

# Pocket Microscope Slide Scanner

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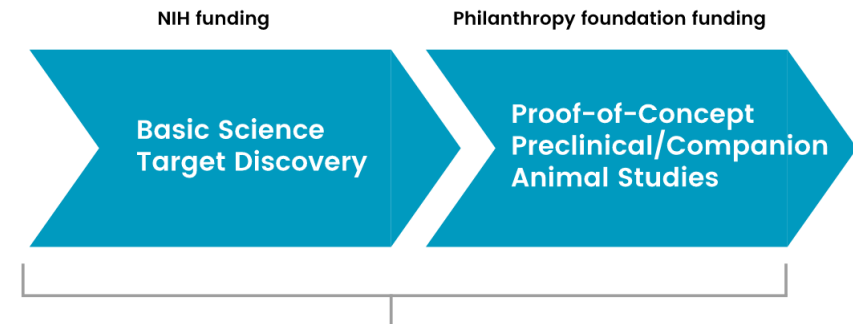
# Presentation Outline

- ❖ Project Summary:
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  - ❖ Project Value Proposition
  - ❖ Project Requirements
- ❖ Project Final Design:
  - ❖ Concept
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  - ❖ Stage Design
  - ❖ Cassette/Lighting
  - ❖ Enclosure Design
  - ❖ Electrical System
- ❖ Software Design
- ❖ Budget
- ❖ Question and Discussion

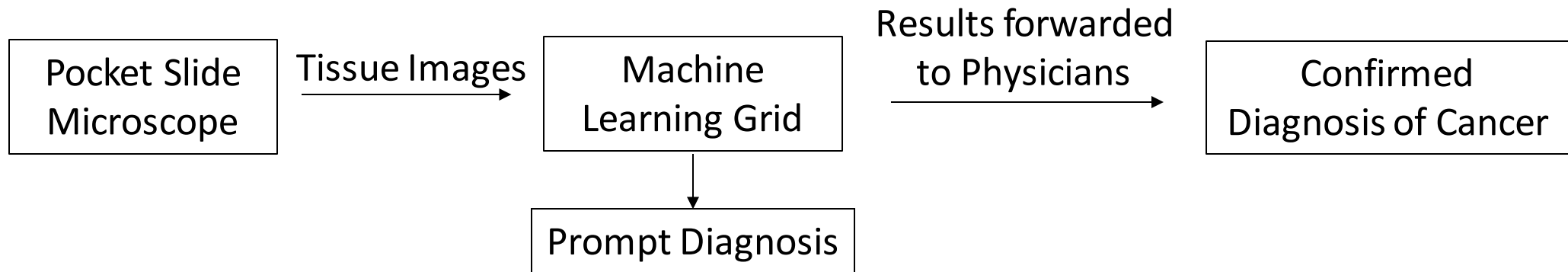


# Background

- According to the World Health Organization, 70% of deaths caused by cancer worldwide occur in developing countries.
- Many forms of these cancers are not terminal if caught early enough.



# Value Proposition



We aim to create a device that will:

- Capture an extremely high-resolution image of a sample of tissue
- Stitch 100's of images to achieve desired resolution
- Interface directly with a user's phone

We offer an affordable, highly portable, rugged, and practical solution for early cancer detection.



# Project Requirements

## Cost Requirement

- Device will cost < \$1000

## User Interface Requirements

- Minimal buttons
- Interface smartphone via Apollo app support
- Live view of slide
- Coarse and fine adjustments to adjust field

## Storage and Battery Requirements

- MicroSD card support
- Utilization on phone storage
- Connectivity with online cloud storage
- Minimum of 8000 acquisitions per charge cycle

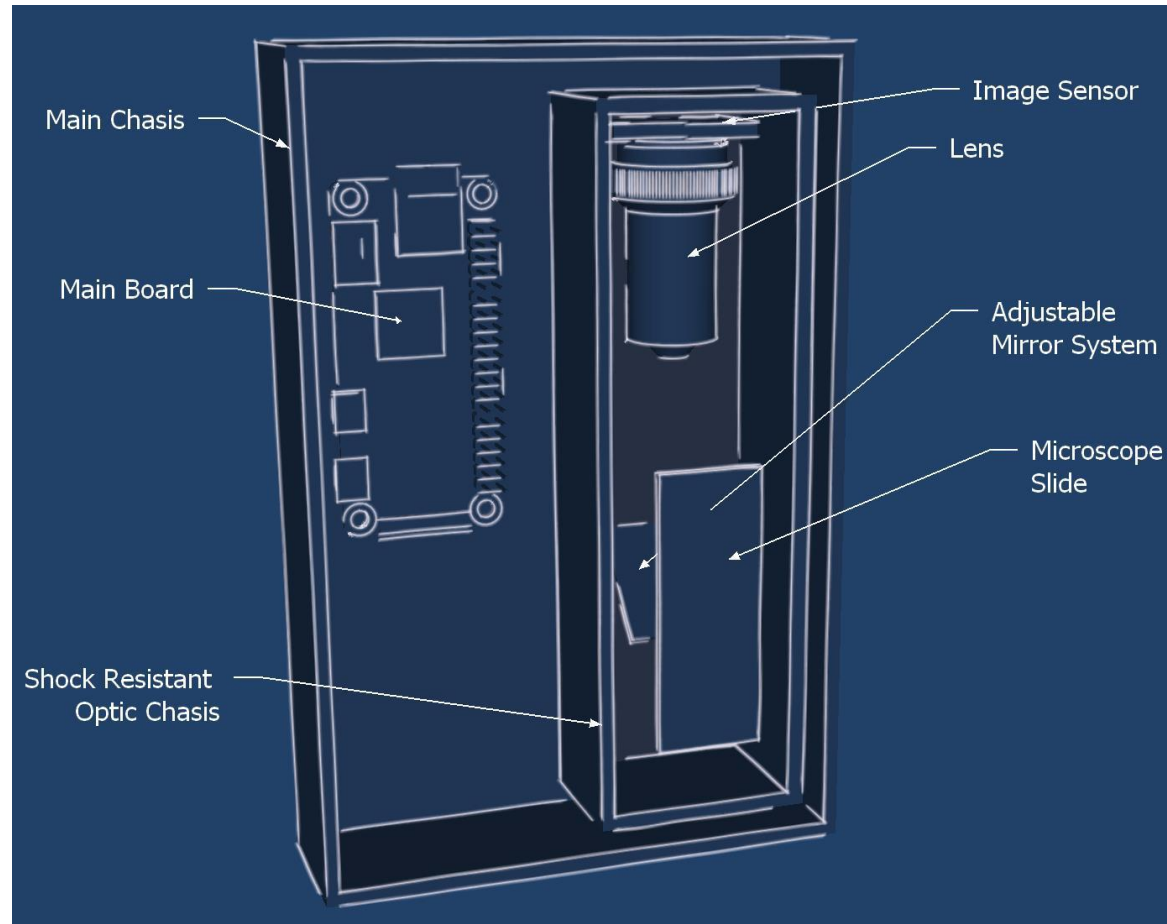
## Optics and Camera Requirements

- 40X effective zoom
- 0.5  $\mu\text{m}$ /pixel resolution
- large format imaging capability (up to 1cm<sup>2</sup>)
- LED light source (5600K)
- Auto white-balance (optional)
- Auto-focus

## Networking Requirements

- Wi-Fi (802.11 b/g/n compliant)
- Bluetooth 4.1 compliant
- 4G LTE when paired with smartphone

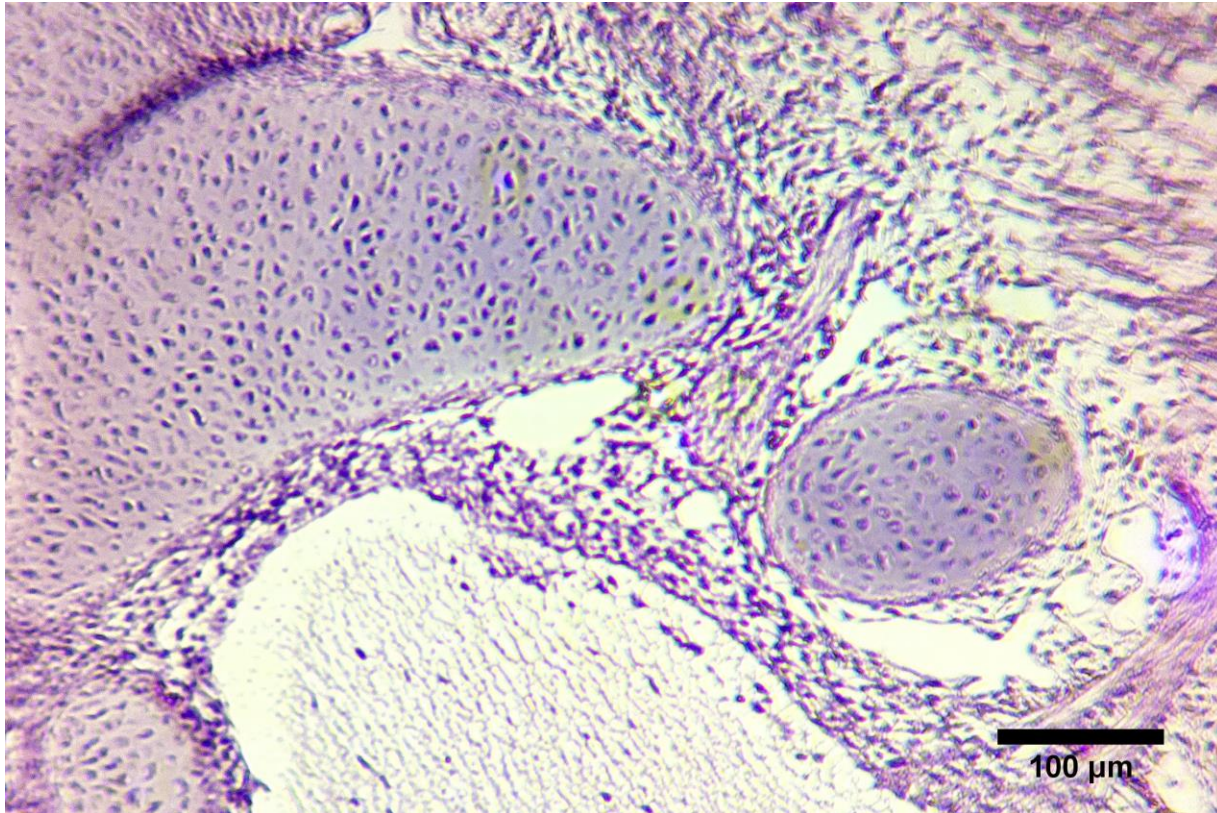
# Design Concept



- Standalone and optimized device
- Utilizes a Raspberry Pi 4 to process and distribute image to phone
- Optimized stitching algorithm executed on-board RPi 4
- RPi4 Compatible CMOS image sensor
- Bluetooth connectivity to phone
- Phone app for device control



# Proof Of Concept



- Prototype of Optics System yielded 0.31μm/px image resolution



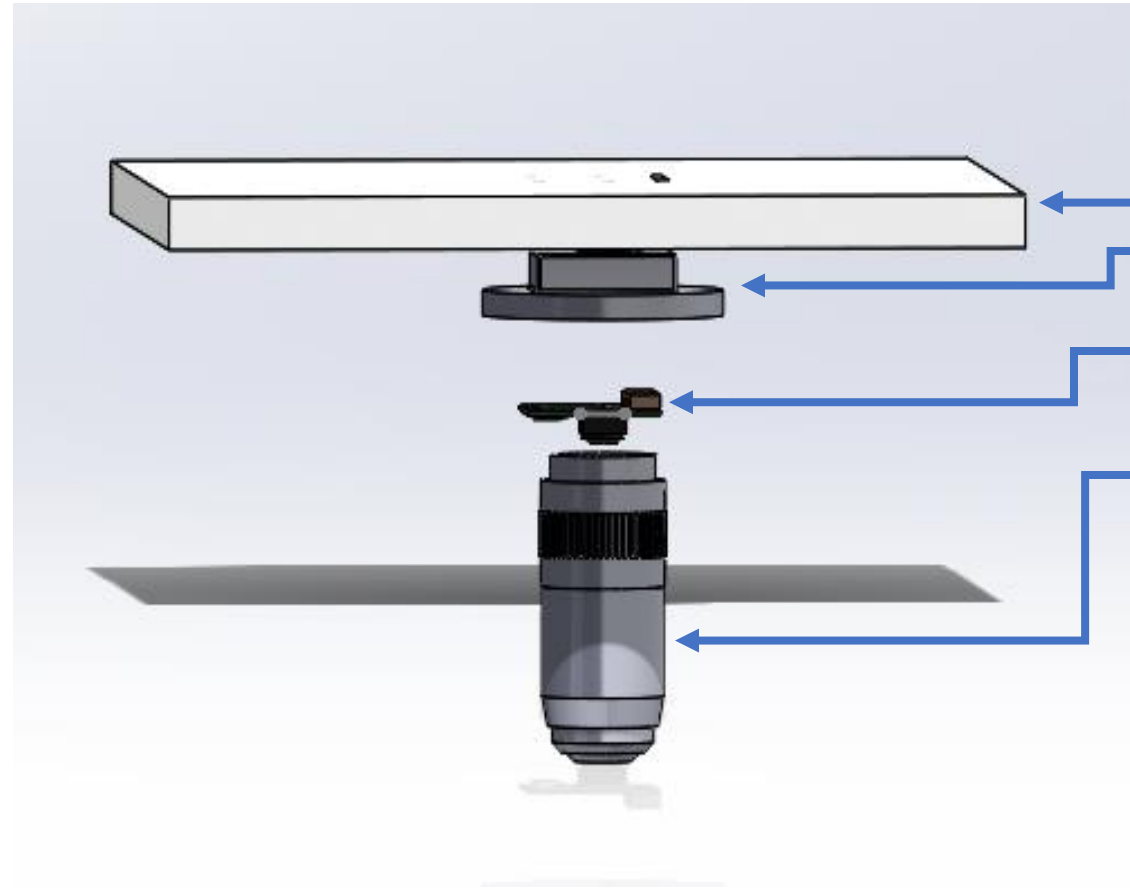
# Complete Design Overview

- 5 Systems

System	Purpose
Optics System	capture 0.35 $\mu$ m/px images
Stage	able to move in XYZ planes
Lighting Apparatus	shine monochromatic light through slide
Cassette	insert slide into device
Electrical	provide power to needed components



# Optics Design



Camera mounting platform

RMS threaded adapter for  
image sensor

8MP Sony IMX219 Sensor

20X Plan Apo objective  
( $0.35 \mu\text{m}/\text{pixel}$ )

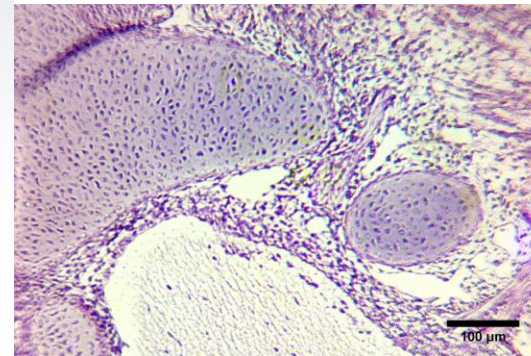
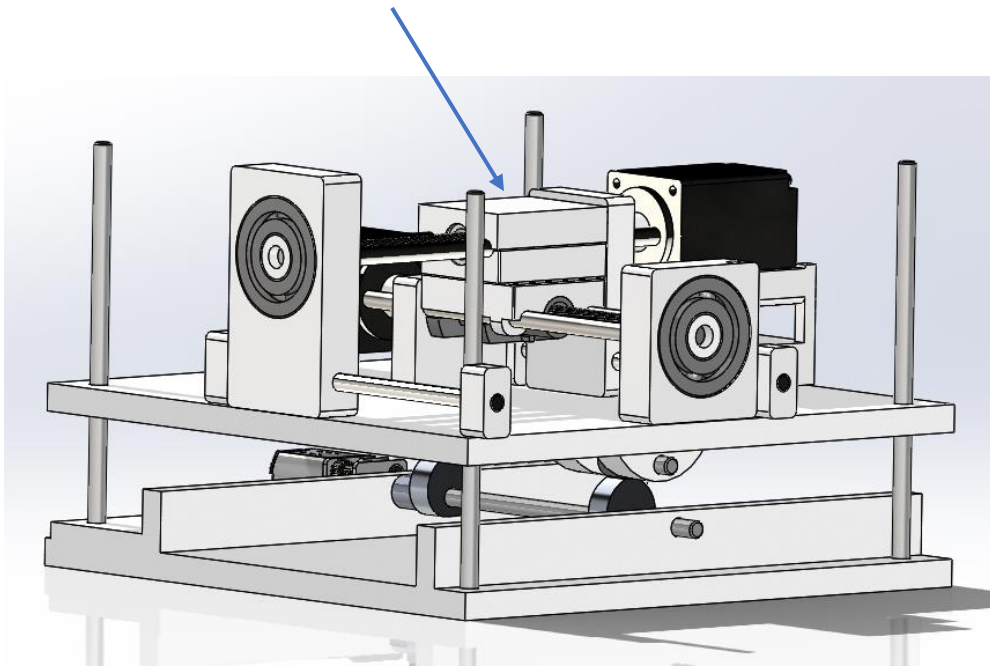


Image obtained during  
prototyping with the given  
hardware

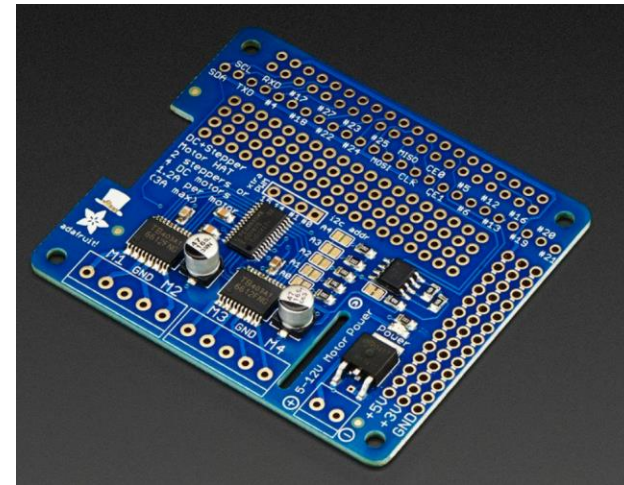


# Stage Design

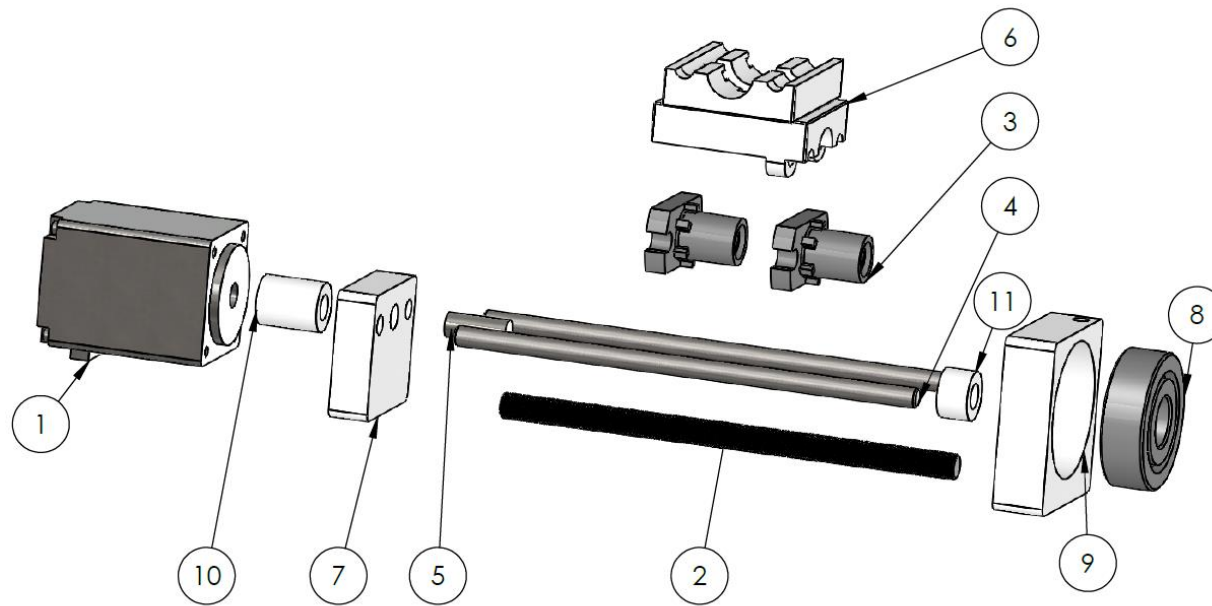
Cassette with microscope slide



- Dimension: 4.53 in (L) \* 4.25 in (W) X 2.5 in (H)
- Motor connected to Raspberry Pi using Motor HAT



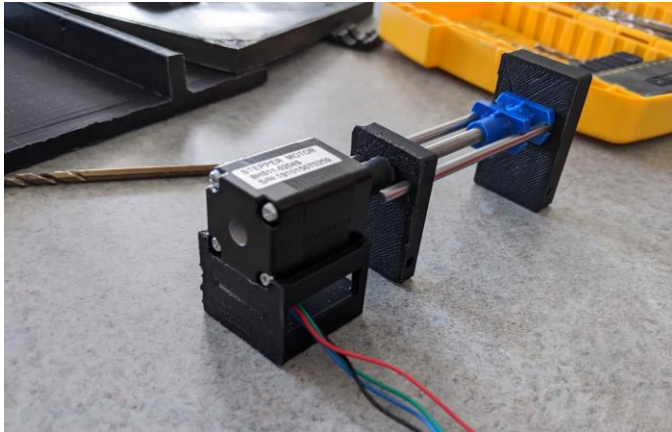
# X Stage



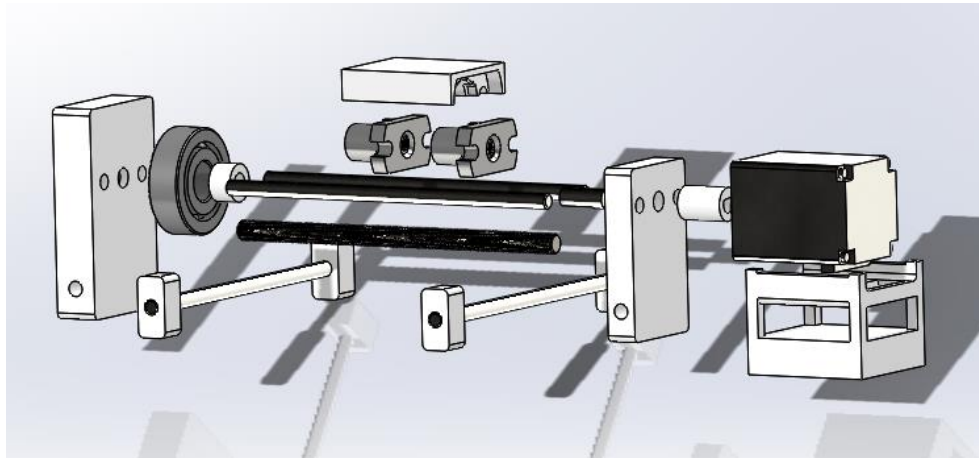
ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	01-01 Stepper Motor	Plain Carbon Steel	1
2	7549K53	Acetal Plastic	1
3	01-06 7549K630_RIGHT-HAND PRECISION ACME LEAD SCREW	Acetal Plastic	2
4	1327K93	12L14 Carbon Steel	2
5	01-02 Stepper motor Shaft	Plain Carbon Steel	1
6	01-05 Carriage	ABS	1
7	01-07 End Cap for Rail	ABS	1
8	5972K91	Steel	1
9	01-09 End Cap with ball bearing	ABS	1
10	01-10 D-shaft fitting	ABS	1
11	01-11 Bearing fitting	ABS	1

- Stepper motor: 1.8 deg step angle
- Lead Screw: 0.3 mm per turn
- 0.0015 mm per step
- Image Size: 0.010168 (H) 0.0076 mm (V)





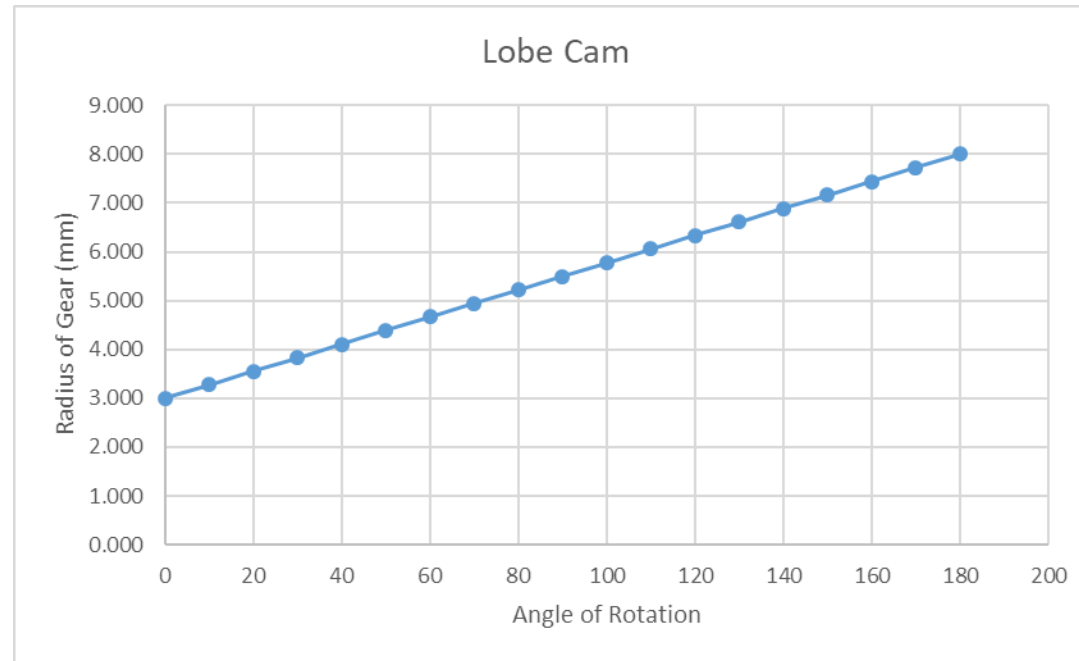
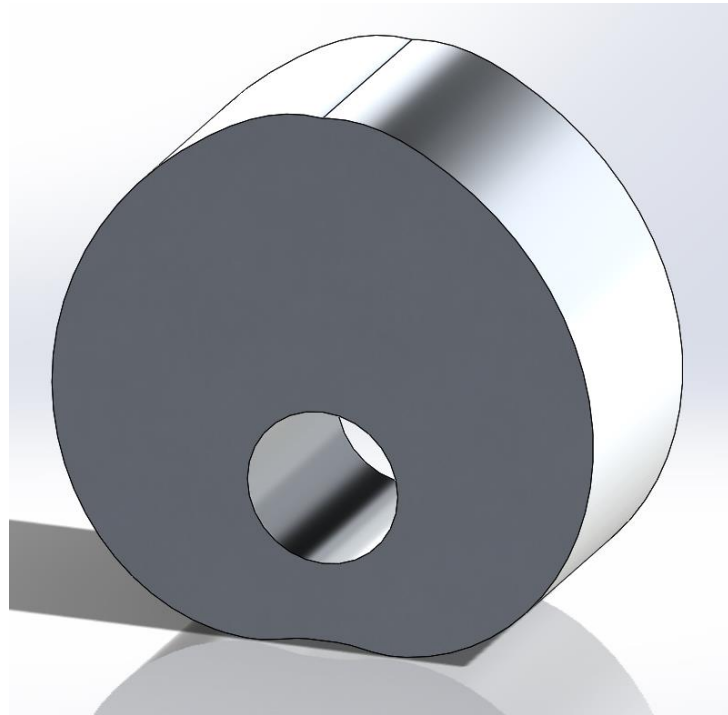
# Y Stage



ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	02-01 Stepper Motor	Alloy	1
2	7549K53	303 Stainless Steel	1
3	02-07 Flange Nut 7549K630_RIGHT-HAND PRECISION ACME LEAD SCREW	Acetal Plastic	2
4	02-06 End Cap for rail	ABS	1
5	02-02 Stepper motor Shaft	Plain Carbon Steel	1
6	1327K93	12L14 Carbon Steel	4
7	02-05 Carriage	ABS	1
8	02-013 End Cap for rail with Ball Bearing	ABS	1
9	5972K91	Steel	1
10	02-10 D-shaft fitting	ABS	1
11	02-11 End Rail cap 2	ABS	4
12	02-12 Bearing fitting	ABS	1
13	02-08 Stepper motor Stand	ABS	1

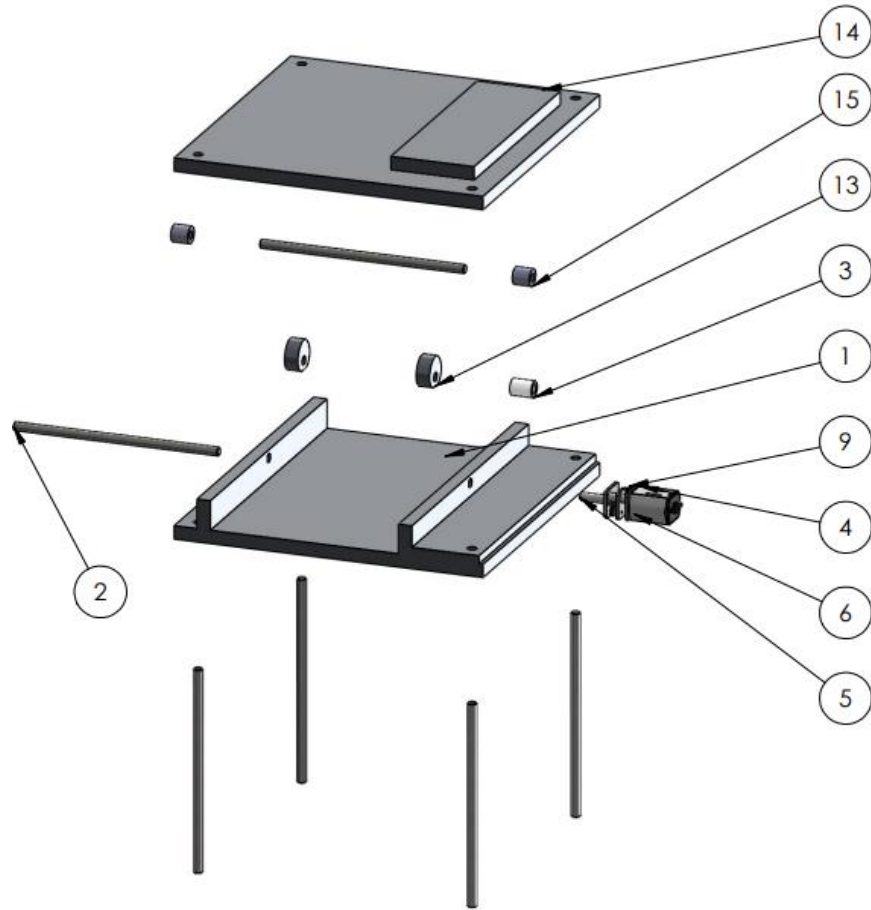


# Z Stage





# Z Stage

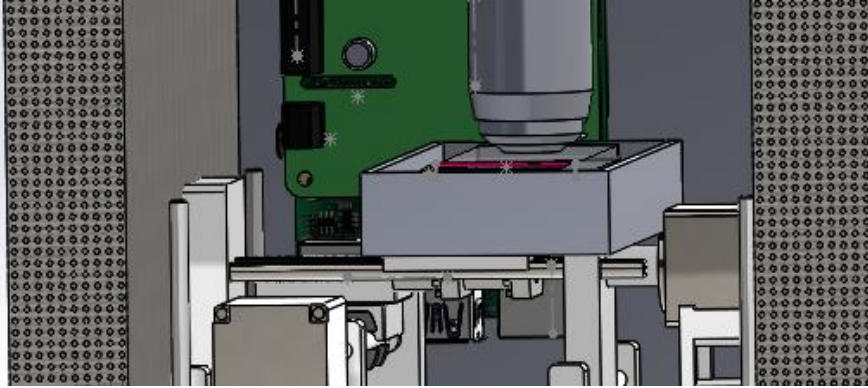


ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	03-01 Z-stage bottom part V2	1060 Alloy	1
2	1327K93	Plain Carbon Steel	6
3	03-06 Dshaft Z DC motor coupling	ABS	1
4	motor	N/A	1
5	n20_shaft	N/A	1
6	n20_gearbox	N/A	1
7	GB_CROSS_SCREWS_T YPE4 M1.6X3-2 H type-N	N/A	2
8	GB - Spur gear 5M 20T 20PA T2FW --- S20A75H50L10.0N	N/A	2
9	GB - Spur gear 5M 20T 20PA T2FW --- S20A75H50L10.0N	N/A	1
10	GB - Spur gear 5M 20T 20PA T2FW --- S20A75H50L10.0N	N/A	1
11	GB - Spur gear 5M 20T 20PA T2FW --- S20A75H50L10.0N	N/A	1
12	GB - Spur gear 5M 20T 20PA T2FW --- S20A75H50L10.0N	N/A	1
13	03-07 Lobe Cam V2	1060 Alloy	2
14	03-03 Z-stage top part V2	1060 Alloy	1
15	2639T1	Nylon 101	2





# Cassette/Lighting



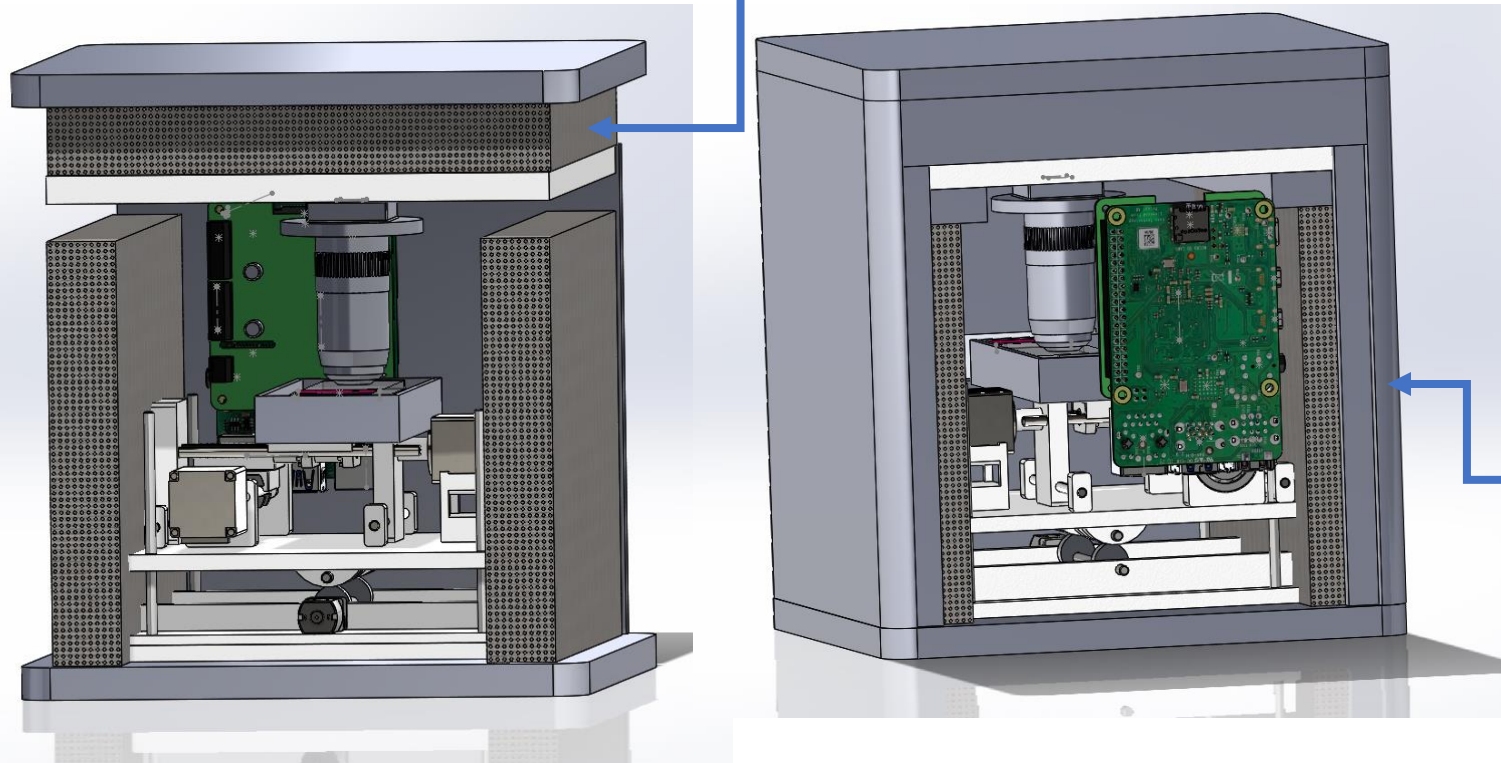
Slide cassette slides through drawer and has lighting system built in.



White light LED backlighting module diffused through glass



# Enclosure Design

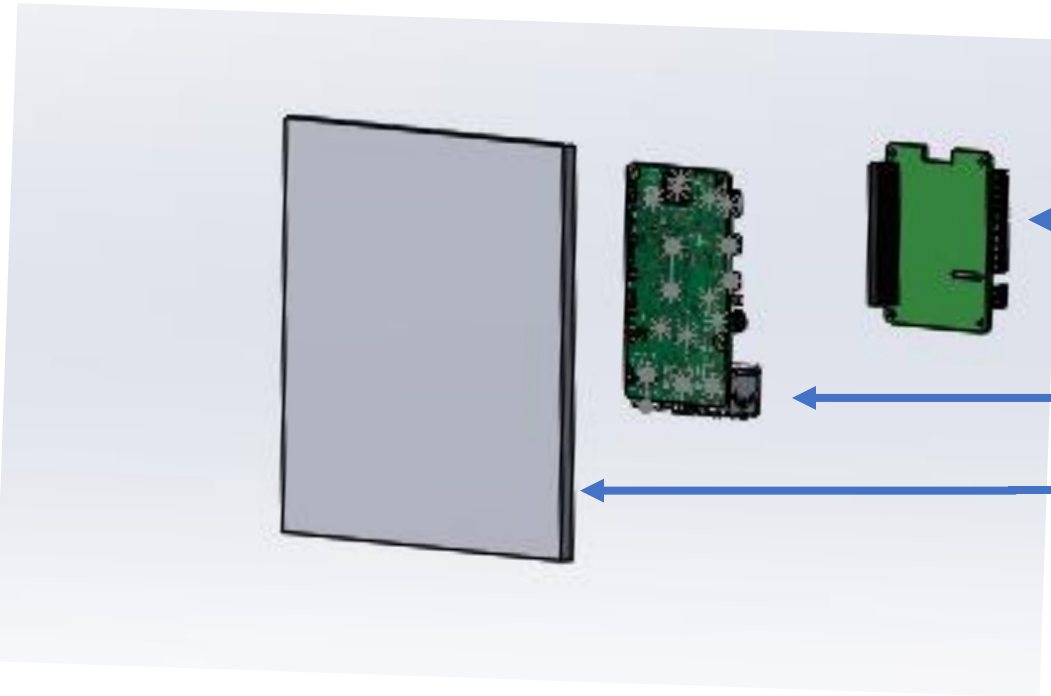


TPU flexible filament printed with 1.0 mm diameter pores for shock absorption, allowing up to ~1.5 cm of displacement

Enclosure is made of ABS plastic composed of 3 pieces, top, bottom, and side walls. The rear piece is an aluminum block that acts as a heat sink for the computer hardware.



# Electrical System



Motor hat for DC and  
stepper motor control  
system

Raspberry Pi 4 for image  
acquisition and processing

Components are mounted  
to alluminium block for  
heat exchange



# Electrical System

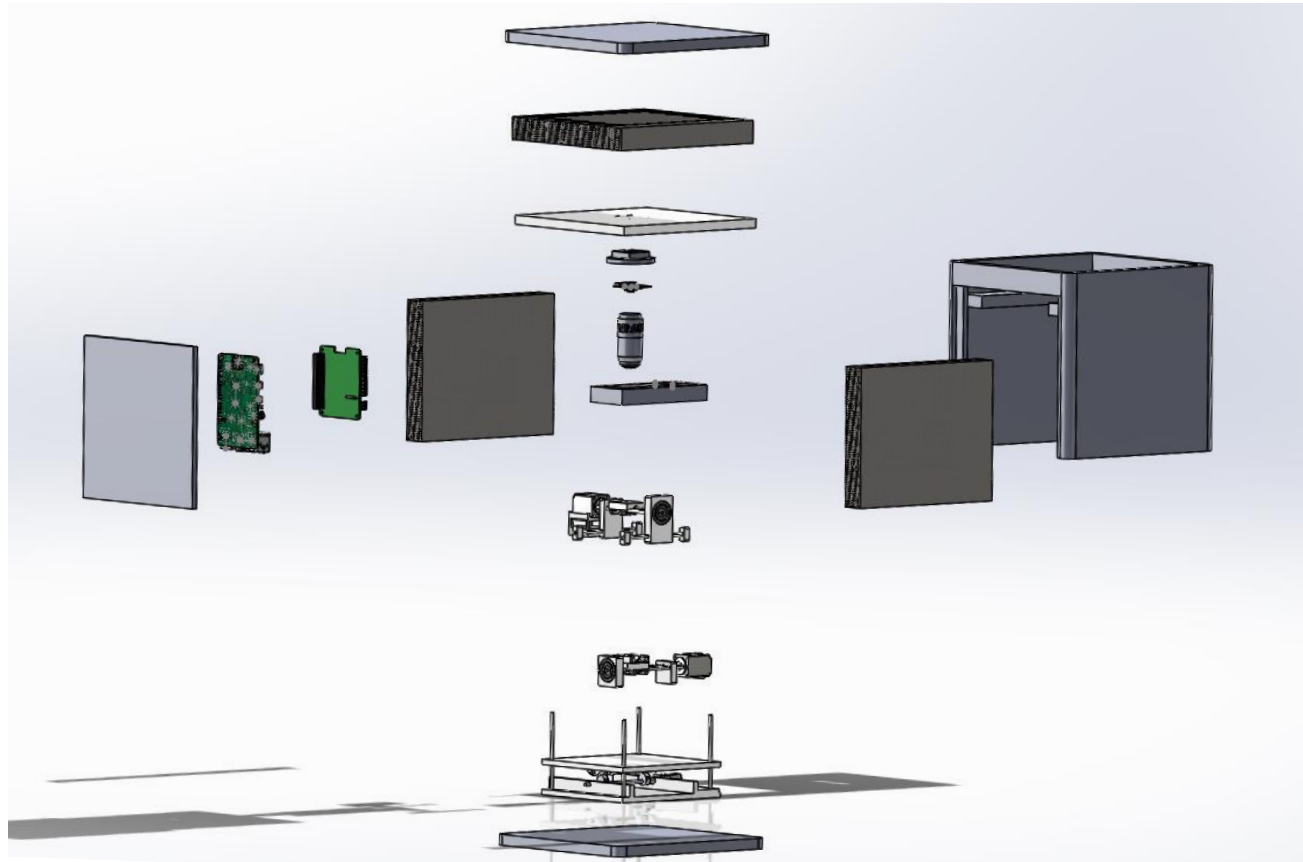


PiJuice Hat – Provides power to raspberry Pi

Options available of up to 12,000 mAh capacity



# Final Assembly



## Assemblies

1. Optics Housing
2. XYZ assembly
3. Slide Cassette
4. Enclosure/  
5. Shock Absorbing System





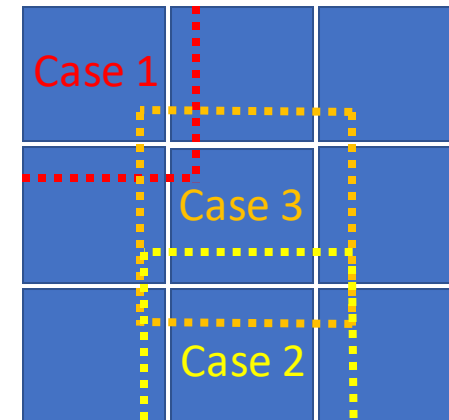
# Image Stitching Calculations

## Calculations done on an Excel Spreadsheet

	A	B	C	D	E	F	G
1	Resolution	0.31 microns/pixel					
2	Pixels in an image	3280	2464	H and V respectively	*got from lens manufacturer website		
3	Size of the image	1016.8	763.84	microns	1.331168831	Aspect ratio (H/V)	1.33117
4		0.10168	0.07638	cm			0.00583
5	Total area of an image	0.007766725	cm <sup>2</sup>		*Without overlap	V	0.07638
6	Target Image Area	1	cm <sup>2</sup>			H	0.10168
7	<b>Number of images needed</b>	<b>128.7543958</b>		1.33117			
8	<b>Percent Overlap</b>	<b>25.00%</b>		0.00583			
9			V	0.07638			
10			H	0.10168			
11		Horiz.	Vert.				
12	Initial Assumption of Rows and coulms respect	24	24	if we don't meet the target area then will add rows/column as needed			
13	<b>Number of cells (images)</b>	<b>576</b>					
14	Desired deduction of area per strip	0.001941681					
15	Horizontal deduction	0.019096					
16	Vertical deduction	0.02542	cm <sup>2</sup>				
17	<b>Case 1 (Corner Images)</b>						
18	Number of Images	4					
19	Actual Horizontal length	0.082584					
20	Actual vertical length	0.050964					
21	Total Area Occuipied with this type of cell	0.016835244	cm <sup>2</sup>				
22	<b>Case 2 (Edge Images)</b>						
23	Number of Images	96					
24	Actual Horizontal length	0.063488					
25	Actual vertical length	0.050964					
26	Total Area Occuipied with this type of cell	0.310617833					
27	<b>Case 3 (Middle Images)</b>						
28	Number of Images	476					
29	Actual Horizontal length	0.063488					
30	Actual vertical length	0.025544					
31	Total Area Occuipied with this type of cell	0.771947037					
32							
33	<b>Total Area</b>	<b>1.099400114</b>					

### Highlights:

- 0.35 $\mu$ m/px
- 8MP camera
- **576 images**
- 25% overlap



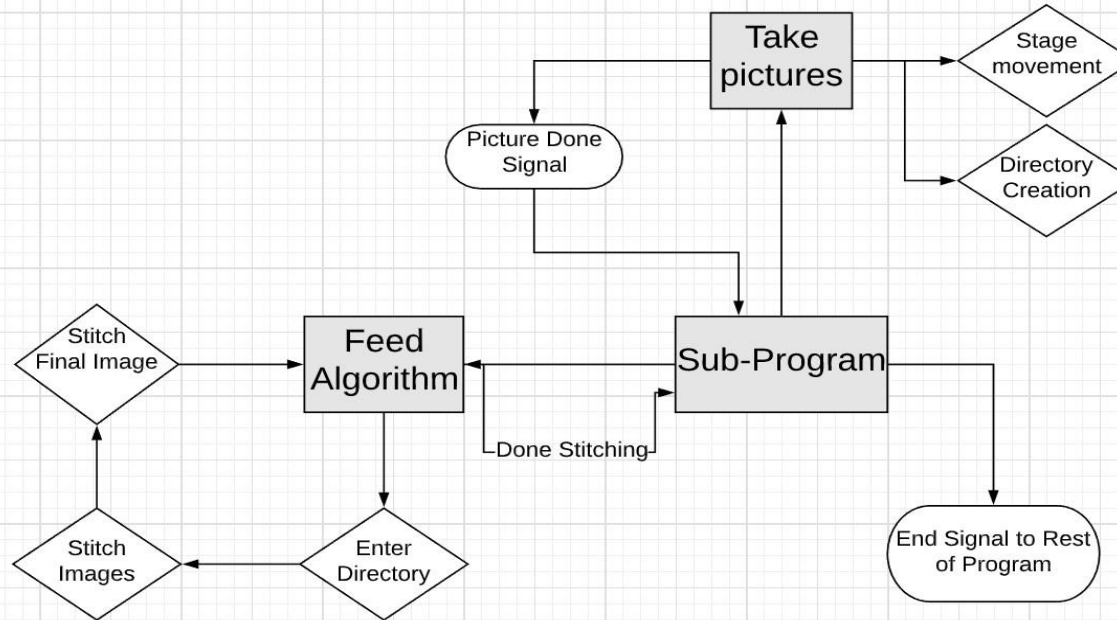
### Theory:

- Overlap Problem
- 3 Cases of Images



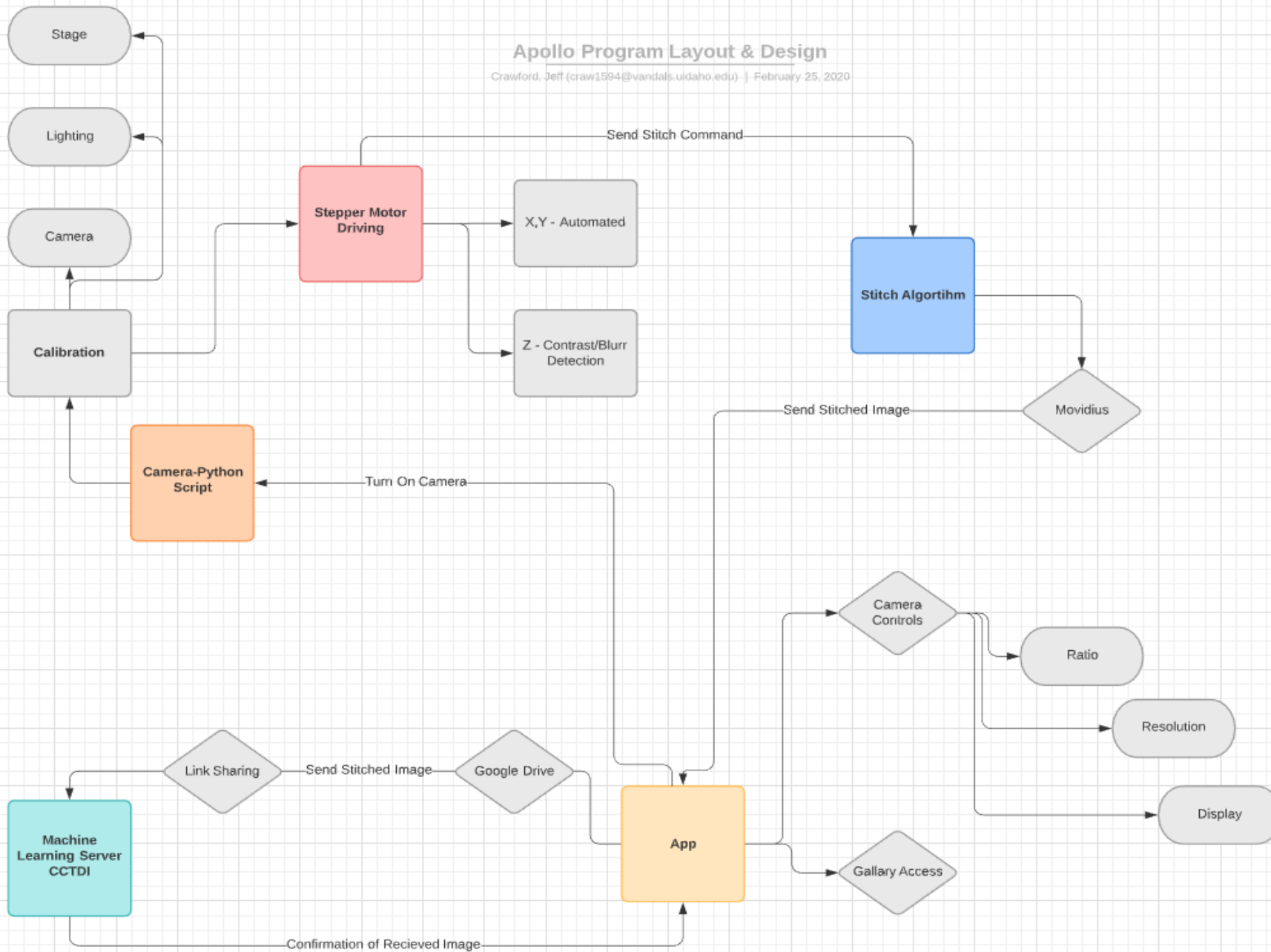


# Feed & Image Stitching Algorithm



# Apollo Program Layout & Design

Crawford, Jeff (craw1594@vandals.uidaho.edu) | February 25, 2020

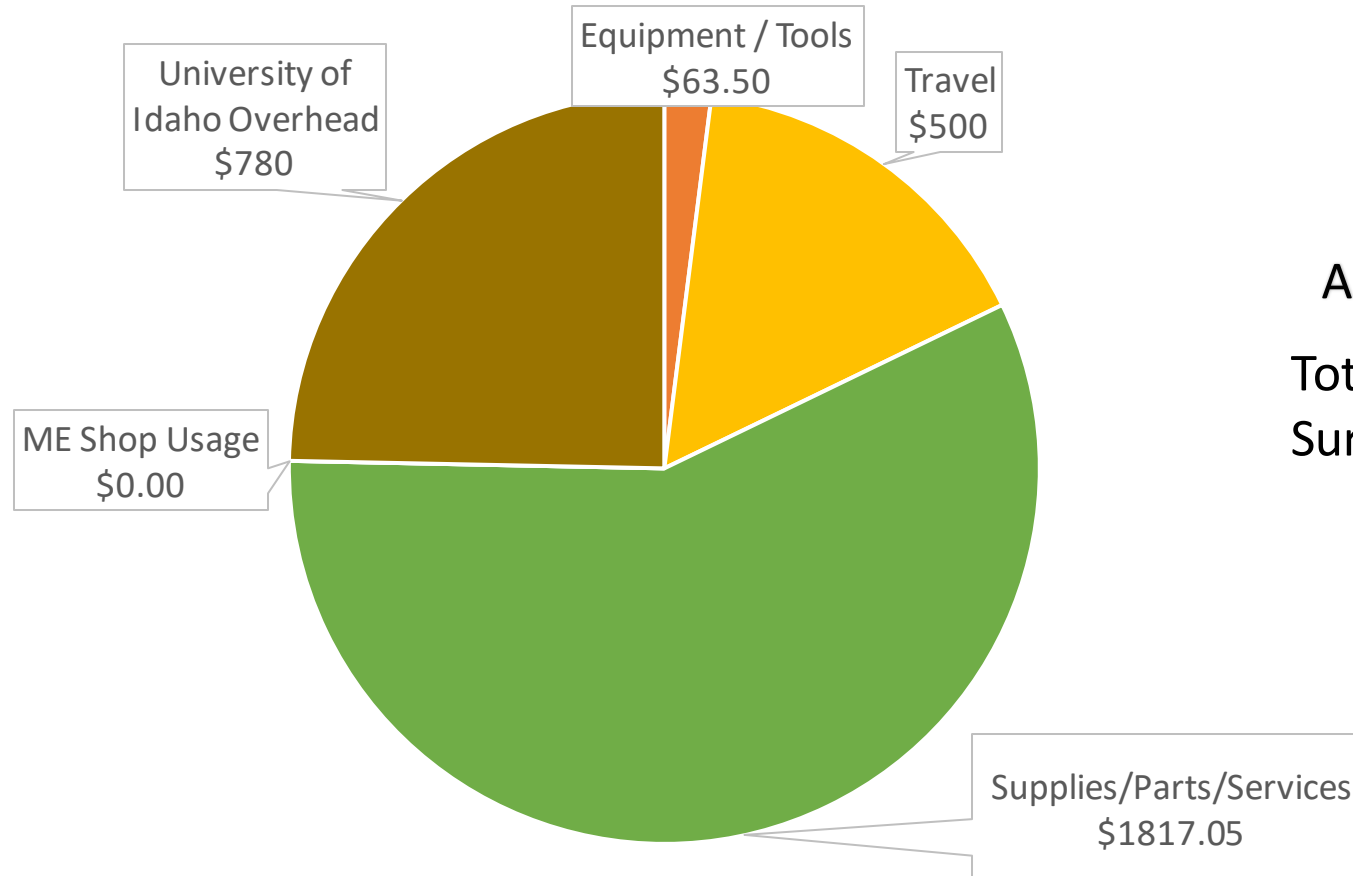


# Testing/Validation

Test	System	Metric	Possible Solution
Image Sharpness	Optics	Modulation Transfer Function (MATLAB)	Adjust light source distance/ working distance
Precision of movement	XYZ Stage	Standard deviation	Tune step size and voltage output of motor hat
Shock (1 meter drop)	Shock mesh	System Functionality	Tune pore sizes in mesh to reduce/increase K
Water Resistance (30 second submerge)	Enclosure	Physical observation	Adjust gasket size or placement



# Budget



As of March 2, 2020

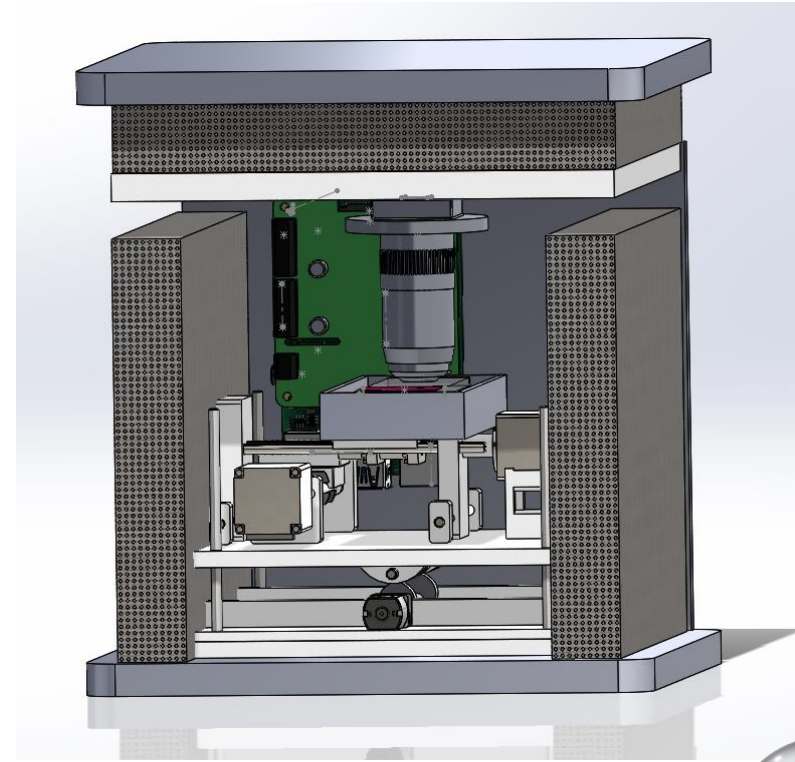
Total Spent: \$3,160.55

Surplus: \$1,839.45



# Future Tasks

1. Assemble parts
2. Machine finer parts
3. Design gasket system for housing
4. Proceed to testing and validation



# Questions?

