CROACS

Test Readiness Review

Feb 14th, 2022

ASEN 4028-011 Team #6

Company Sponsor:
Astroscale

Faculty Advisor:
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Presenters:
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TRR Outline

- I. Project Overview
- II. Project Schedule
- III. Test Readiness
  - Servicer
  - Client
  - Comprehensive System
- IV. Project Budget

Project Overview

Project Purpose
Overview

Background:

- Space Debris is growing concern, as more and more satellites are put into orbit.
- **Astroscale** is working on **end of life satellite servicing** for cooperative and noncooperative satellites.
- In order to attempt at de-orbiting debris its **dynamics must be accurately measured.**

Space Debris Field Timeline

https://upload.wikimedia.org/wikipedia/commons/3/3d/Tough_Love_ESA19243296.gif

Motivation:

- **Accuracy & Complexity:** Current ground based satellite tracking has large margins of positional error, and is ineffective at determining attitude and pointing.
- **Safety:** The servicing satellite must have a way to sense the client satellite's attitude and position without increasing the risk of a collision or creating more debris.

ADRAS-J, Phase 1: Approach & inspect a tumbling rocket body

https://upload.wikimedia.org/wikipedia/commons/3/3d/Tough_Love_ESA19243296.gif

Project CONOPS
Overview

Project Success
Overview

What the highest level of project success looks like for us:

- A physical client model is built and can has **three axis of motorized rotation**
- The servicer **LiDAR sensor collects and sends data** about the client to the servicer PC
- All the servicer electronics are housed in a **physical enclosure**
- Servicer System can be **translated in 1 direction**
- Determination Software is capable of **client vs background differentiation**
- Determination Software can **match client attitude** state to within **10% error**
- Determination Software can solve **steady state future** attitude trajectory
- Servicer system is unaffected by **variable lighting**

Critical Project Elements
Overview

CPE	Description	FR
[E1] Servicer Infrastructure	-Physical enclosure to **house all electronics and sensors** of the servicer. -Capable of **translation** during testing.	**[FR4]**
[E2] Client Model	-**Physical model** of space debris with **three axes of motorized rotation.** -Onboard sensors **report truth data**.	**[FR5]**
[E3] Data Processing	-Imaging sensor **collects and transmits** usable data to **on-board processor** -On-board processor meets specifications to run software **close to real time**	**[FR1]** **[FR3]**
[E4] State Determination	-Software **differentiates client from background**. -Software calculations **match truth data to a <10% margin of error**.	**[FR2]**
[E5] State Prediction	-Software is **capable of characterizing the future steady state trajectory** of the client	**[FR2]**

Project FBD
Overview

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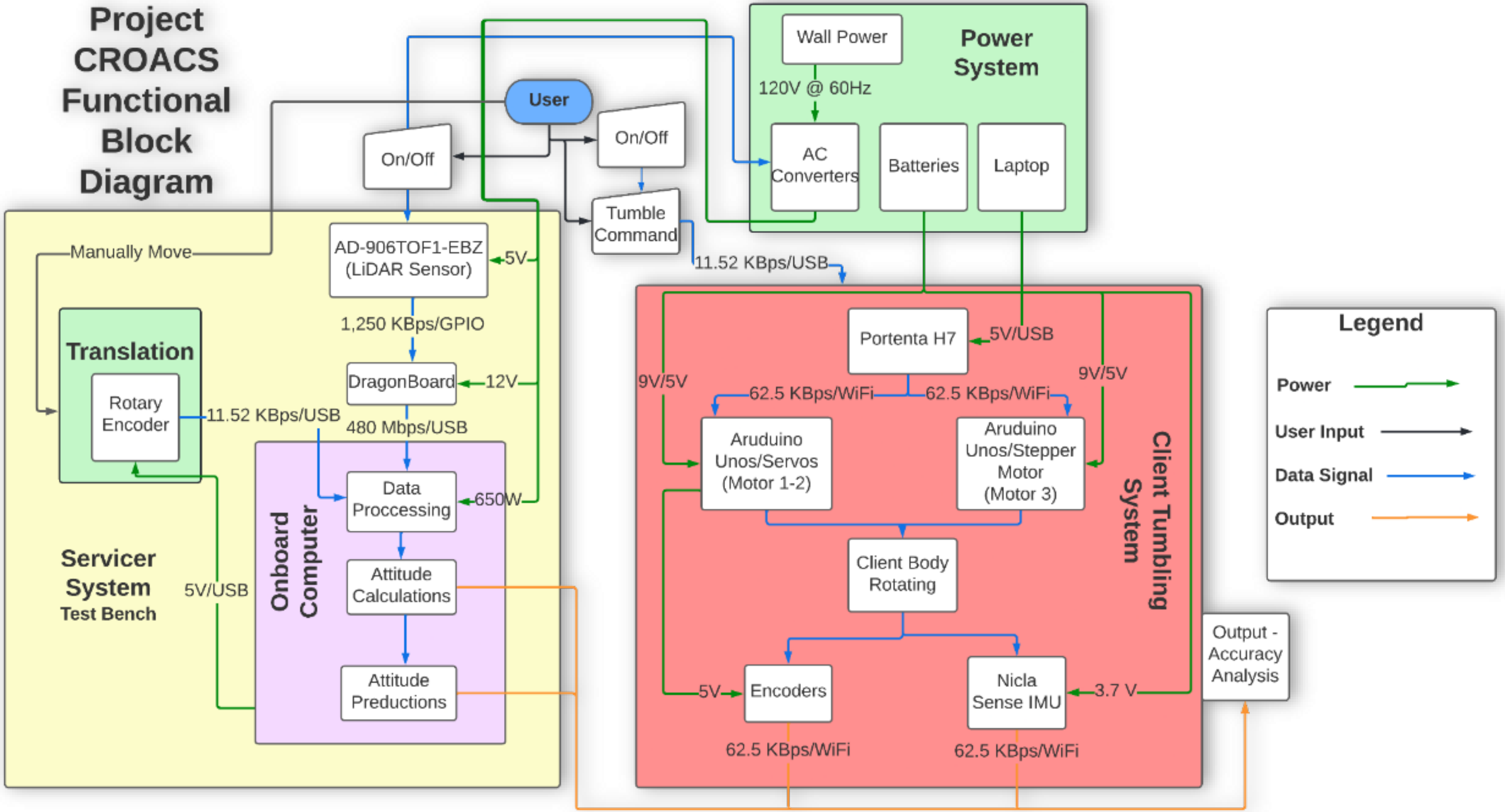
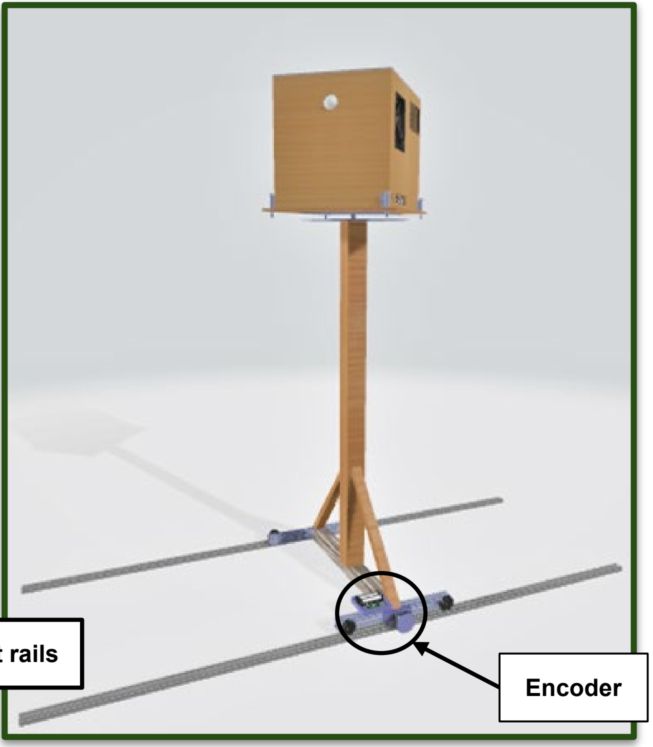
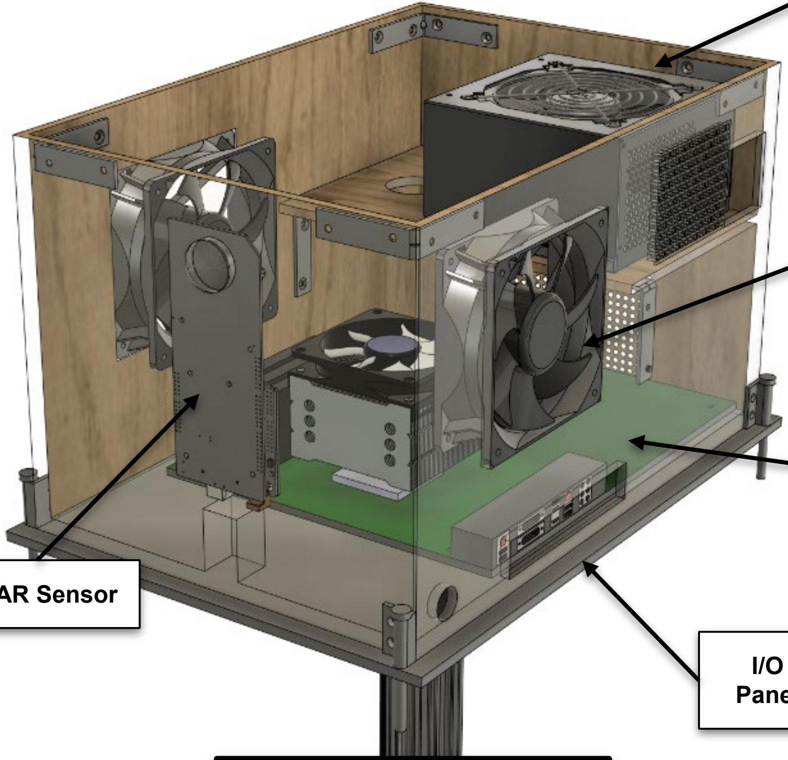


Project Baseline Design - Servicer
Overview



5ft rails

Encoder



Power Supply

Cooling Fans

ATX Motherboard

LiDAR Sensor

I/O Panel

Dimensions: 15” x 10.5” x 11”

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Enclosure

Computer

Project Baseline Design - Client
Overview

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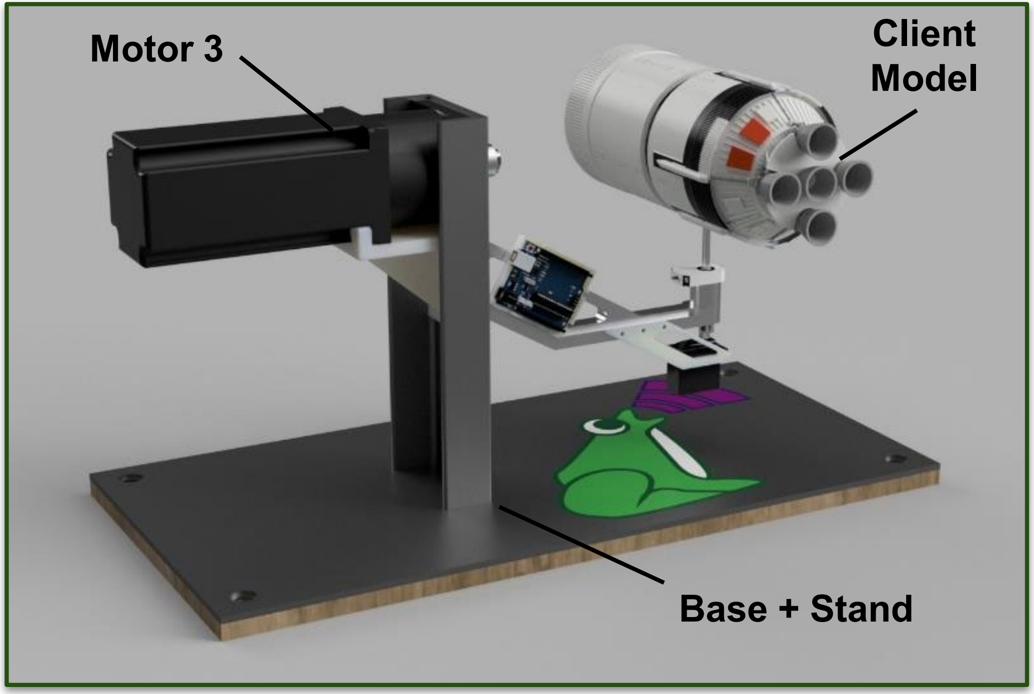

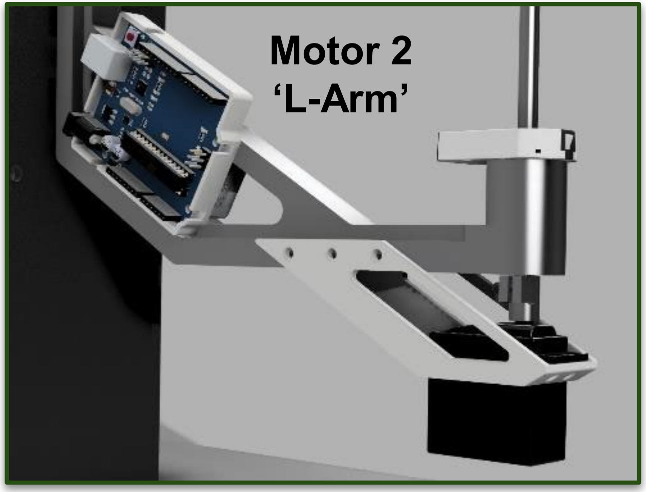

Project Updates - Client

Overview

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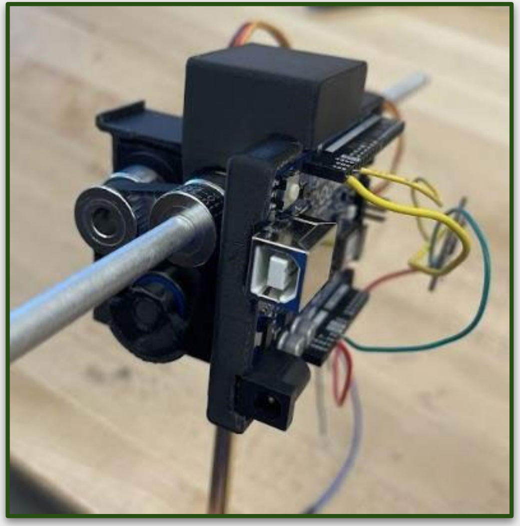
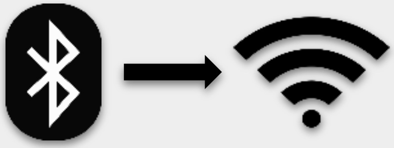
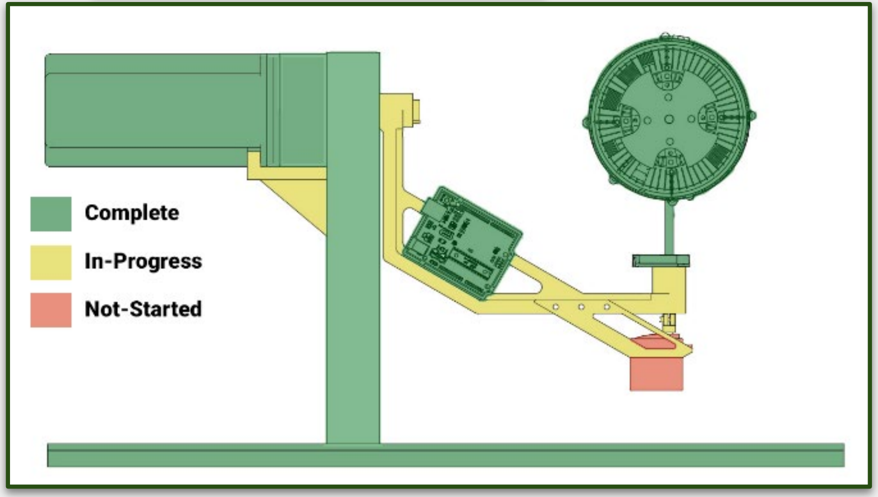


Motor 1 Cluster Assembly Completed
Electronics testing & integration - in progress

***Motor 3** :*
Mounting and Testing - in progress

Client Model:
Fully Printed





Project Updates - Servicer LiDAR
Overview

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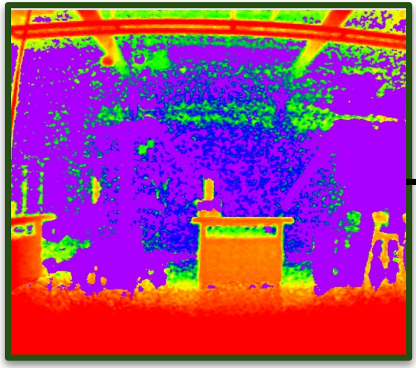
<u>Since CDR:</u>

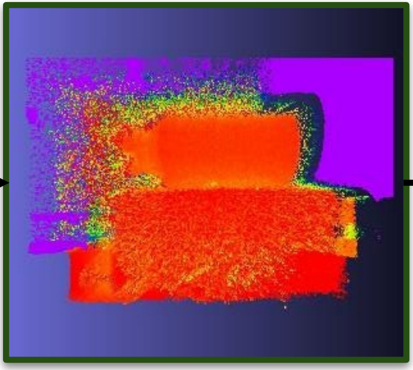
- Obtained Point Cloud Data (.ply) rather than IR map
- Imported pt cloud data into matlab
  - Matlab visualization gives a much better picture of LiDAR resolution
- LiDAR SDK is very sensitive and breaks easy
  - Strict version control and dependencies moving forward

IR Depth Map [ADI Demo]

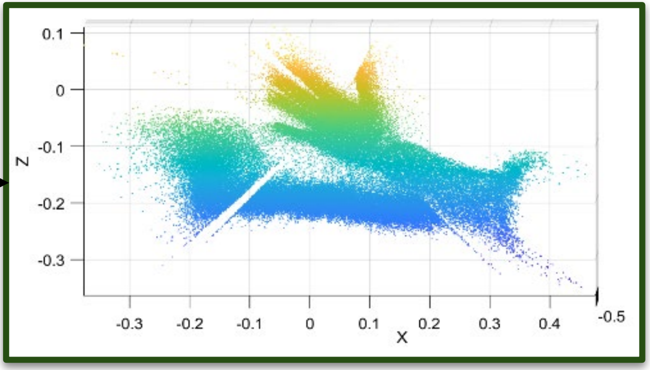


CDR

Pt Cloud [*SDK Vis*]

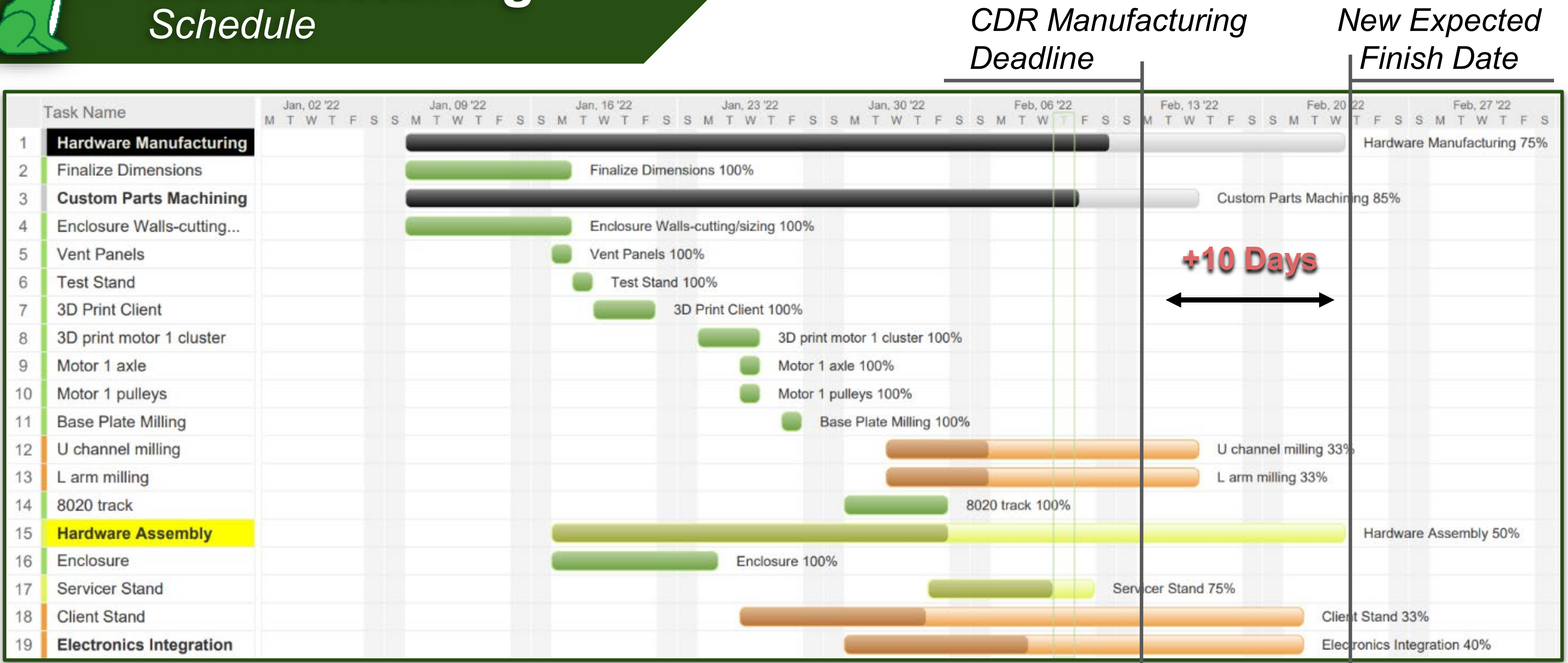


Pt Cloud [*MatLab Vis*]



Project Schedule

Manufacturing
Schedule



Feb 14th
Feb 24th

Behind Schedule: *Unforeseen Supply Issues & Remote Start Slowed Progress.*

Testing Details
Schedule

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Test Name	Starting Date	Ending Date	Location	Testing Started	Test Completed
Component Testing	11/30/2021	2/2/2022			
Encoders	1/26/2022	1/28/2022	Aero N200	☑	☑
Client Motors	1/25/2022	2/15/2022	Aero N200	☑	☐
Arduinos	1/28/2022	2/2/2022	Aero N200	☑	☑
Servicer Stand	1/20/2022	2/15/2022	Aero N200	☑	☐
Sevicer Enclosure	1/18/2022	2/6/2022	Aero N200	☑	☑
Client Structures	1/24/2022	2/23/2022	Aero N200	☑	☐
Lidar Sensor	11/30/2021	1/21/2022	Aero N200	☑	☑
Client Model	2/1/2022	2/4/2022	Aero N200	☑	☑
Client Communication	2/2/2022	2/21/2022	Aero N200	☑	☐
Subsystem Testing	1/1/2022	3/6/2022			
Client Hardware	2/7/2022	3/6/2022	Aero N200 / Machine Shop	☑	☐
Client Electronics	2/7/2022	3/6/2022	Aero N200 / Aspen Lab	☑	☐
Servicer Hardware	2/7/2022	3/6/2022	Aero N200	☑	☐
Servicer Electronics	2/7/2022	3/6/2022	Aero N200	☑	☐
Servicer Software	1/1/2022	3/20/2022	Aero N200	☑	☐
Client Software	1/26/2022	2/28/2022	Aero N200 / Other	☑	☐
Comprehensive Testing	3/7/2022	4/6/2022			
Client System Testing	3/7/2022	3/20/2022	Aero N200 / Planetarium	☐	☐
Servicer System Testing	3/7/2022	3/20/2022	Aero N200	☐	☐
Full Day In the Life Testing	3/21/2022	4/6/2022	Aero N200 / Planetarium / Other	☐	☐

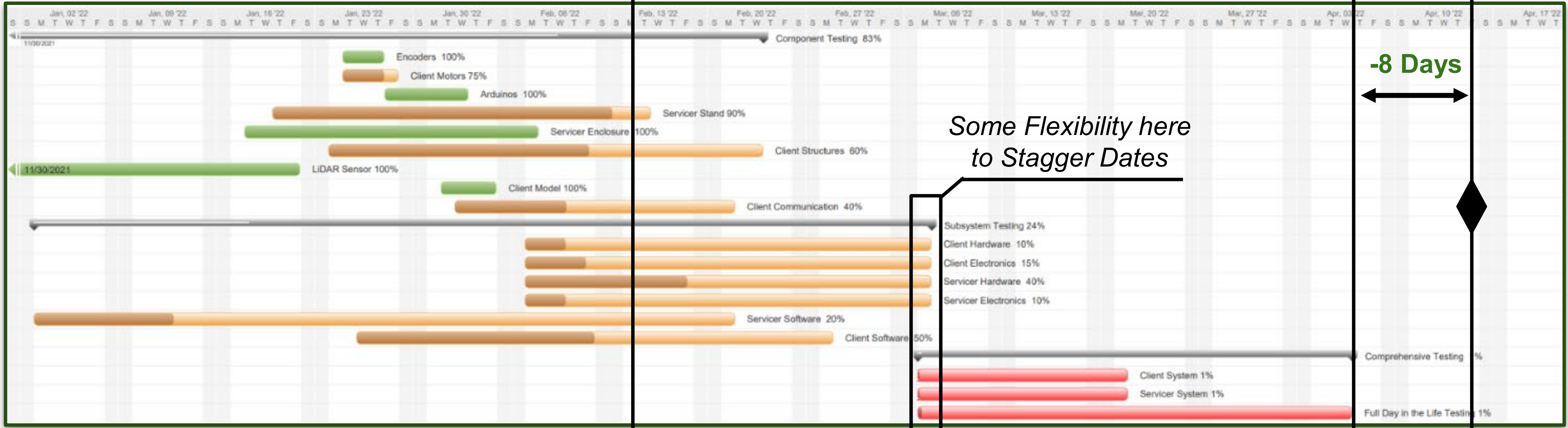
Testing Timeline

Schedule

Apr 6th *Apr 14th*

-8 Days

Some Flexibility here to Stagger Dates



TRR Deadline *Feb 14th*

Expected Testing Finished Date

Class Symposium (Final Deadline)

- **Behind CDR Projected**
- **Still within margin**
- *Delay due to manufacturing lead times*

- Complete
- In Progress
- Not Started

Milestone Progress Since CDR

Schedule

A lot in a short amount of time

~2 Weeks

TRR Deadline
Feb 14th

- Complete
- In Progress
- Upcoming

<u>AIAA Conference Update:</u>

Abstract is submitted to the conference. Our team plans to present in April. Our paper is focused on the point cloud attitude determination algorithm

Test Readiness

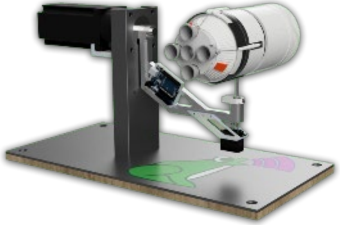
Testing Overview
Test Readiness


Servicer

- Software Identification
- Software Prediction


Client

- Arduino Communications
- Motors & Controllers




Comprehensive

- Vicon Testing
- Day in the Life Testing

Servicer

DR 1.3: The sensor suite shall be able to gather data of the client at a range of at least 3m.
DR 2.1: The software algorithm shall identify the known client from the background.

Test Status	In Progress

Rationale:

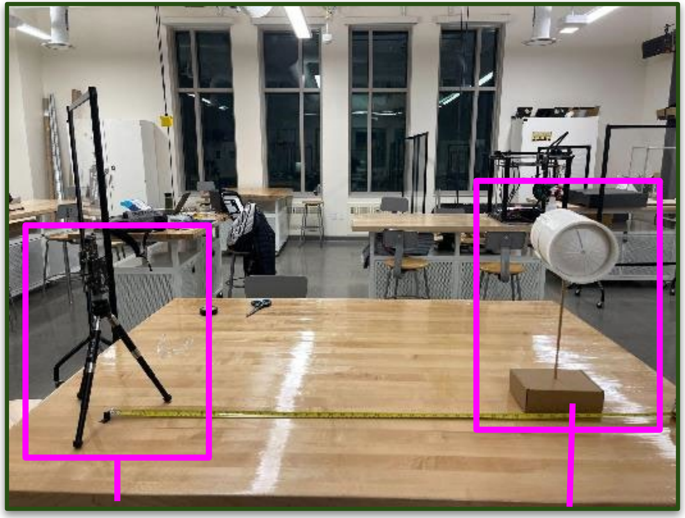
- Demonstrate point cloud capture of client body
- Verify that LiDAR resolution is sufficient to **identify unique features**

Procedure:

- Scan client body:
  - For multiple distances at one orientation
  - For multiple orientations at the target distance (3 m)
- Send point cloud data through background differentiation and feature recognition modules

Additional Equipment: Micro-USB cable, computer with monitor

Location: Aero N200



LiDAR Sensor *Client Model*

DR 1.3: The sensor suite shall be able to gather data of the client at a range of at least 3m.
DR 2.1: The software algorithm shall identify the known client from the background.

Outcomes:

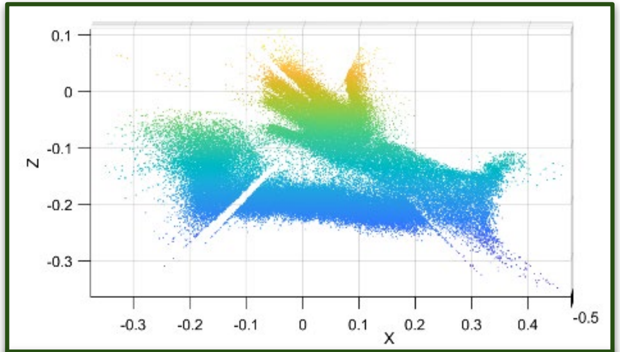
- Expected Results
  - Validate feature recognition models from CDR
    - Identification of nozzles, ridges, and/or surfaces

Risk Reduction:

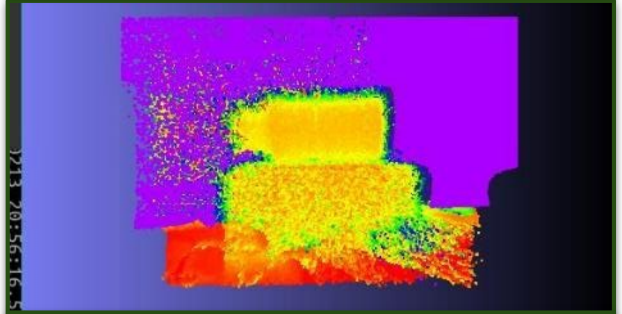
- Validates LiDAR performance before comprehensive system testing
- Verifies features on the client can be recognized

Pass Criteria

- Minimum distance achieved with ±1 cm range accuracy
- Clear visual separation between client model and background when point clouds are converted & parsed



Point Cloud in Matlab (as of 2/7)



Point Cloud in ADI SDK (as of 2/13)

Software Prediction
Test Readiness

Servicer

DR 2.2: The software algorithm shall make predictions of the client's future attitude states.

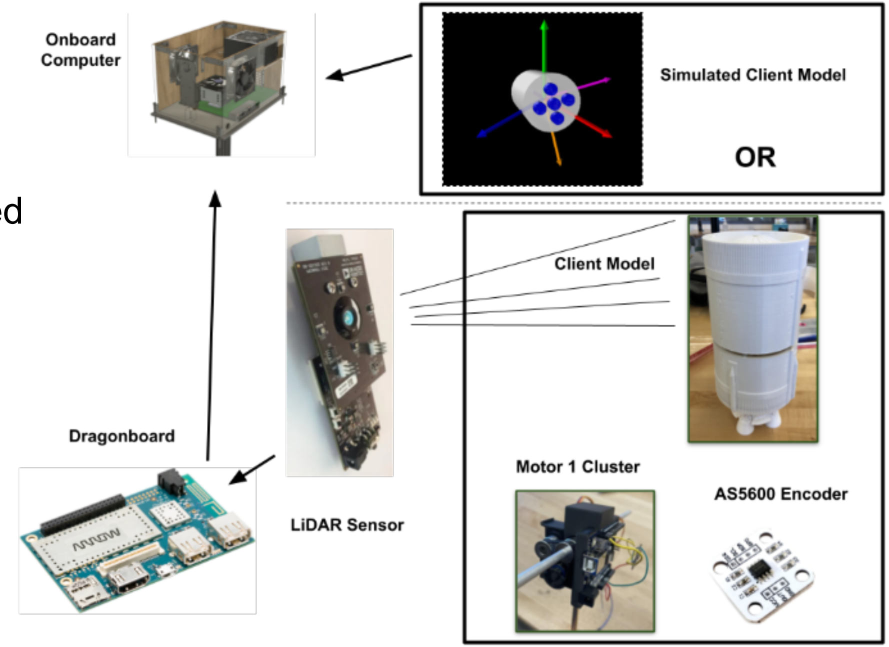
Test Status	In Progress

Rationale:
- Demonstrate that software is capable of characterizing client's dynamics and predict them

Procedure:
- Scan client while rotating with Motor 1
  - Can replace this with simulated data if needed
- Send through template matching and angle characterization modules
- Analyze differences between predictions and measurements

Equipment: LiDAR sensor & DragonBoard, client model, on-board computer, motor 1 cluster

Location: Aero N200



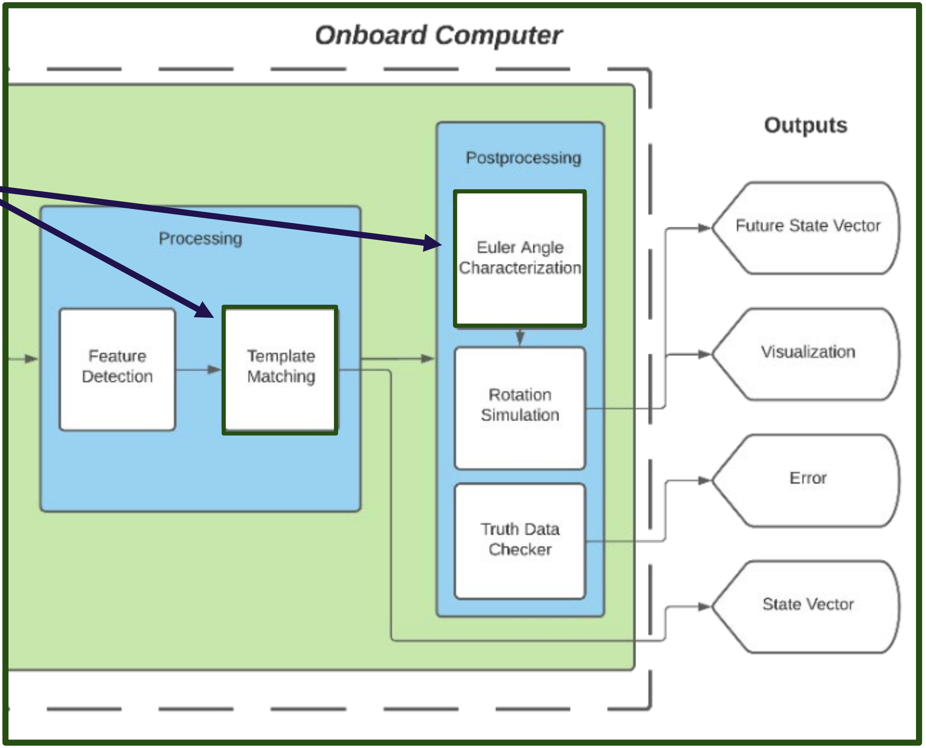
DR 2.2: The software algorithm shall make predictions of the client's future attitude states.

Outcomes:

- Expected Results
  - Validates template matching and Euler angle characterization modules

Risk Reduction:

- Confidence in predicting future attitude states
- Software ready for comprehensive testing



Pass Criteria
Predictions match measurements with
> 95% accuracy

DR 5.1: The client shall record measurement data about its position, orientation, and angular velocity.

Test Status	Failed

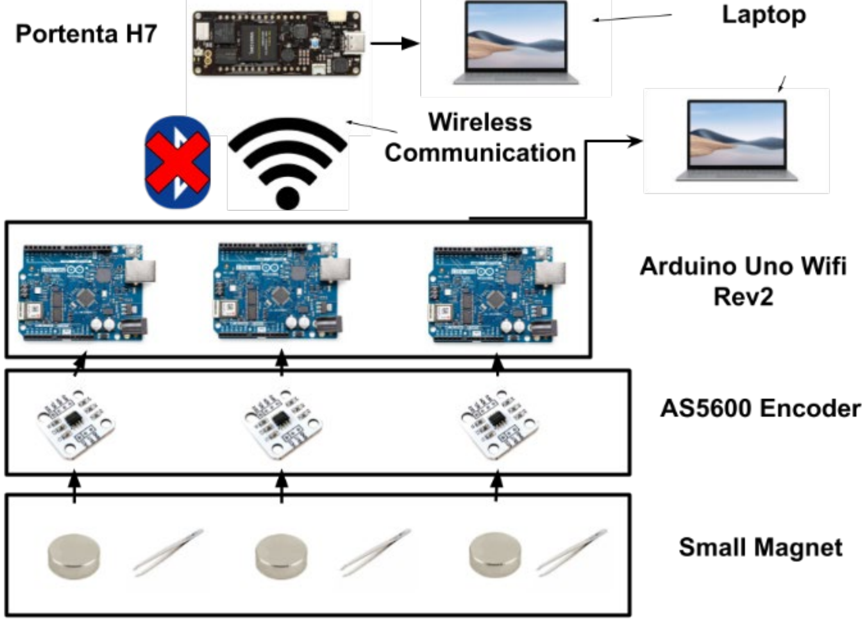
Rationale:

- Demonstrate peripherals controller can send encoder angle data to central microcontroller wirelessly

Procedure:

- Set up AS5600 (magnetic encoder)
  - Connect encoder to UNOs
- Run wireless communication script on microcontroller and data recording script on laptops
  - Peripheral script on Unos and Central script on Portenta
- Hold magnet 0.5-3 mm above the encoder and turn with tweezers
- Extract data after 15 minutes of run time
- Evaluate data between the angular position from the Portenta (central) and Unos (peripheral)

Test Setup:



Location: AERO N200
Equipment: Arduino UNO, Portenta H7, AS5600, Magnet

DR 5.1: The client shall record measurement data about its position, orientation, and angular velocity.

Expected Results:
- Angular position of small magnetic is measured and received every 50 ms
- Data is not altered during wireless communication

Risk Reduction:
- Validate wireless communication
- Confidence in fast unaltered communication for client

Validation Method:
- Compare the angular position from Portenta and Arduino Unos
  - Compare timestamp of measured and received and its within ~ 1ms
  - Compare the measurements values between Portenta and Unos

Test Status
- Outcome: Bluetooth libraries do not work well with Portenta
  - Received data every second, severely altered and terminates suddenly
- Next option is to work with Wifi connections
  - Offramp to XBEE if Wifi doesn't work

```
Magnet status: 10111
Magnet status: 100111
Deg angle: 3.78
Deg angle: 1.58
Corrected angle: 357.80
Deg angle: 1.76
Corrected angle: 357.98
Deg angle: 2.90
Corrected angle: 359.12
Deg angle: 2.55
Corrected angle: 358.77
Deg angle: 0.35
Corrected angle: 356.57
Deg angle: 0.18
Corrected angle: 356.40
```

Expected Output from Portenta

Client

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DR 5.2: The client shall be able to spin about three different axes at a rate of at least 10 deg/sec.

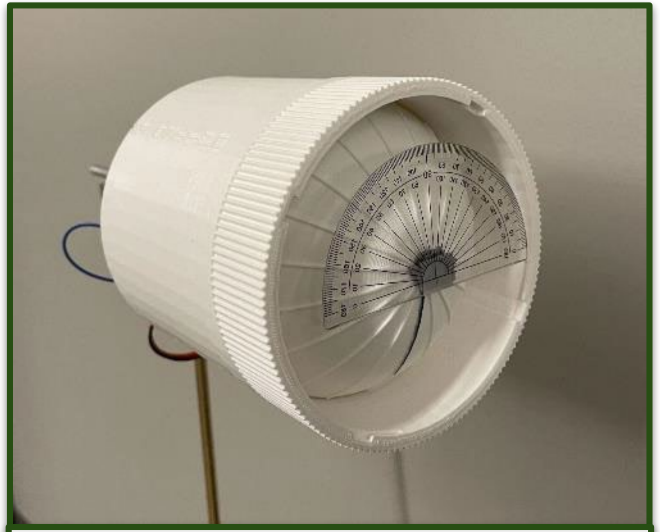
Rationale:

- Demonstrate arduinos can **command motors above desired rate**
- Demonstrate physical interference is not an issue
- Verify electrical connections & power draw
- Validate that motors provide sufficient torque

Procedure:

- Assemble each motor setup individually
  - Motors 1 & 2 with their respective arduinos
  - Motor 3 using compatible driver & arduino
- **Verify each spins at or above desired rate under load**
  - Hand measurement and stopwatch timing
- Assemble overall client setup by incrementally adding the next motor and testing rotations in various positions

Test Status	In Progress



Motor 1 Test Setup
Manual Angle Measurement

Client

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DR 5.2: The client shall be able to spin about three different axes at a rate of at least 10 deg/sec.

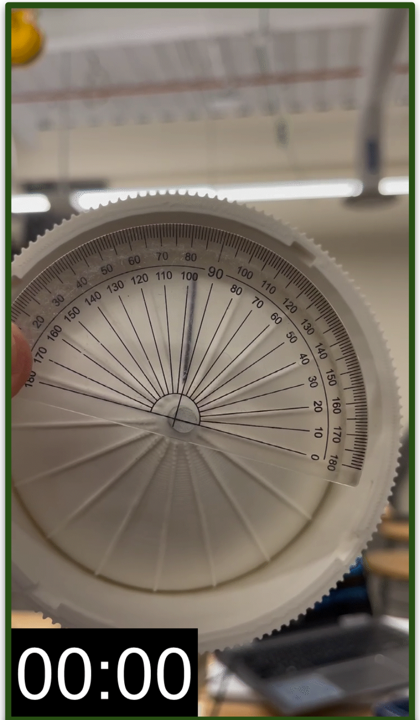
Outcomes:

- Motor 1 assembly is completed and functioning as desired
- Expected: Motor 2 performs desired rate on its own and while rotating Motor 1 "Cluster"
- Motor 3 is functional, but requires more set up

Risk Reduction:

- Demonstrates motor & driver compatibility
- Validates power feasibility
- Validates torque models

Motor 1 Results
~350°/1.5 sec
~230 deg/sec
>>> 10 deg/sec



Motor 1 "Cluster" Test

Equipment: Servo 1/2, Stepper motor/driver, Arduino UNO, Battery, Motor 1 cluster, L arm, jumper cables, protractor, power supply

Location: Aero N200

Vicon/Comprehensive Test

Test Readiness

Client

DR: All design requirements for client

Test Status	Not Started

Rationale:

- Ensure electronics and hardware of Client are integrated properly
- **Verify position, orientation, and angular velocity** from the encoder and IMU on the client model are accurate

Procedure:

- Calibrate Tracking system and create object
- Record various rotation scenarios using on-board truth data sensors in addition to Vicon
- Data will be taken during **steady state operation**

Pass Criteria

Encoder and IMU data is within 5% relative error at 10 degrees/sec

Vicon System and tracking cameras in ASPEN Lab

DR: All design requirements for client

Outputs:

- Vicon Software outputs .csv file containing linear and rotational position of object
- Encoder and IMU data from client

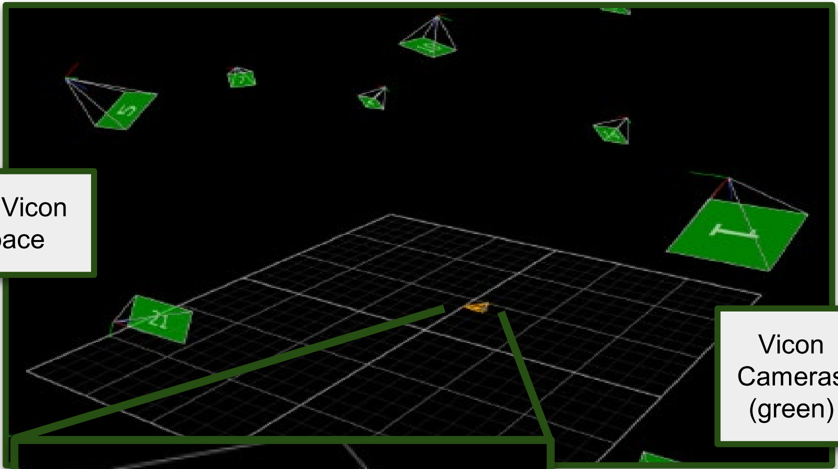
Expected Outcomes:

- Integrate position data from Vicon to get velocities
- Vicon and IMU/encoder data are compared to identify possible bias and errors in IMU/encoder data

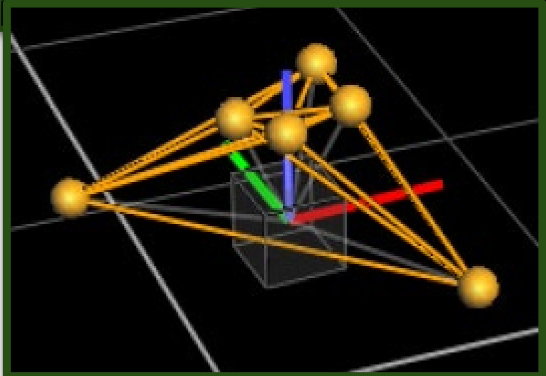
Risk Reduction:

- Identifies possible truth data biases and errors
- Allows team to rely on IMU/encoder data for “Day in the Life” test

ASPEN Lab Vicon working space



Vicon Cameras (green)



Courtesy of Integrated Remote and In-Situ Sensing ASPEN Lab

Client+Servicer

DR: All design requirements

Test Status	Not Started

Rationale:

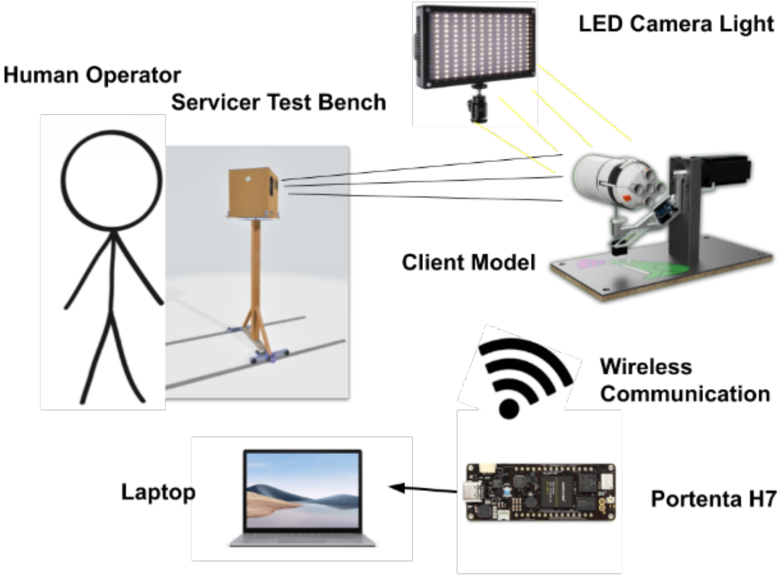
- Validate design requirements against original project goals
  - Evaluate achieved levels of success
- Validate Servicer software with client model in a various of modes

Procedure:

- Run servicer environment and begin LiDAR data capture
- Begin client model rotation
  - 1, 2, and/or 3-axis rotation
- Compare future state predictions with client sensor data
- Repeat for variety of dynamical states and lighting conditions

Expected Outcomes:

- Minimum success levels achieved
- Flaws and areas of improvement determined at a full system scale



Equipment: Full System
Location: AERO N200/Fiske Planetarium

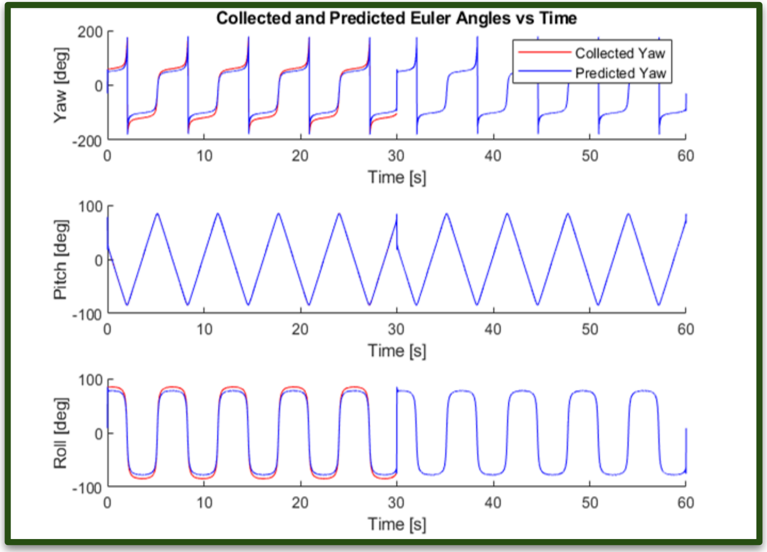
DR: All design requirements

Validation Method:

- Compare predictions from servicer and data from client
  - Encoders/IMU data to compare with prediction data from the servicer

Outputs:

- Client outputs
  - Encoder data of motor positions
  - IMU data of rocket body orientations
  - Combine to create an accurate model of client motion
- Servicer outputs
  - LiDAR data containing client point cloud
  - Algorithm output with client rotation estimations and future prediction



Pass Criteria [Software Validation]

- Software calculations match truth data to a <10% margin of error.
- Software is capable of characterizing the future steady state trajectory of the client

Testing Status Update
Test Readiness

Level	Test	Test Status	Next Steps
Servicer Subsystem	Software Identification	In Progress	• Restore point clouds to Matlab • Implement range mask & bounding box
Servicer Subsystem	Software Prediction	In Progress	• Optimize template matching algorithm (for time and accuracy)
Client Subsystem	Arduino Communications	Failed	• Retest with Wifi communications
Client Subsystem	Motors & Controllers	In Progress	• Motor 2 basic functionality test • Motor 3 test under load
Full Client System	Vicon Testing	Not Started	• Finish metal manufacturing for client • Validate arduino communications • Schedule ASPEN room testing time
Full System	Day in the Life Testing	Not Started	• Complete lower level testing

Project Budget

Project Financials
Budget

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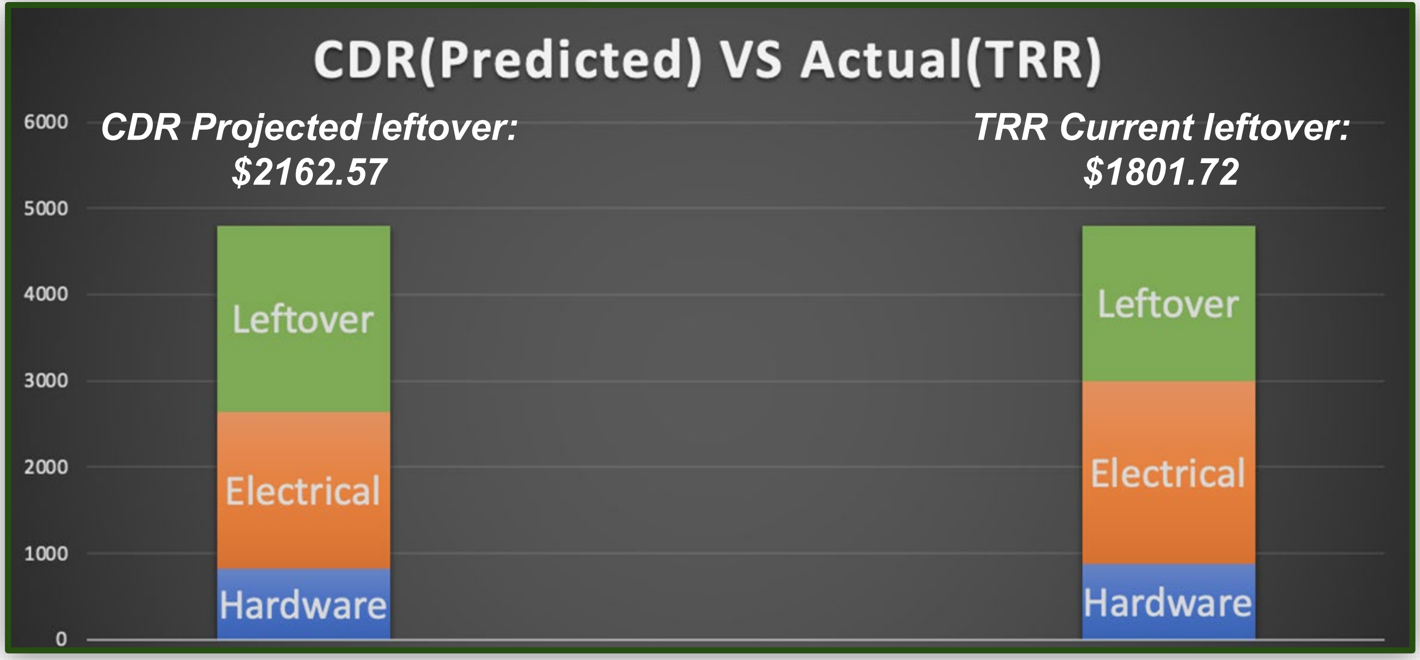
- ➢ All Planned Expenses Completed
- ➢ $1500 of margin reserved for possible LiDAR improvement.

Total Budget	$5000
Deposit	- $200
All tracked expenses	-$2998.28
Leftover	**$1801.72**

← *Large Margin*



Acknowledgements

Astroscale:

Sam Laurila and Rebeca Griego

Senior Design Coordinators:

Dr. Kathryn Wingate and Dr. Jelliffe Jackson

Our Project Advisor:

Dr. Yu Takahashi

And the rest of the PAB and TAs

Backup Slides

Backup Slides - Software/LiDAR

Backup Slides - Servicer

Backup Slides - Client

Budget Detailed Spendings

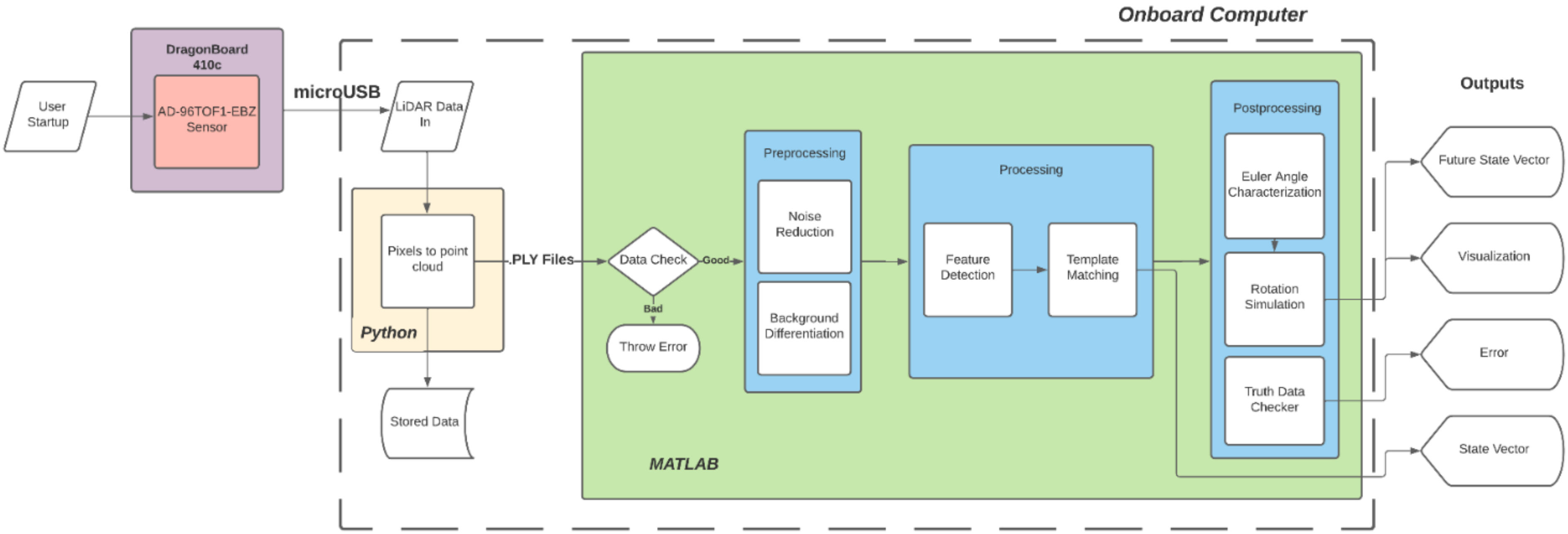
Project Levels of Success

Overview

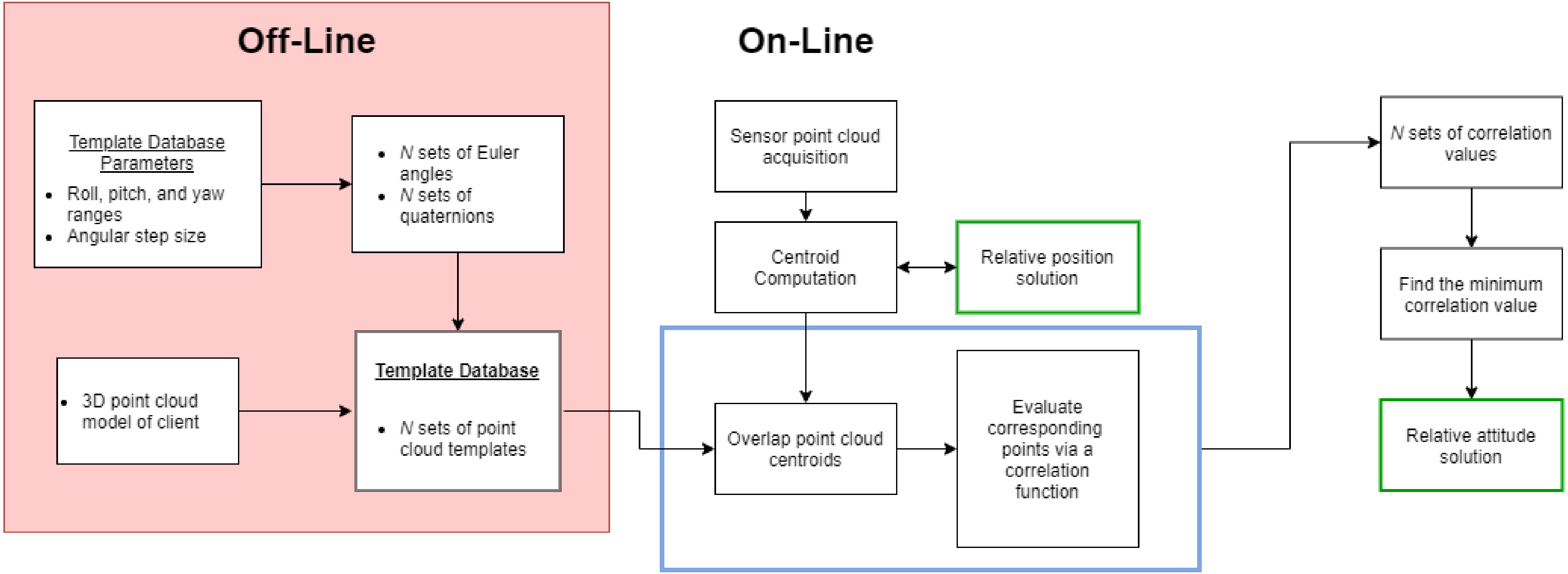
Level 4		**Physical enclosure** housing all electronics and sensors	Physical model of client with **three axes of rotation**		**Continuous real time** imaging data collection of client model	Software **differentiates client** from background and models tumble under variable lighting conditions	Software meets accuracy requirements of level 2 and **predicts future steady state** trajectory
Level 3	Imaging sensor **gathers and transmits** data to on-board processor, software verifies data is usable		Physical model of client with two axes of rotation	**Variable lighting** arrangement, various surface materials	Continuous slower than real time imaging data collection of client model	Software differentiates client from background and models tumble under fixed lighting conditions	
Level 2	Imaging sensor gathers and transmits data to on-board processor		Physical model of client with one axis of rotation	Variable lighting arrangement, fixed surface material	Automatically rotated stop motion imaging data collection of client model	Software processes image data input to differentiate stationary client from background	Software matches truth data to a <10% level of accuracy
Level 1	Imaging sensor on test bench that is verified to be gathering data	Electronics, sensors, and other hardware are integrated on simple test bench and organized	Physical model of stationary client	Fixed lighting arrangement, fixed surface material	Manually rotated stop motion imaging data collection of client model	Software received image data input	Software matches truth data to a <20% deviation level of accuracy
Project Elements	**Sensors and Imaging**	**Test Bench**	**Client Model**	**Testing Environment**	**Imaging Timescale**	**Data Processing**	**Prediction and Accuracy**

Backup Slides - Software/LiDAR

Software Flowchart



Template Matching



Template Matching
Update

CDR

- Only responsible for position and attitude estimates
    - Additional algorithm for the velocities
- Went through same template database for each point cloud frame

TRR

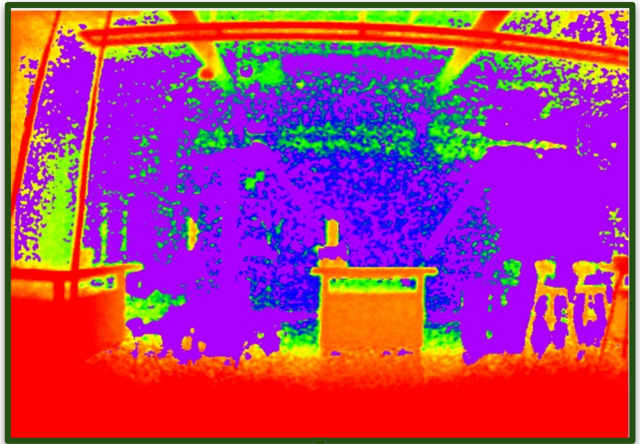
- Responsible for position, attitude, translational velocity, and angular velocity
    - Use timestamps of point clouds to compute velocities
- Each frame, in a given second, will go through a different database
    - First frame goes through a larger database
    - Take the prediction and use that for the next frame’s database
    - Next database is within 10 degrees of prior frame’s prediction
    - Repeats based on fps

Project Updates - LiDAR

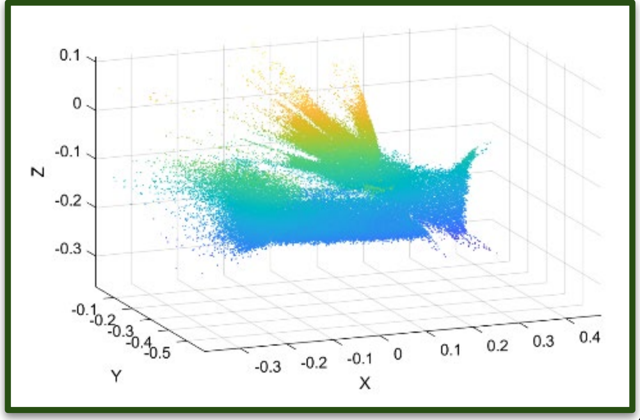
Overview

- After IDR, we successfully obtained point cloud images from our LiDAR sensor
- On 2/7, we became unable to gather point cloud data
  - Analog Devices Software Development Kit (SDK) began experiencing, what we believe to be, version compatibility issues with updated Linux OS
- Revised as of 2/13 when built on servicer computer

CDR



TRR



Project Updates - Servicer LiDAR
Overview

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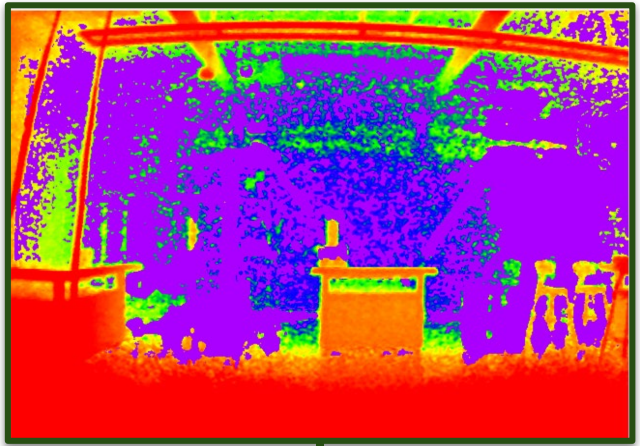
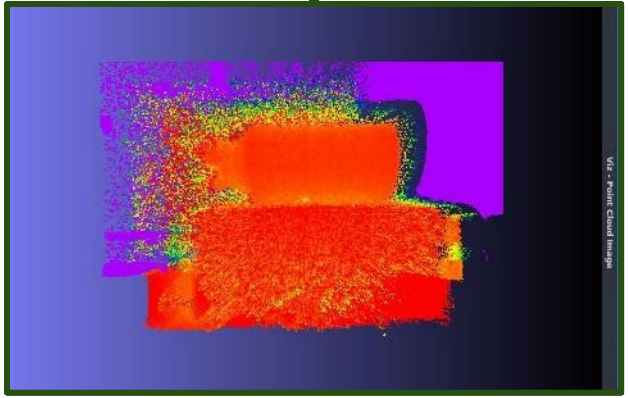
- On 2/7, the LiDAR became unable to send data
- As of 2/13, successfully obtained point cloud images from our LiDAR sensor
    - Still working to return to 2/7 state with point clouds in Matlab
- System is very finicky with respect to dependencies & version control
    - Virtual Machine, Open3D, OpenCV, Matlab, Python, Linux, etc

CDR



TRR



LiDAR Point Clouds
From 2/7

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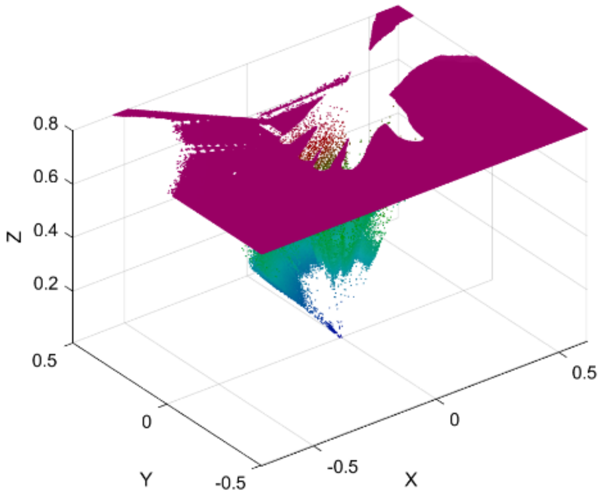
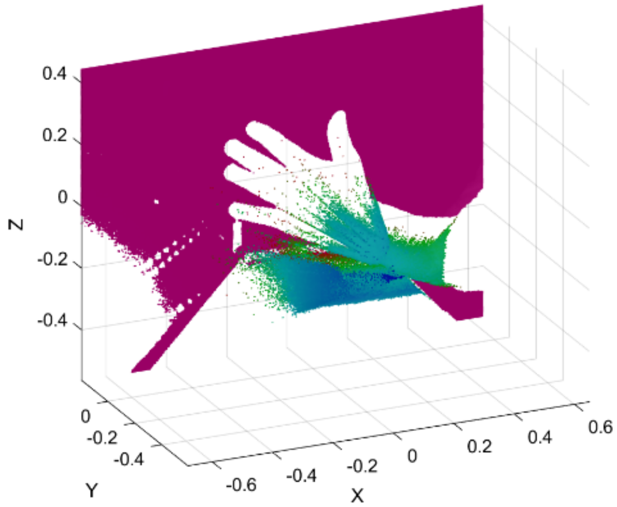
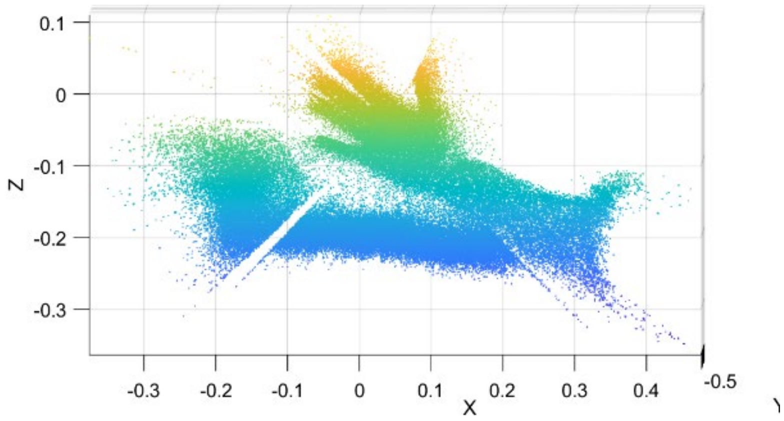


Raw Point Cloud of Hand

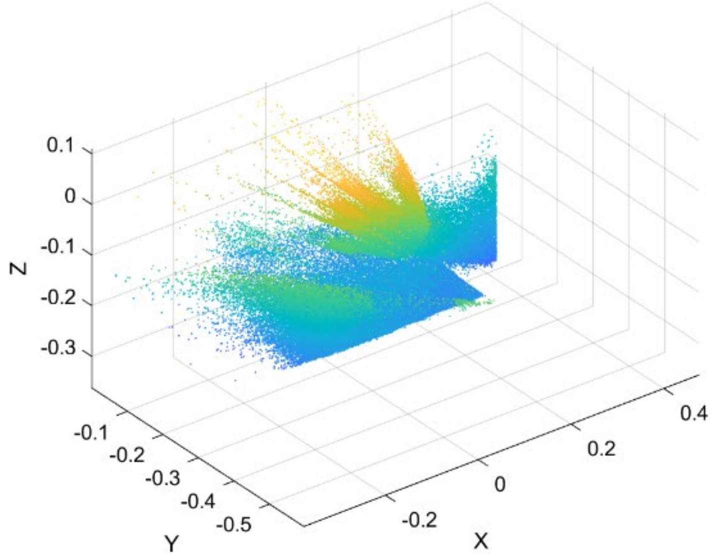


90 degree X-Axis Rotation

LiDAR Point Clouds
From 2/7

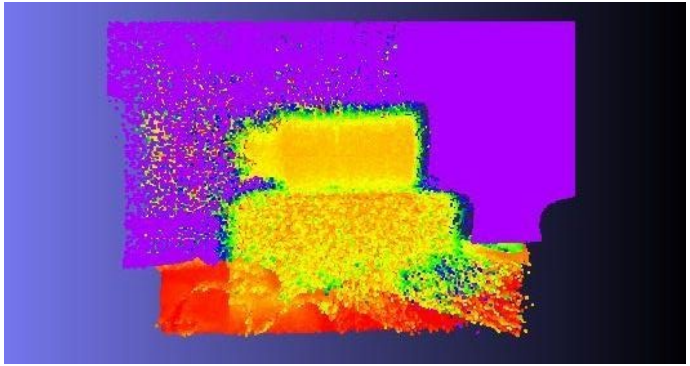


LiDAR POV

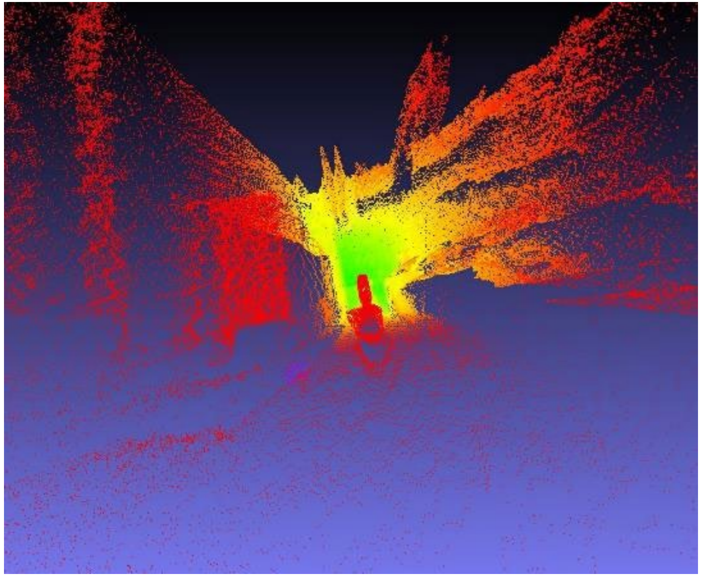


Geometric Bounding Box

LiDAR Point Clouds
From 2/13



Client in Near Mode (0.5 m)

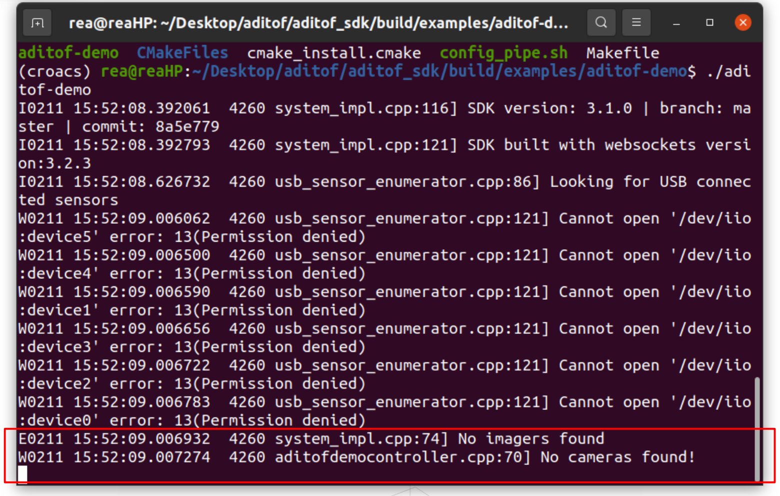


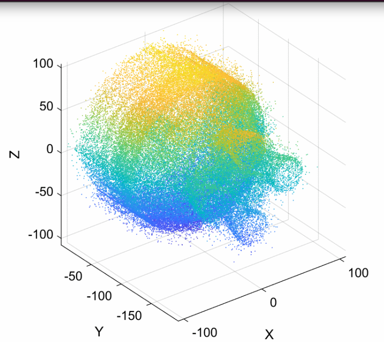
Client in Far Mode (3 m)

LiDAR Issues - Timeline

- Jan 10 - 19: Attempted to get SDK built in Linux Virtual Machine (VM)
- Jan 20: Determined that SDK cannot find the camera connection through the VM
- Jan 24 - 31: Successfully built SDK on personal Linux machine
    - Obtained point clouds from aditof-demo application
- Jan 31 - Feb 4: Successfully obtained point clouds using Python
- Feb 4 - 7: Waiting for client model to become available
- Feb 7: Scheduled client testing - LiDAR connection issues begin
- Feb 13: Successfully gained connection with LiDAR!!

Project Updates - LiDAR
Overview





<u>Plan of Action</u>

- Troubleshoot SDK issues on user-end
  - Rewrite the SD card image on the DragonBoard
  - Rebuild the SDK on the Linux environment
  - Downgrade to a previous Linux version
  - Build SDK with on-board computer
- Explore other data output methods
  - LiDAR still works, we cannot interface with it
- Purchase new LiDAR sensor
- Use simulated data to continue testing algorithms

LiDAR Issues


```
rea@reaHP: ~/Desktop/aditof/aditof_sdk/build/examples/aditof-d...
aditof-demo  CMakeFiles  cmake_install.cmake  config_pipe.sh  Makefile
(croacs) rea@reaHP:~/Desktop/aditof/aditof_sdk/build/examples/aditof-demo$ ./adi
tof-demo
I0211 15:52:08.392061  4260 system_impl.cpp:116] SDK version: 3.1.0 | branch: ma
ster | commit: 8a5e779
I0211 15:52:08.392793  4260 system_impl.cpp:121] SDK built with websockets versi
on:3.2.3
I0211 15:52:08.626732  4260 usb_sensor_enumerator.cpp:86] Looking for USB connec
ted sensors
W0211 15:52:09.006062  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device5' error: 13(Permission denied)
W0211 15:52:09.006500  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device4' error: 13(Permission denied)
W0211 15:52:09.006590  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device1' error: 13(Permission denied)
W0211 15:52:09.006656  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device3' error: 13(Permission denied)
W0211 15:52:09.006722  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device2' error: 13(Permission denied)
W0211 15:52:09.006783  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device0' error: 13(Permission denied)
E0211 15:52:09.006932  4260 system_impl.cpp:74] No imagers found
W0211 15:52:09.007274  4260 aditofdemocontroller.cpp:70] No cameras found!
```

```
rea@reaHP: ~/Desktop/aditof/aditof_sdk/build/examples/aditof-d...
I0211 15:52:08.626732  4260 usb_sensor_enumerator.cpp:86] Looking for USB connec
ted sensors
W0211 15:52:09.006062  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device5' error: 13(Permission denied)
W0211 15:52:09.006500  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device4' error: 13(Permission denied)
W0211 15:52:09.006590  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device1' error: 13(Permission denied)
W0211 15:52:09.006656  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device3' error: 13(Permission denied)
W0211 15:52:09.006722  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device2' error: 13(Permission denied)
W0211 15:52:09.006783  4260 usb_sensor_enumerator.cpp:121] Cannot open '/dev/iio
:device0' error: 13(Permission denied)
E0211 15:52:09.006932  4260 system_impl.cpp:74] No imagers found
W0211 15:52:09.007274  4260 aditofdemocontroller.cpp:70] No cameras found!
^C
(croacs) rea@reaHP:~/Desktop/aditof/aditof_sdk/build/examples/aditof-demo$ dmesg
 | grep TOF
[ 2009.877632] usb 1-1: Product: ADI TOF DEPTH SENSOR
[ 2009.899791] usb 1-1: Found UVC 1.00 device ADI TOF DEPTH SENSOR (1d6b:0102)
[ 2009.904974] input: ADI TOF DEPTH SENSOR: ADI TOF D as /devices/pci0000:00/000
0:00:14.0/usb1/1-1/1-1:1.0/input/input31
(croacs) rea@reaHP:~/Desktop/aditof/aditof_sdk/build/examples/aditof-demo$
```

LiDAR Action Plan

SDK Troubleshooting

- ❏ Contact Analog Devices
- ❏ Rewrite the SD card image on the DragonBoard
- ❏ Rebuild the SDK on the Linux environment
- ❏ Downgrade to a previous Linux version
- ❏ Build SDK with on-board computer

Environment Location

- ❏ Install SDK environment directly on the DragonBoard
- ❏ Transfer point cloud data from DragonBoard to on-board computer

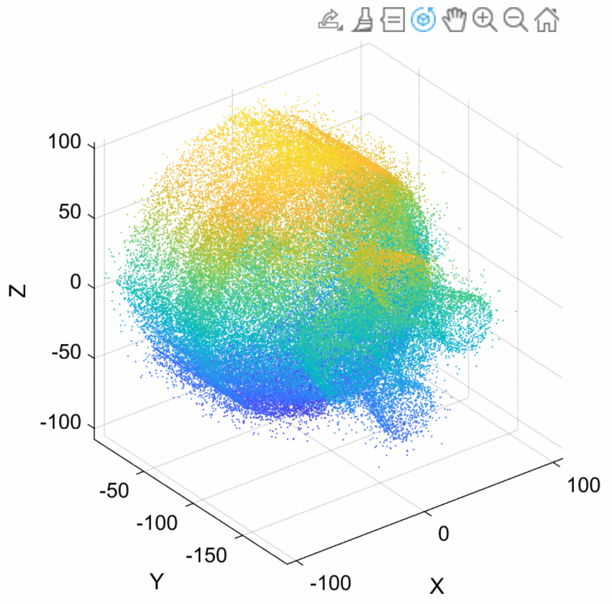
Purchase New LiDAR

- ❏ Neuvition Titan S2
- ❏ Helios2 Time-of-Flight Camera

Simulate LiDAR Data

- ❏ Create data from full point cloud of client
- ❏ Send through software

LiDAR Simulation



1. Use .STL file of client to create full 3D point cloud
2. Add noise
3. Set viewing position (looking positive y-axis)
4. Simulate rotation through transformation matrices (3-2-1)
5. Send through software algorithms

LiDAR Alternates

Neuvition Titan S-2

- Interface:
  - 4-pin, M12 x 1 connector, A-Coded (power interface)
  - 8-pin,M12 x 1 connector, A-Coded (ethernet interface)
- Output:
  - 3D space coordinate & timestamp

Helios2 Time-of-Flight Camera

- Interfaces:

Digital Interface	1000BASE-T GigE, M12 X-coded, PoE
GPIO Interface	8 pin M8 connector
Opto-Isolated I/O Ports	1 input (2.5V-24V and 10.5V-24V), 1 output
Non-Isolated I/O Ports	2 bi-directional

- Output:
  - Binary .PLY file (via Arena SDK)

Servicer

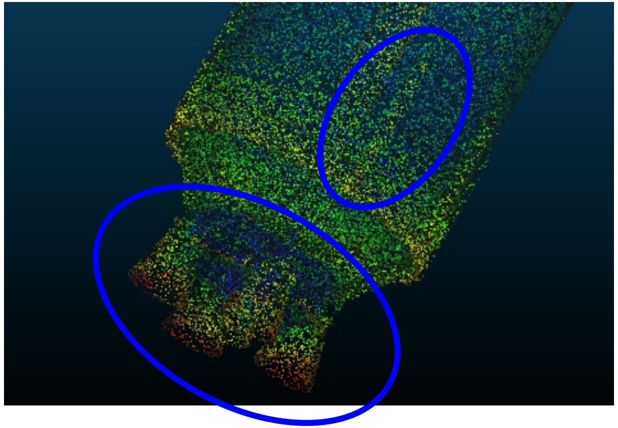
DR 2.1: The software algorithm shall identify the known client from the background.

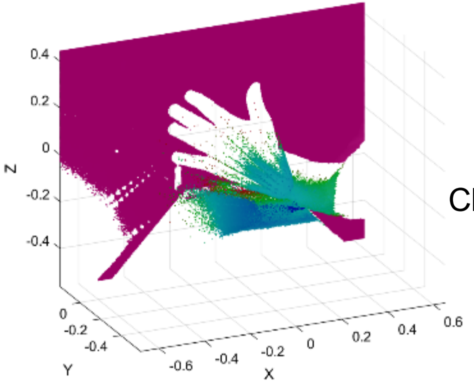
Outcomes:

- Expected Results
  - Validate feature recognition models from CDR
    - Identification of nozzles, ridges, and/or surfaces

Risk Reduction:

- Validates LiDAR performance before comprehensive system testing
- Verify that features on the client can be recognized





Raw Point Cloud Data at ~80cm

Backup Slides - Servicer

DR 4.1: The enclosure shall be built to secure the physical electronics in place.
DR 4.2: The enclosure shall supply the correct power to all hardware and integrate electrical components it is housing.

Test Status	Completed

Rationale:

- Demonstrate that the servicer can house and secure the electronics with adequate power allocation.

Procedure:

- Manufacture the enclosure.
- Install the electronics inside the enclosure and provide power to the components.

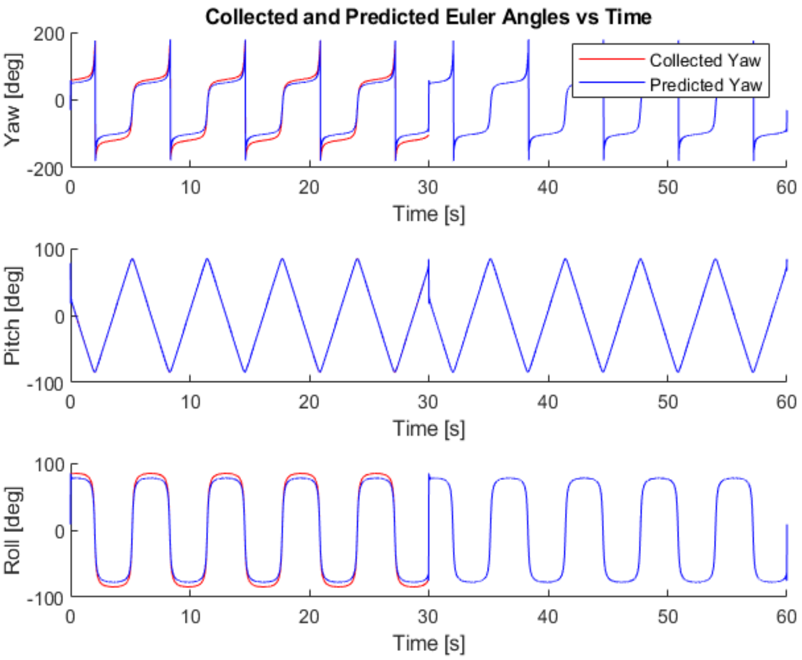
Outcomes:

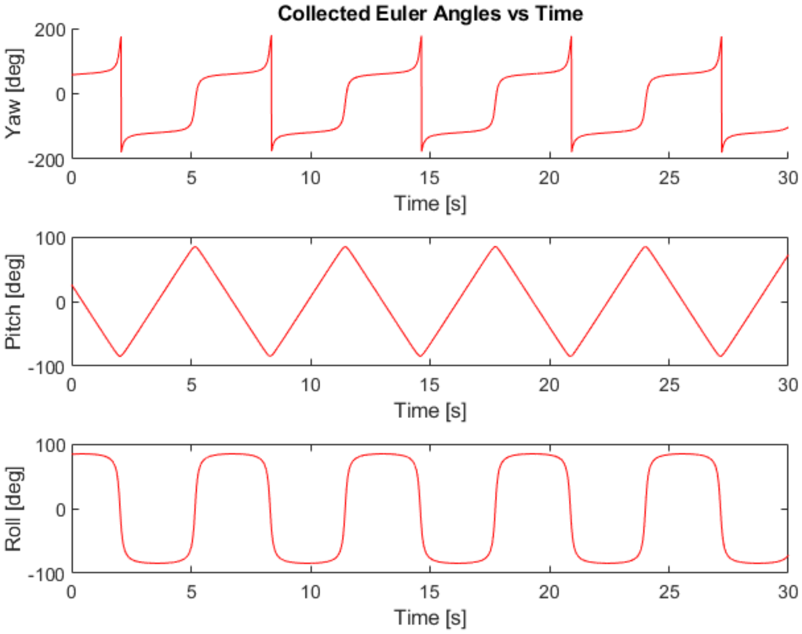
- Risk Reduction: Ease of access allows ability for removal and adjustments.

Completed enclosure with computer installed

PC Building

Servicer Software Predict
Test Readiness





Backup Slides - Client

Client Model
Test Readiness

Client

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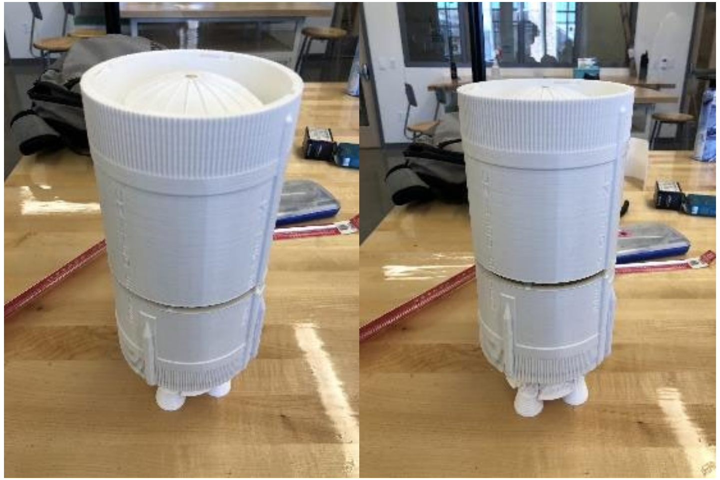
DR 5.4: The target's shape shall resemble that of the second or third stage of the selected characteristic rocket body

Test Status	Complete

Rationale:
- Demonstrate 3D printing is feasible for manufacturing of model
- Verify identifiable details are present

Procedure:
- Finalize model in CAD software
- Print model in sections
- Visually inspect and verify printed model against CAD model

Results & Risk:
- Model is complete and accurate to Saturn V second stage



Completed and verified model

Client Model
Additional Images

Client

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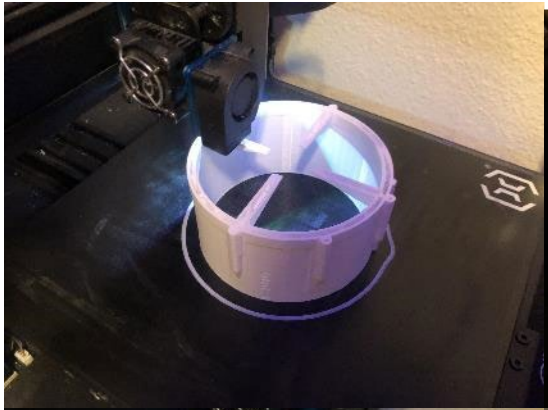
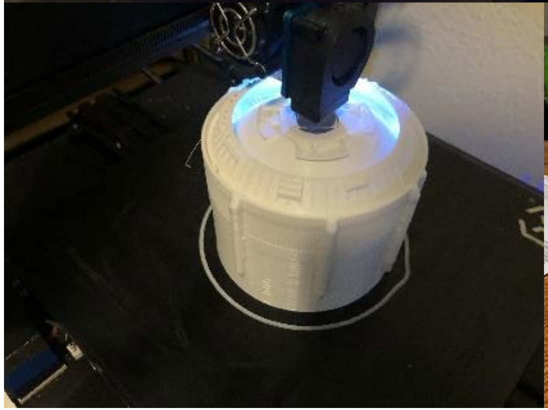
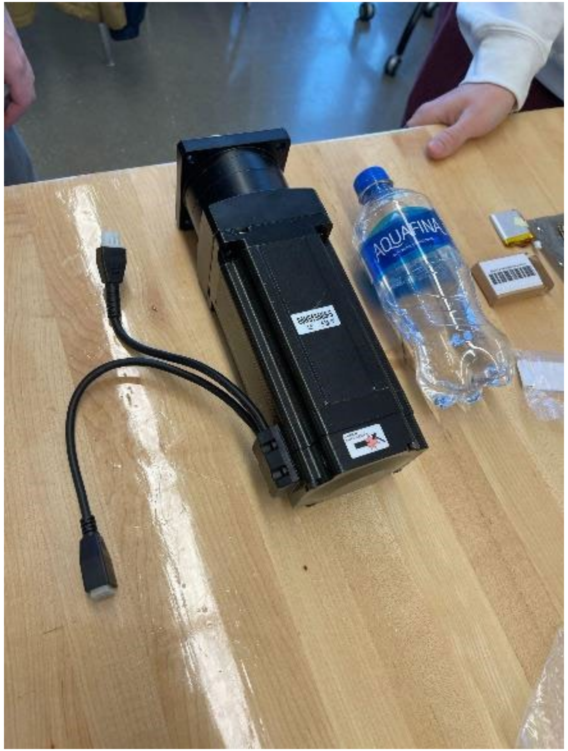



Motor 3
Misc Project Photos

Motor 3 with water bottle for scale



Manufacturing
Misc Project Photos

Client Metal Stock

Servicer Stand

LiDAR + Client Testing

Misc Project Photos

LiDAR Testing + Client Testing

Budget
Detailed Spendings

	A	B	C	D	E	F	G	H	I	J	K	L
1	General Name of product	Actual Name	Price	Purchased date	Source	Expected date of arrival	Secondary Contact / Person Requested	Actual date of arrival				
2	LiDAR	Analog Devices AD-96TOF1-EBZ 3D Time of Flight Platform with Qualcomm Devkit (174898986321)	185.01	Nov 4th, 2021	eBay (with tax paid)/ cover tax later	Nov 12, 2021	Tyler's eBay	Nov15, 2021			**Total left(starting from $4800)**	**1801.72**
3	Vector Board, JST jumper, Servo Nema 34	ebay order on Dec 20.2021--tax free eaby account	121.44	Dec 20,2021	ebay	dec29, dec27, Jan13	Jash	Jan3.2022				
4	Amazon oder	send to school	1486.37	Dec20,2021	School's amazon		Zack, Jash, Jason					
5	Encoder	send to apt	10.18	Dec22.2021	Walmart	Jan,5,2022	Jash	Jan7.2022				
6	homedepot	hardware	73.14	12.28.2021	homedepot	jan4.2022	Zack	Jan9.2022				
7	Digikey	electronics sent to school	73.91	12.23 .2021	digikey without shipping	xxx	Jash	xxx				
8	8020	sent to zack's place	214.19	Jan10.2022	8020		Zack					
9	Homedepot small stuff	pickup	39.51	Jan19.2022	hardware	Jan19.2022	Jake, Zack	Jan19.2022				
10	Metal supermarket	pickup	170.13	Jan 20. 2022	hardware		tyler ZACK					
11	amzon order 2	school	203.75	Jan24.2022	Electronic +hardware		Jash, Jake, Tyler					
12	AMT series substitute	apt	10.18	Jan28.2022	walmart	Feb10.2022	Jash					
13	Servicer encoder	school	7.49	Jan31.2022	amazon		Jake					
14	AMT encoder	school	23.86	Feb2.2022	digikey		Jash, Zack, Tyler					
15	connector	school	6.38	Feb3.2022	amazon		Jash					
16	PWM Signal Generator	school	17.79	Feb3.2023	amazon		Jake					
17	Homedepot	Pickup	18.9	Feb9.2022	Homedepot		Jake, Zack					
18	Micro center	Pickup	238.92	Feb 12.2022	Micro center		Tyler, Max, Jason					
19	Homedepot	Pick up	25.15	Feb 12.2022	Homedepot		Tyler, Jason					
20	BestBuy	Pickup	71.98	Feb13.2022	BestBuy		Tyler, Nick					
21												