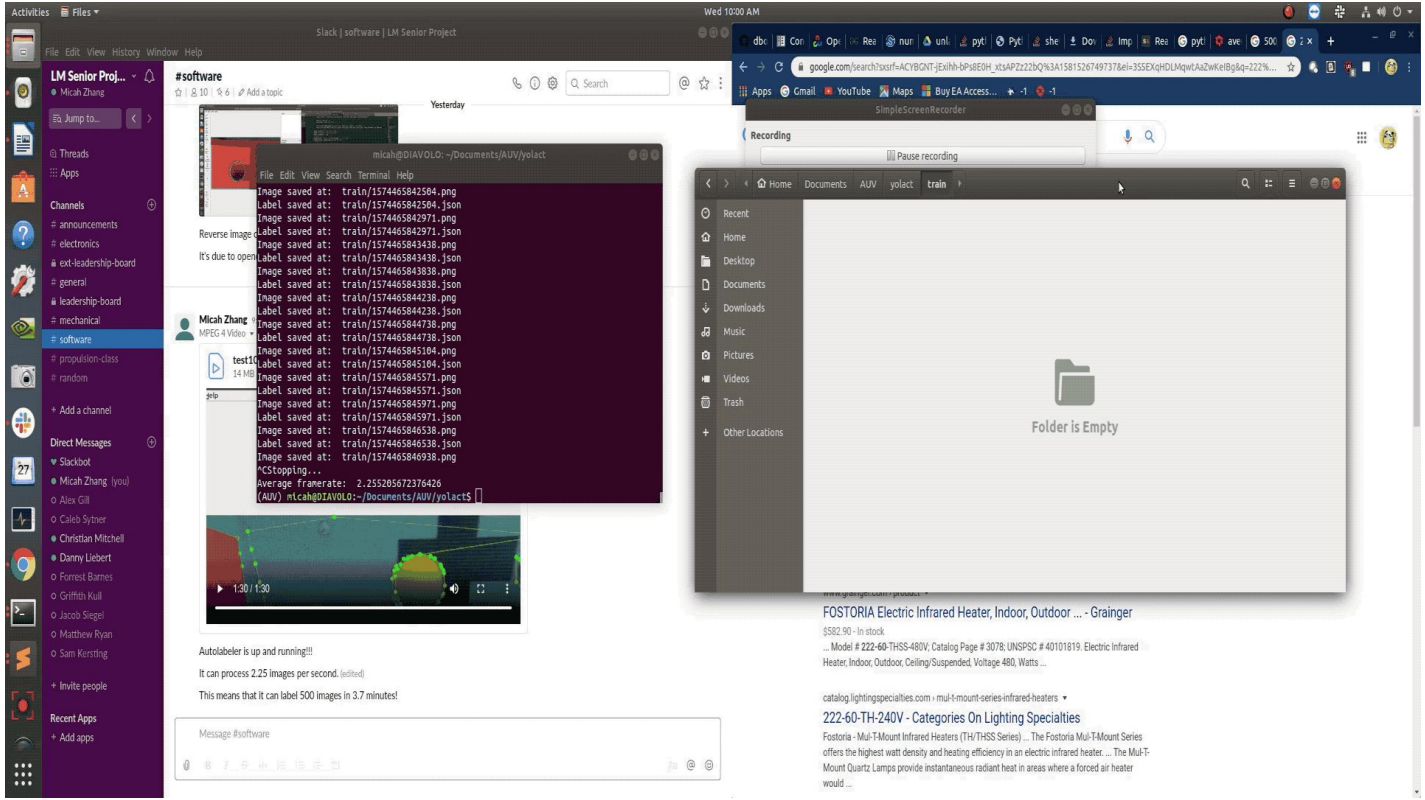
Live in-water YOLACT and Xavier Test



Live in-water YOLACT and Xavier Test



Autolabler In-Action



Collision Avoidance Test

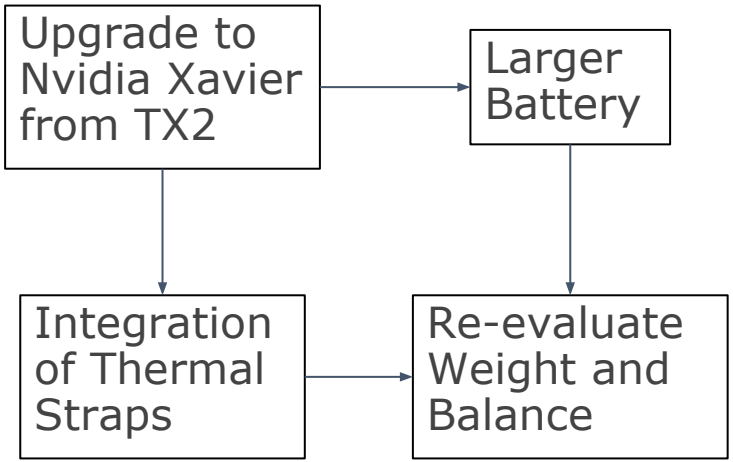
- Scheduled: 3/13 - 3/20
- Completion: In Progress
- Test Readiness
  - Rationale: Ensure that the AUV will safely navigate around objects
  - Location: Rec center pool
- Risk Reduction
  - Collision Chance
- Requirement Verification
  - Requirement 2.1.1.4: Vehicle shall recognize and avoid potential collisions immediately in front of it

Collision Avoidance Test - Procedure

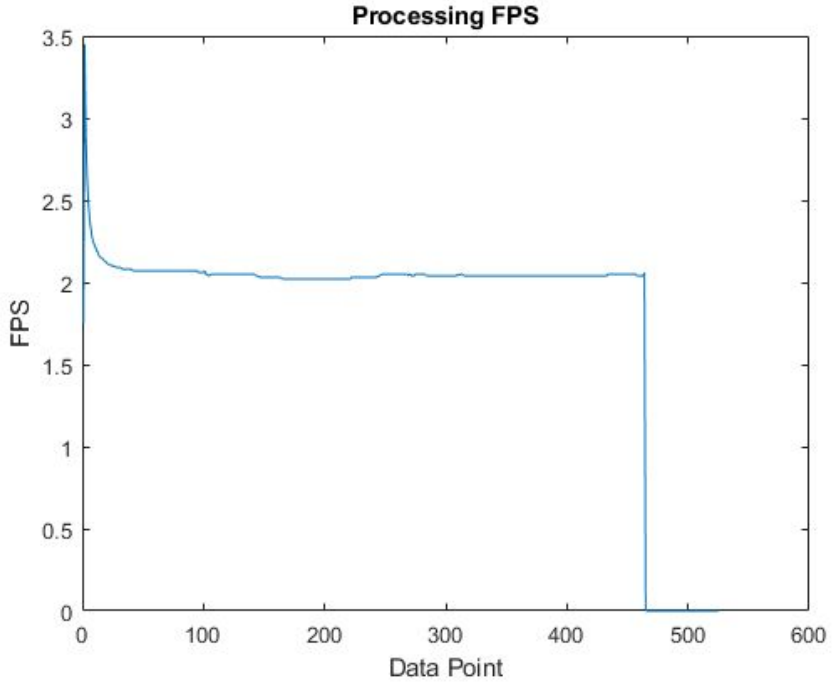
- Put 2 POIs at 4 ft depth in the pool
- Seal electronics in AUV
- Put AUV in pool
- Activate AUV
- AUV will run a script
  - Dive to 4 ft depth
  - Find POI
  - Move towards POI
- Observe AUV behavior
- Deactivate and remove AUV
- Remove computer from AUV

Impact of Nvidia Jetson Upgrade

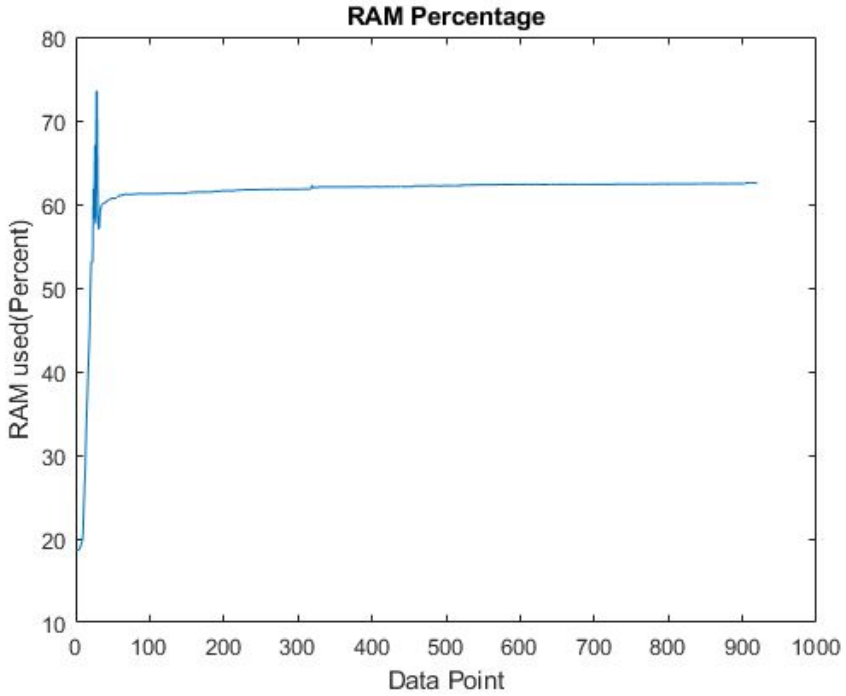
- Due to pre-existing acquisition delay, these design changes pose no schedule risk
  - Part delivery has been spread over the past several weeks, meaning we have some time to modify our orders
  - Acquisition delay has consumed some of our schedule margin, but has not produced a delay in delivering the AUV.
  - Software development remains our critical path, and is proceeding on schedule.



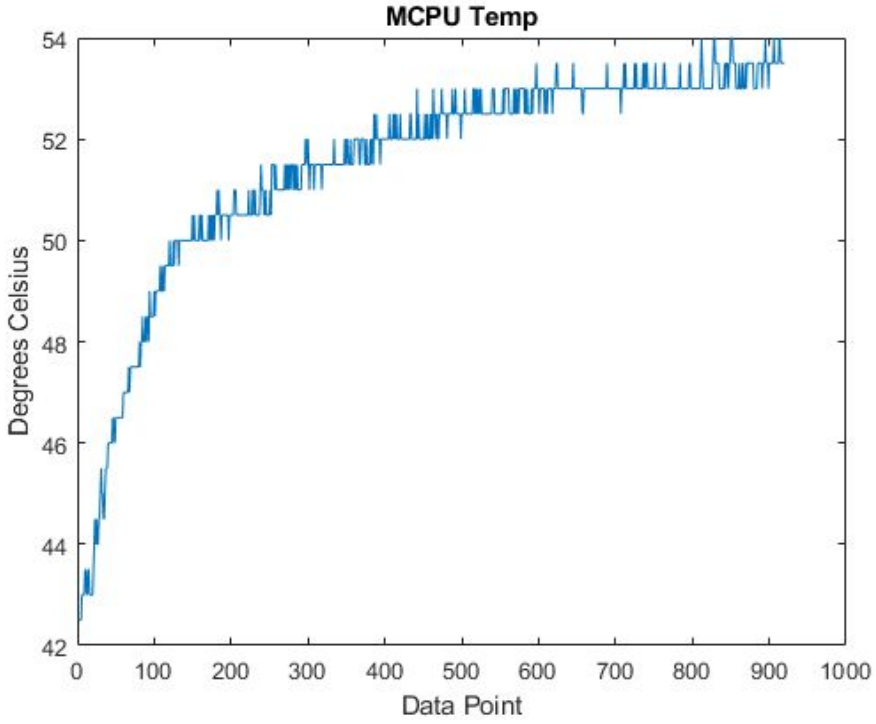
TX2 Framerate



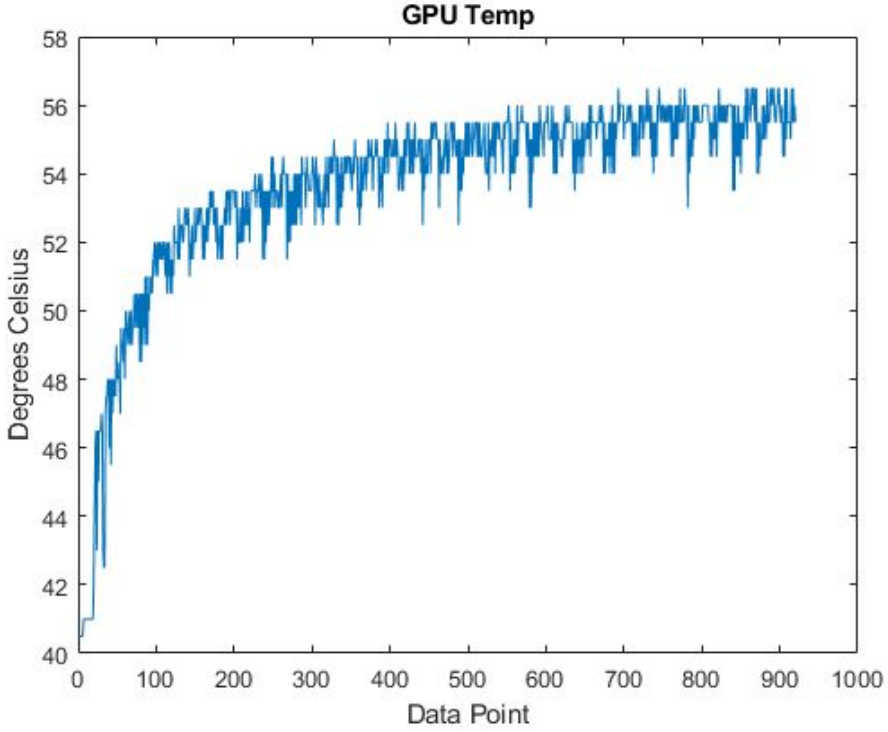
RAM Usage of TX2



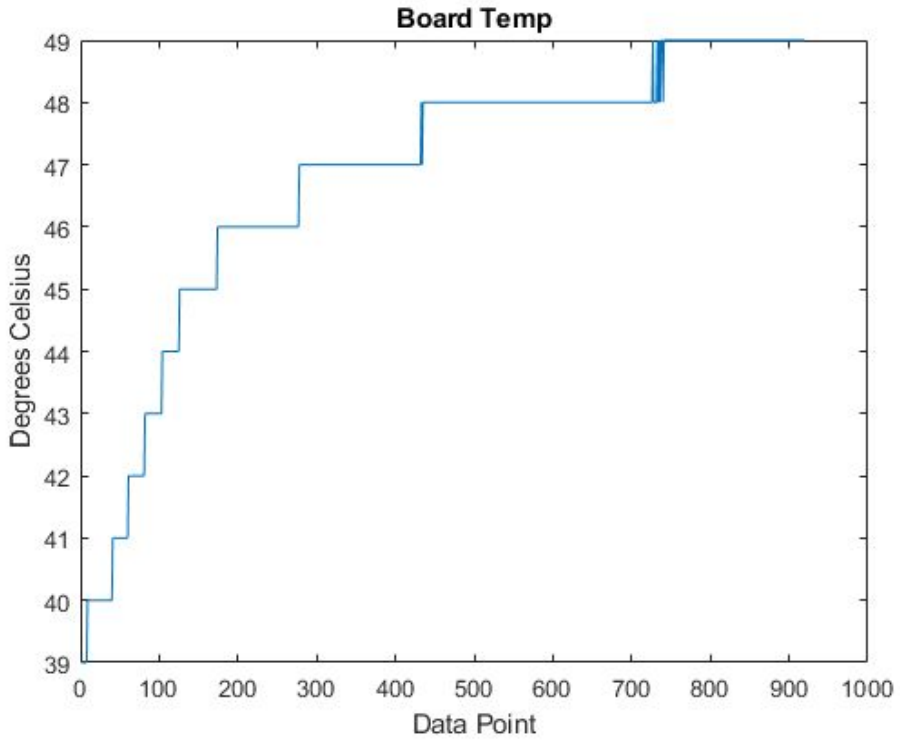
TX2 CPU Temperature



TX2 GPU Temperature



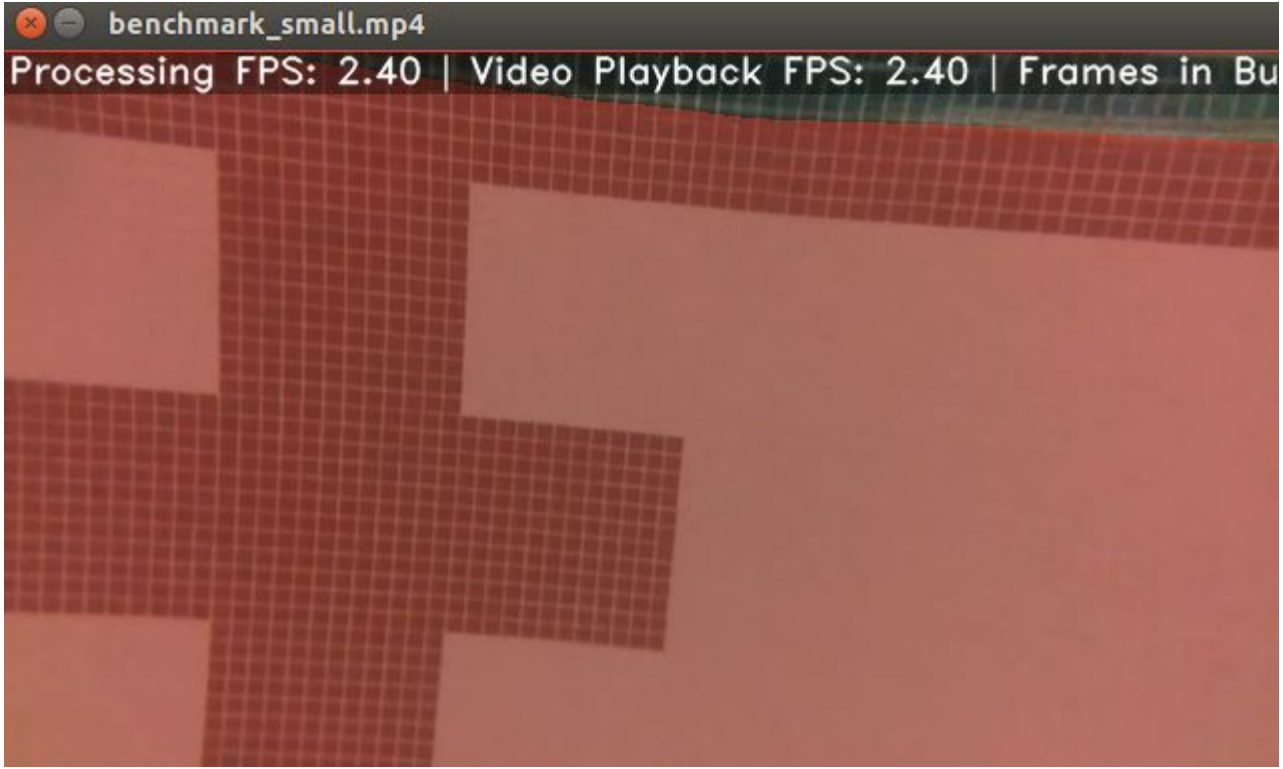
TX2 Board Temperature



TX2 to Xavier rationale

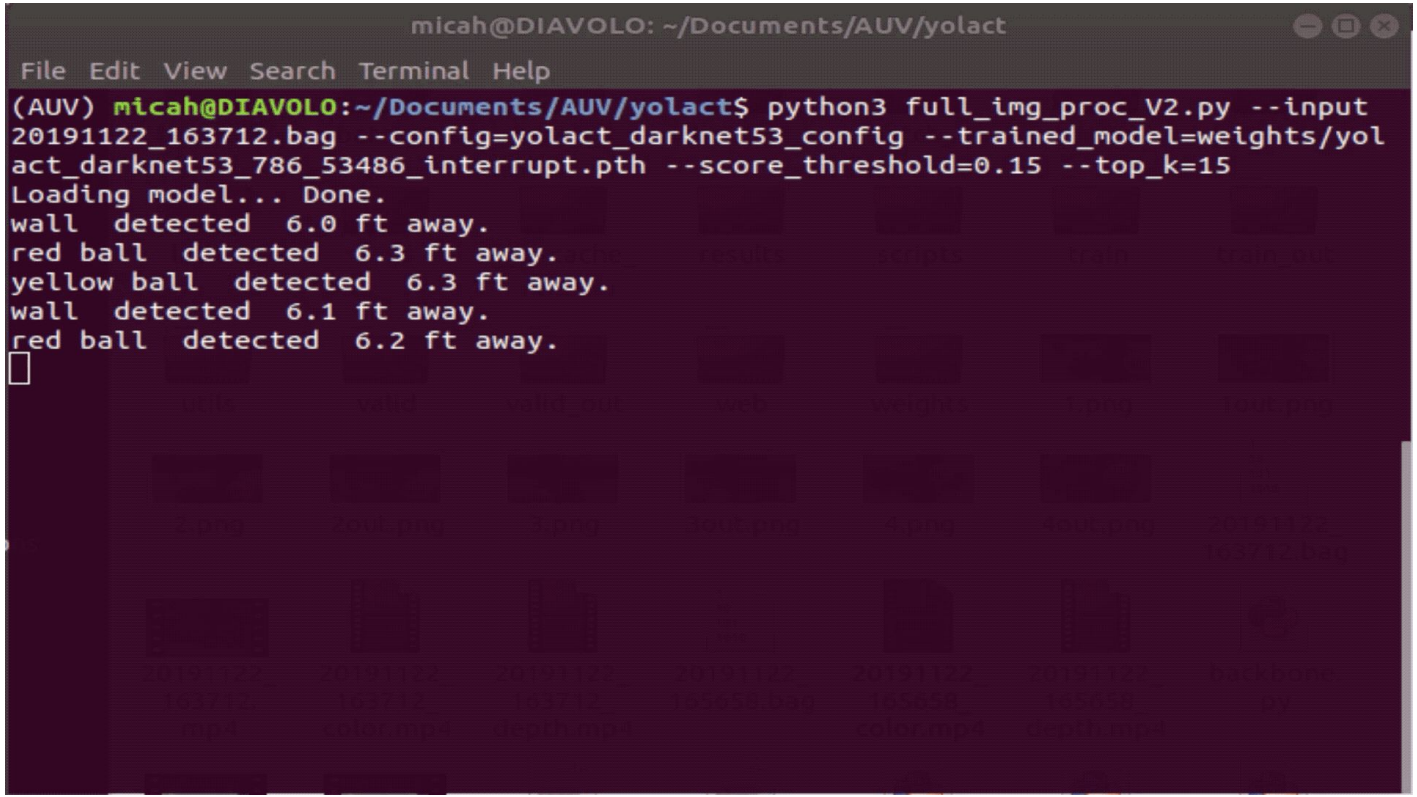
- Double the speed - half the reaction time
  - Simplifies code
  - Makes us less likely to hit obstacles
- Xavier has a newer architecture - more power-efficient
- TX2 was thermally throttled in open air
  - Would have even worse performance underwater
- Thermal strapping gives us a 27C steady-state thermal margin of error
- Mass budget is still wide open
- Use of Nano as testbed mitigates increased budget risk of Xavier

TX2 Benchmark Results



Xavier Benchmark Results

Full Image Processing Stack



Intel Realsense on Jetson Xavier