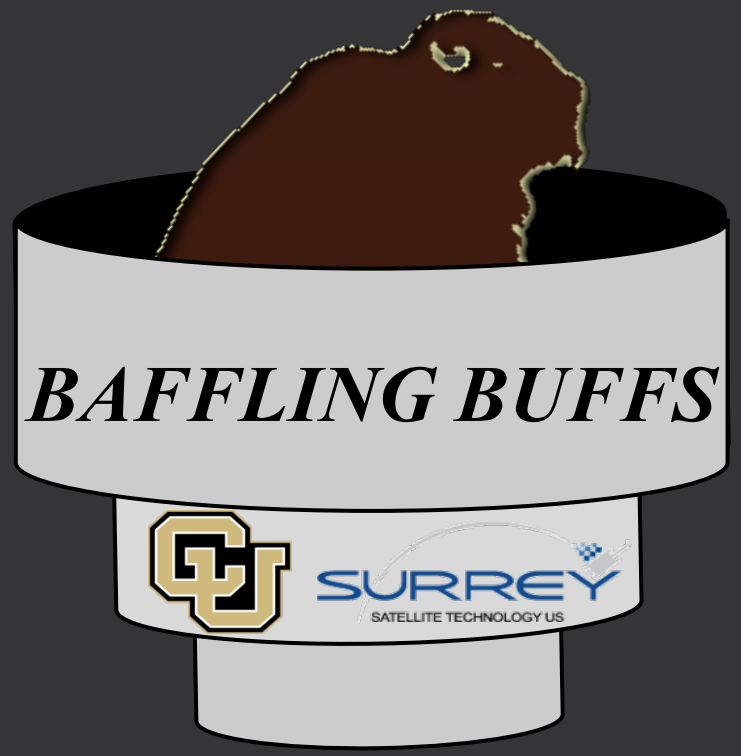
Manufacturing Status Review

Customer:
Scott Taylor,
Surrey Satellite Technology U.S.



PAB Advisor:
Josh Stamps,
Sierra Nevada Corporation

Presenting: Anthony Anglin, Lindsay Goldworm, Elizabeth Luke, Nicholaus Monahan, Mary Scites

Other Team Members: Aspen Coates, Emmett Bailey, Zach McConnel, Sierra Williams

Overview

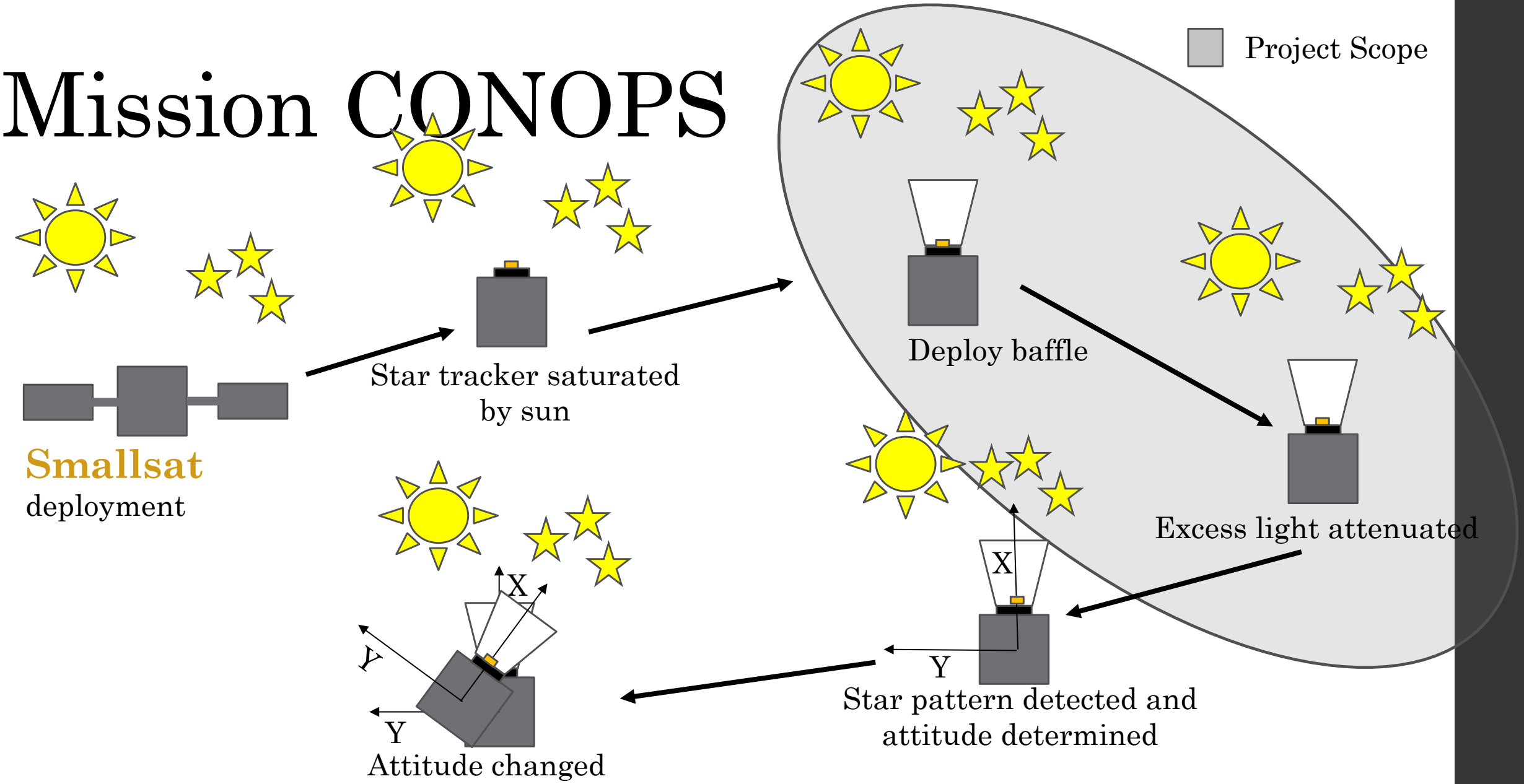
Motivation – Star tracker baffles

- Star trackers need to **see dim light** from distant stars
- They **compare** what they see with on board star catalog to make spacecraft attitude adjustments
- Nearby bodies emit/reflect stray light which **hinders** star trackers ability to see dim light
- Baffles **attenuate and eliminate** stray light from nearby bodies
- **Lightweight deployable** baffle for smallsats

Project Goals

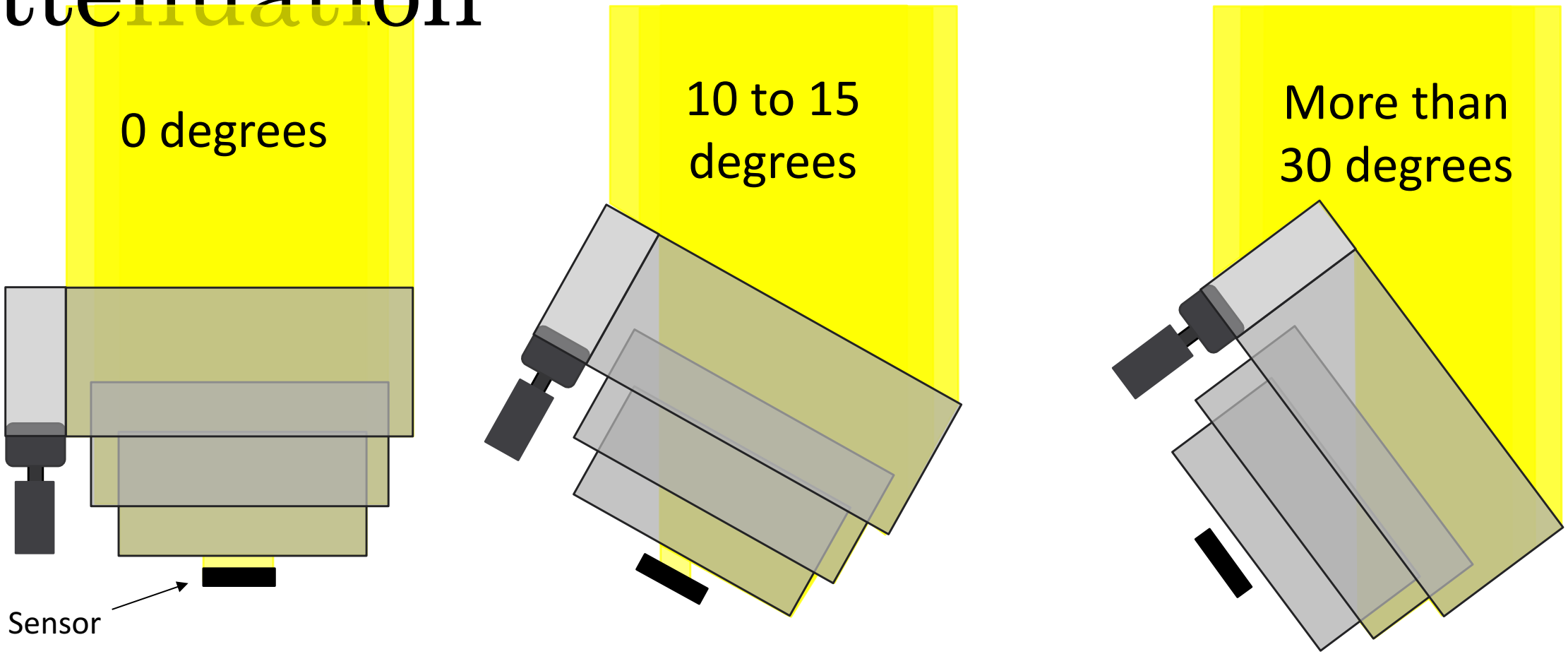
- **Develop a prototype** deployable baffle for a star tracker to be used on a small satellite platform
- **Design and manufacture** a deployable baffle to limit stray light into an optical sensor
- **Develop a test methodology** and instrumentation suite to measure performance of the baffle for stray light elimination
- **Perform the tests** for the deployment and stray light elimination of the baffle

Mission CONOPS



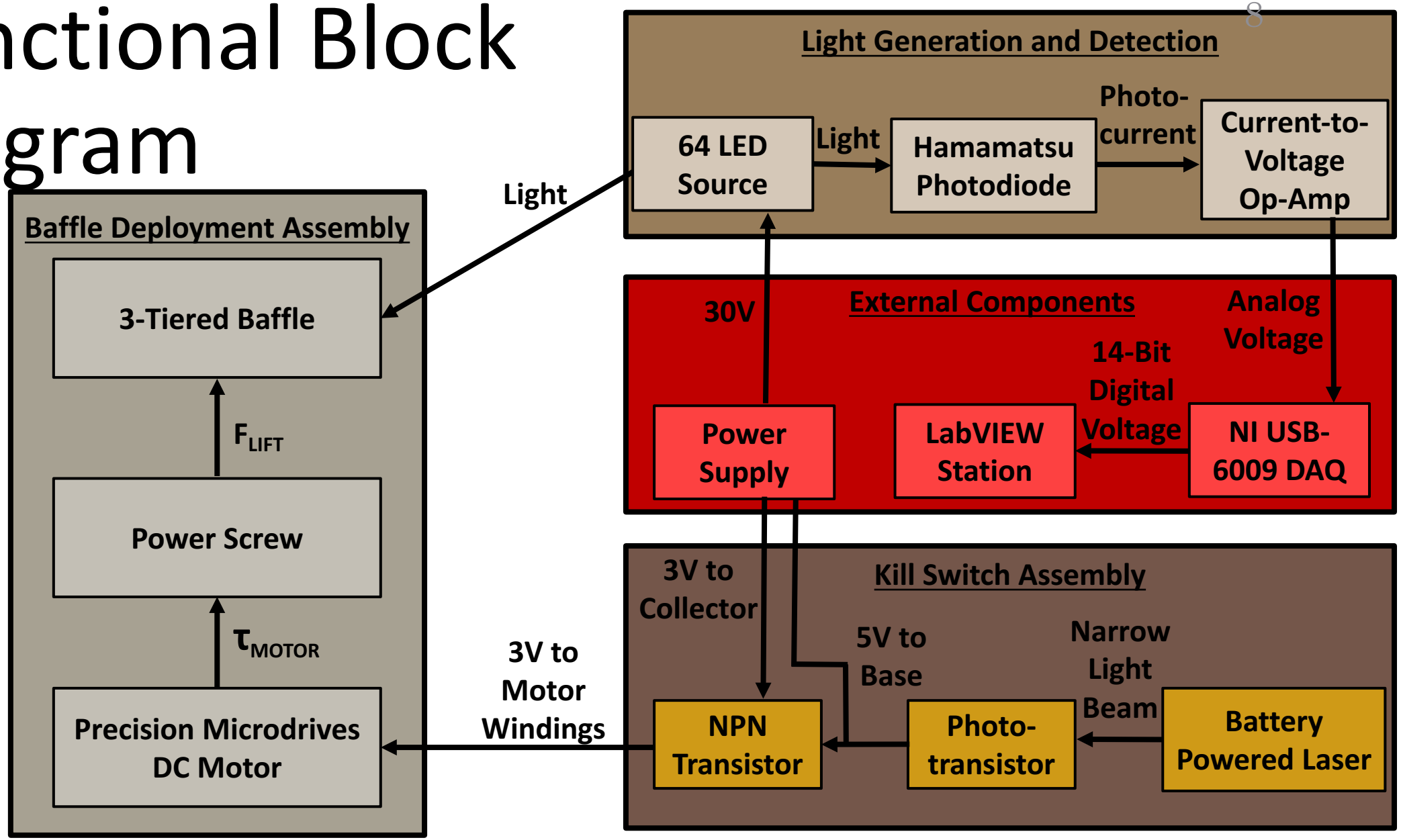
Project CONOPS - Deployment

Project CONOPS – Light Attenuation



* In testing the sensor will not be displaced from the baffle

Functional Block Diagram

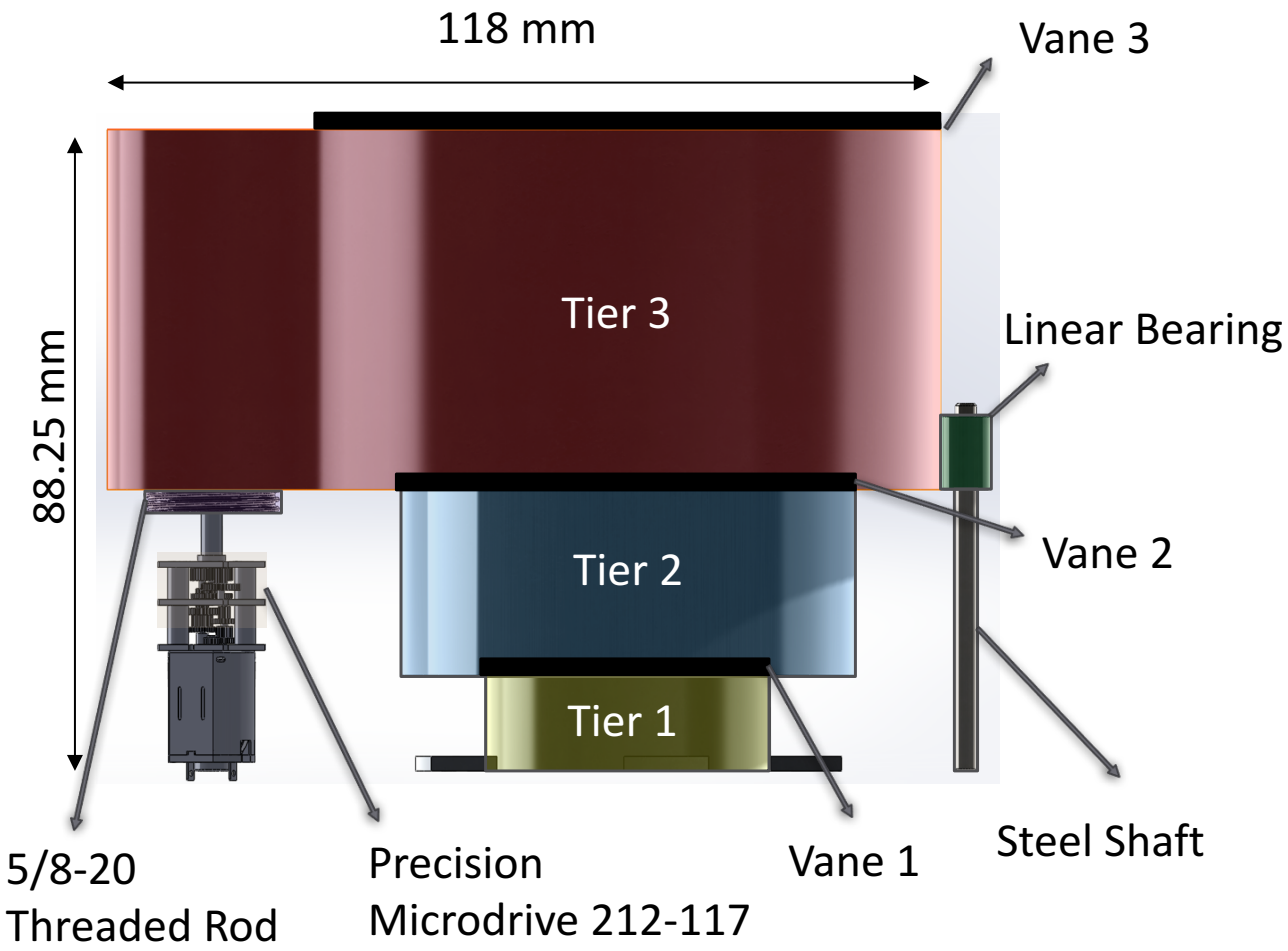


Requirements & Levels of Success

- **FR1: Baffle shall be deployable**
- **FR2: Baffle shall fit within volume constraints**
- **FR3: Baffle shall adhere to mass constraints**
- **FR4: Baffle shall attenuate light**

	TIER 2
DEPLOY BAFFLE (FR1)	Electronic deployment with a wired connection
STOWED BAFFLE VOLUME (FR2)	Constrained by: 125 mm width 125 mm length 50 mm height
BAFFLE MASS (FR3)	<300 grams
BAFFLE LIGHT EXCLUSION (FR4)	30 degree light exclusion angle

Baseline Design From CDR & Major Changes



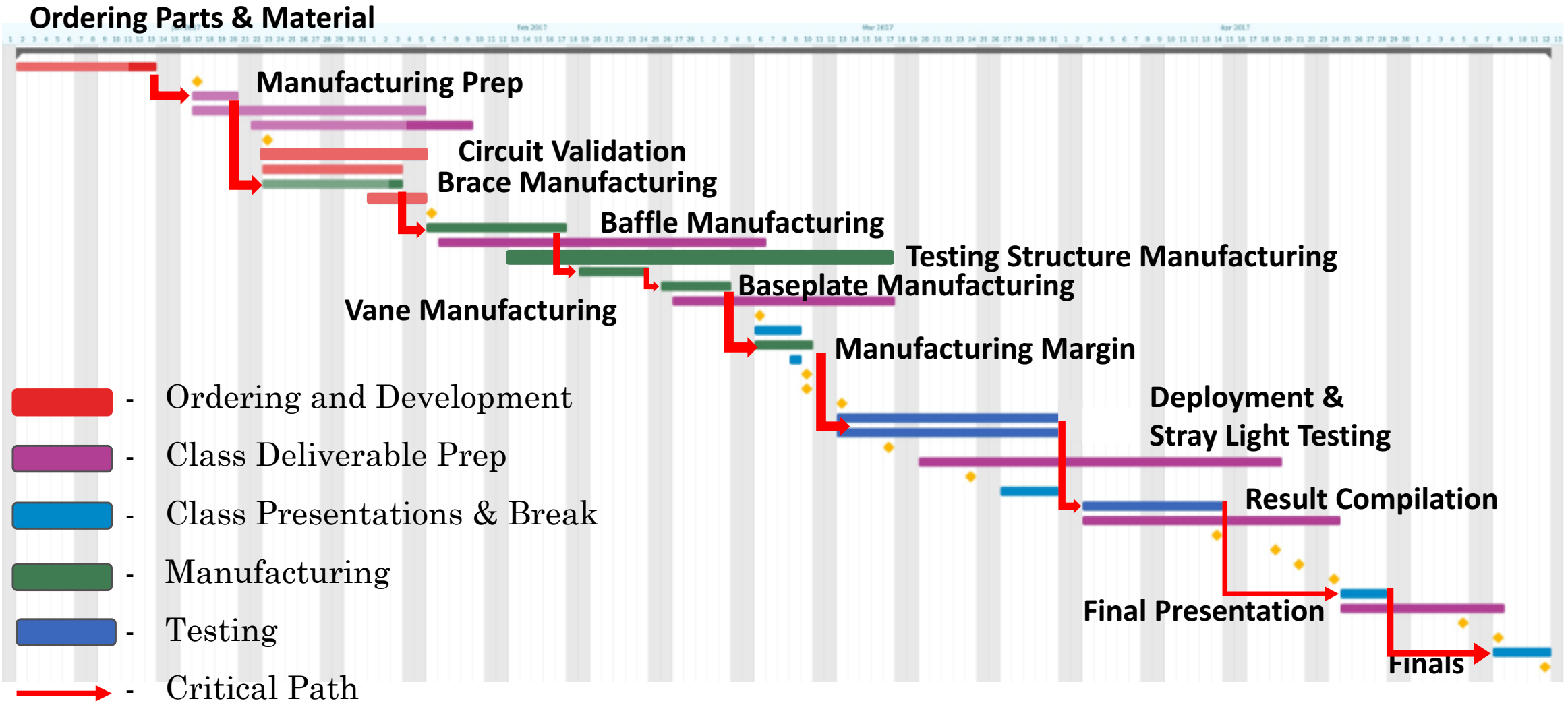
No Major Structural Changes Between CDR and MSR

CPEs & Manufacturing Challenges

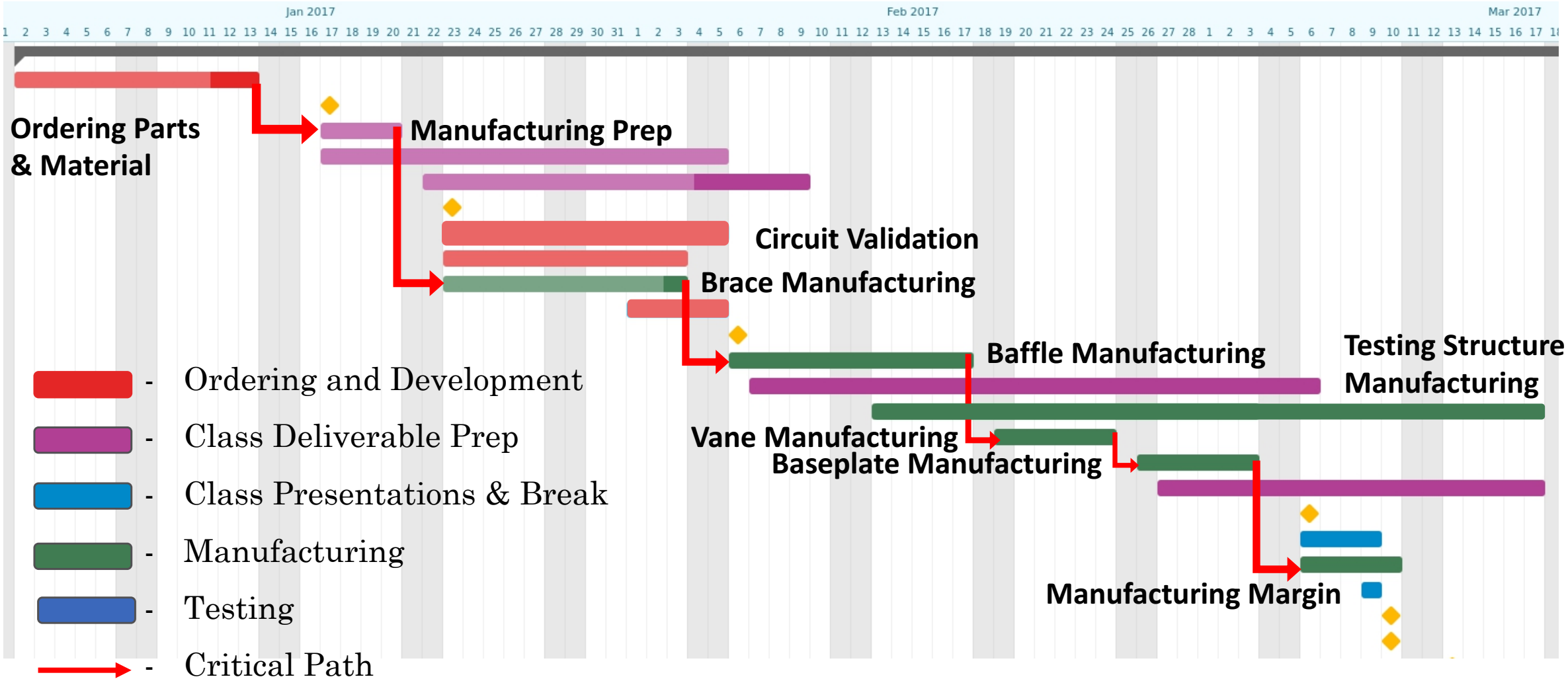
CPE	Project Integration	Manufacturing Challenges
Deployment (FR1-3)	• Electrical Interface • Mechanical Integration • Manufacturing Baffle Challenges & Tolerances	• PCB creation • Time Intensive
Light Attenuation (FR4)	• Manufacturing Vane Tolerances • Simulation Accuracy	• Bending/warping sheet metal
Testing (FR1&4)	• Electrical Interface • Mechanical Integration • Manufacturing Testing Parts • Simulation Accuracy and Precision	• Complex

Schedule

Overall Schedule



Manufacturing Schedule



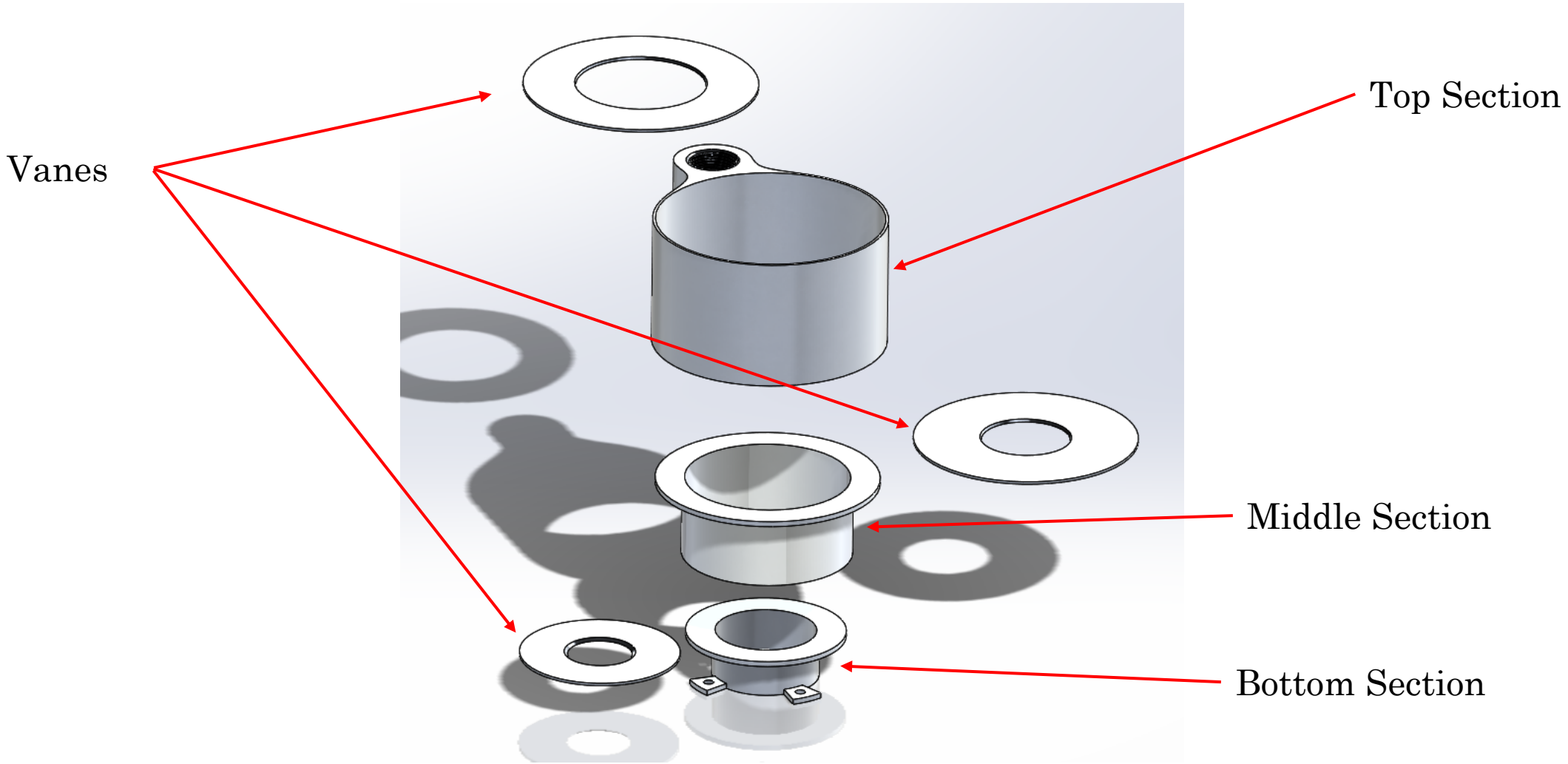
Scheduling Concerns

- Parts & Material
  - Not delivered by start of semester

- Schedule slip
  - As machining picks up for all of the teams, machines become less available

Manufacturing

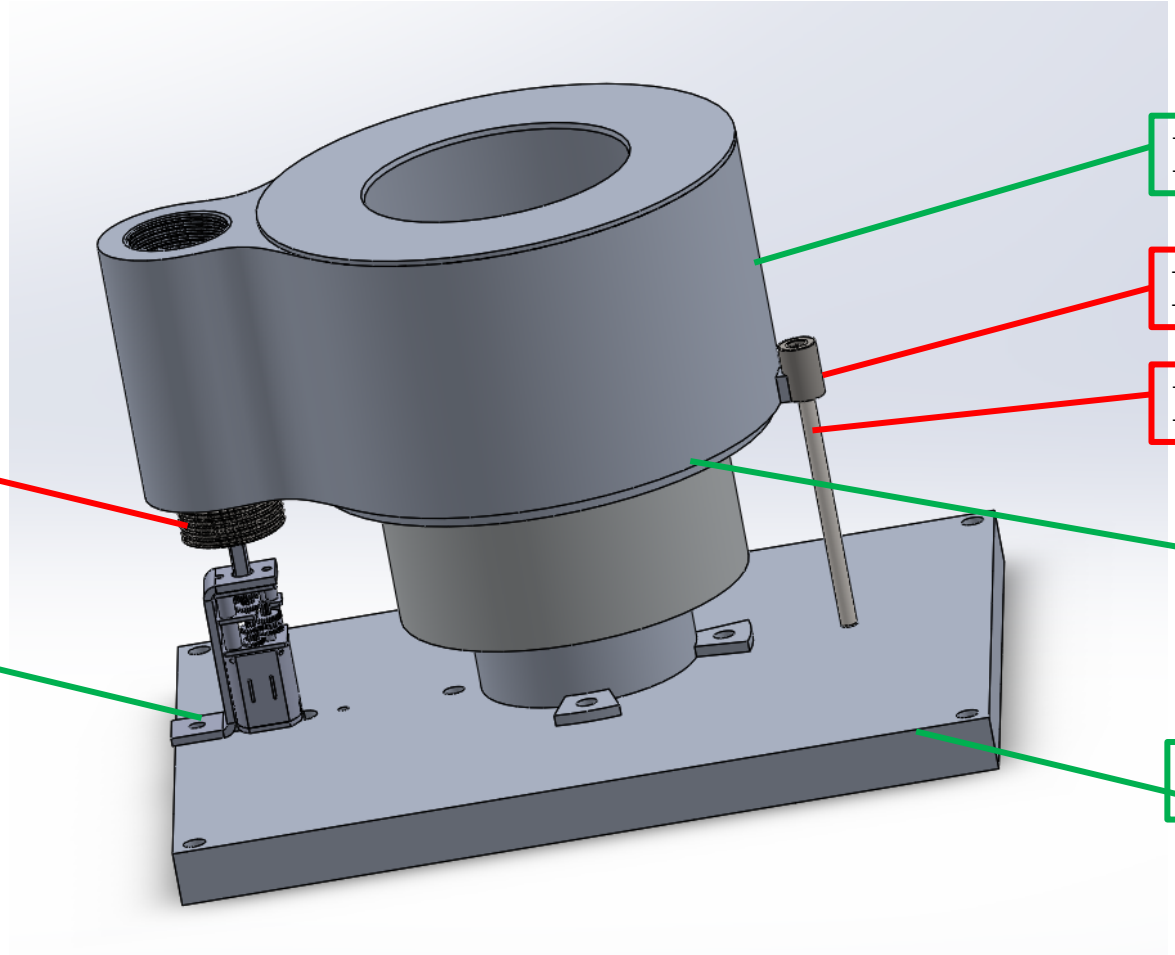
Baffle Overview



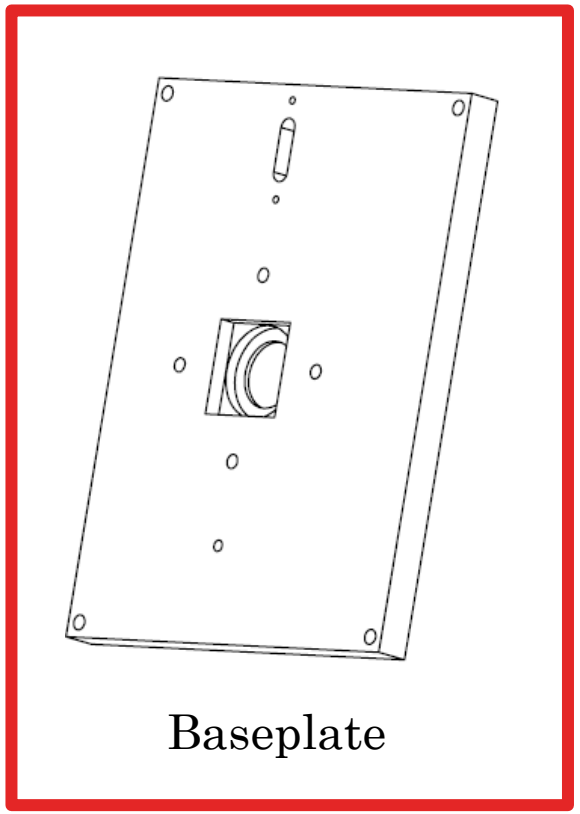
In House vs. COTS

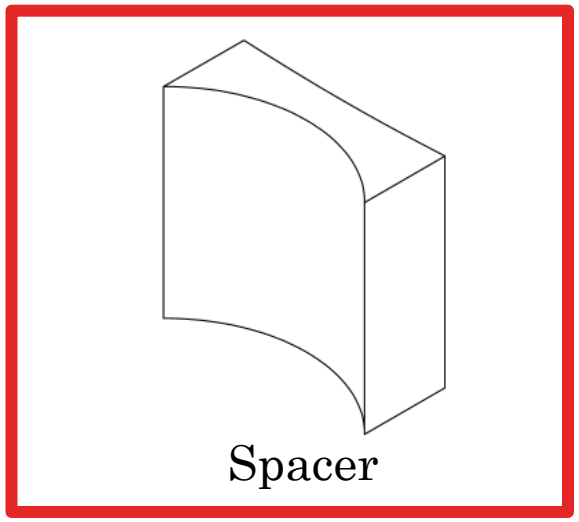
COTS

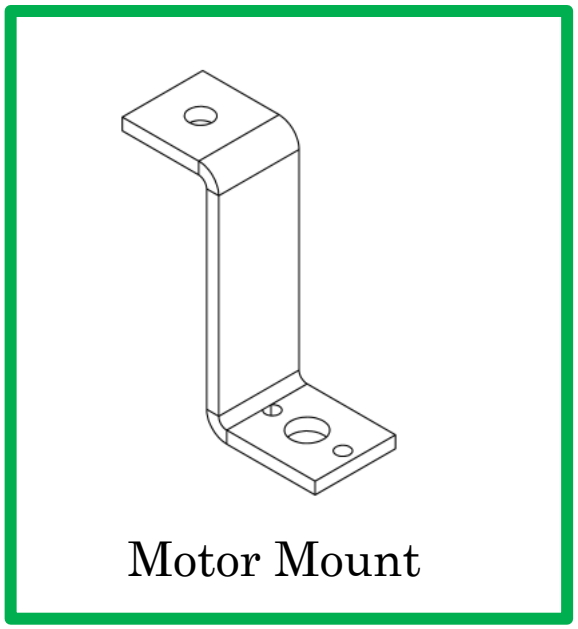
Manufactured in House

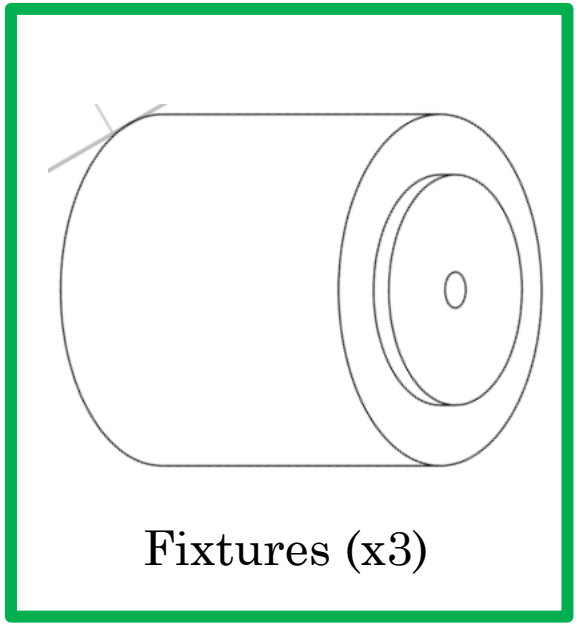


Other Pieces



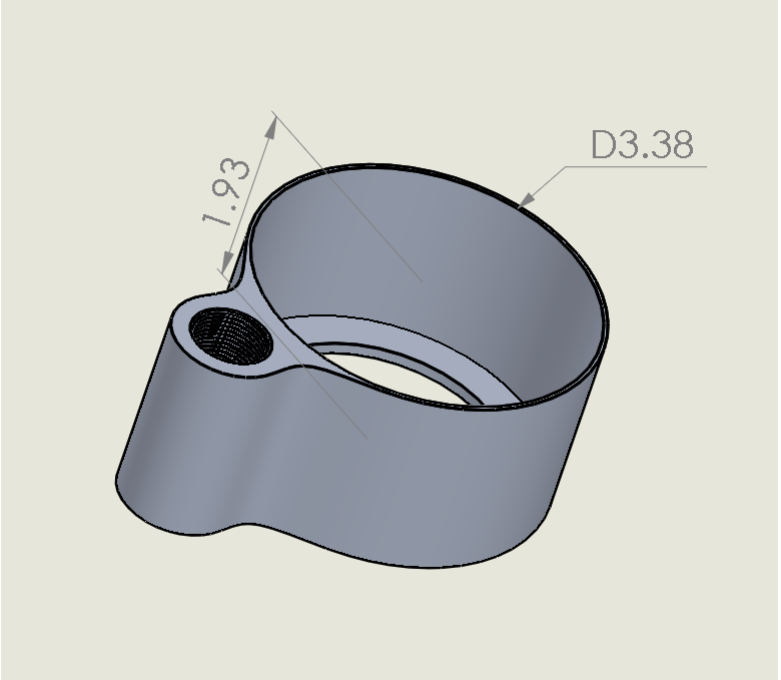






Top Section

Process	Time To complete
Drill holes for fixture attachment	1 hr
Use CNC mill to cut outside to size and shape	4 hrs
Use CNC mill to mill large radius circle	8 hrs
Use CNC mill to mill small radius circle (Shelf)	2 hrs
Use CNC mill to drill hole for threading	0.5 hrs
Thread drilled hole	1 hr
TOTAL	**17 hrs**

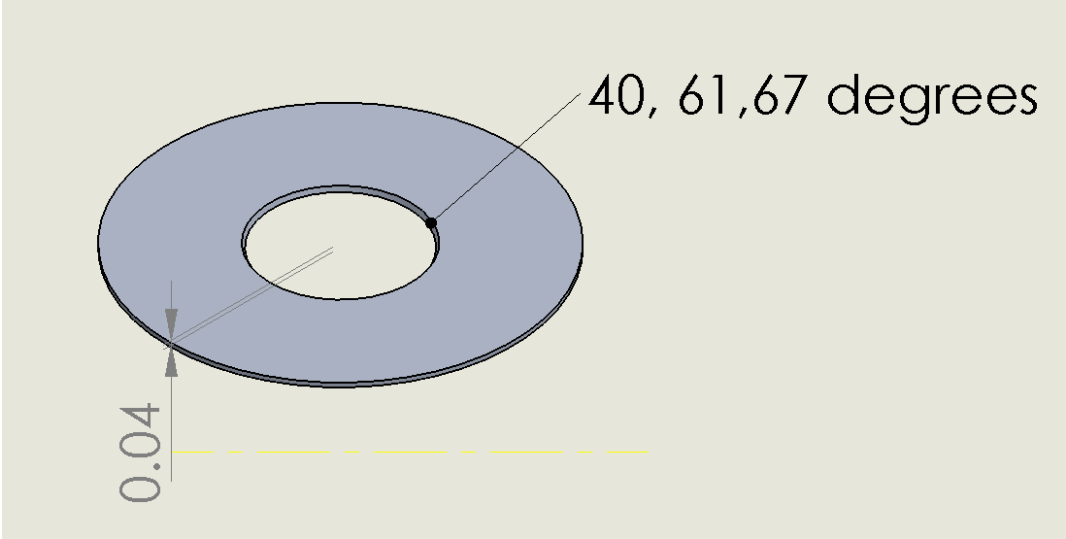


Main concerns

- Time intensive processes
- Many processes to be completed

Vanes

Operation	Time
Use CNC mill for outer diameter	0.5 hr
Use CNC lathe for inner diameter and angle	1 hr
TOTAL	**1.5 hrs each**



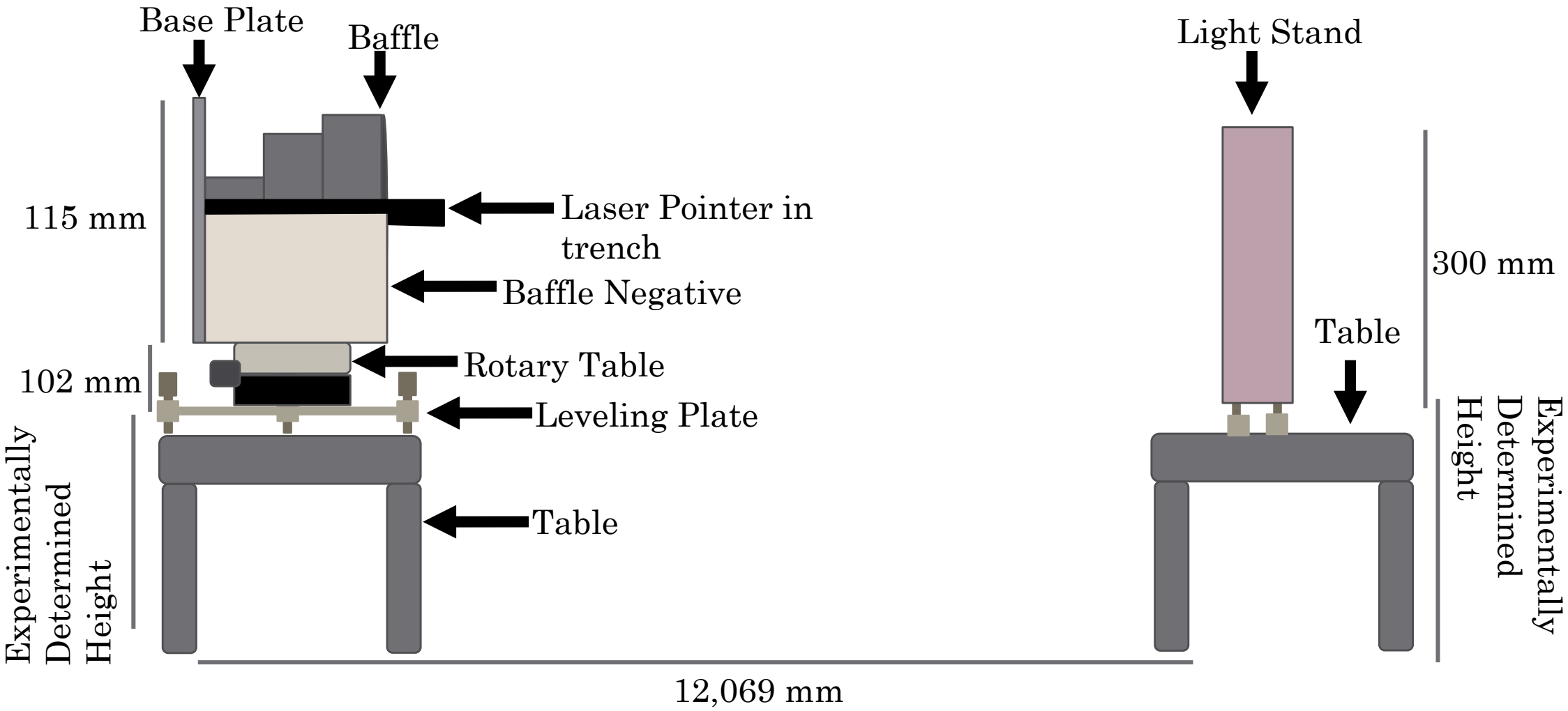
Main Concerns:

- Sheet metal
- Easy to bend or warp

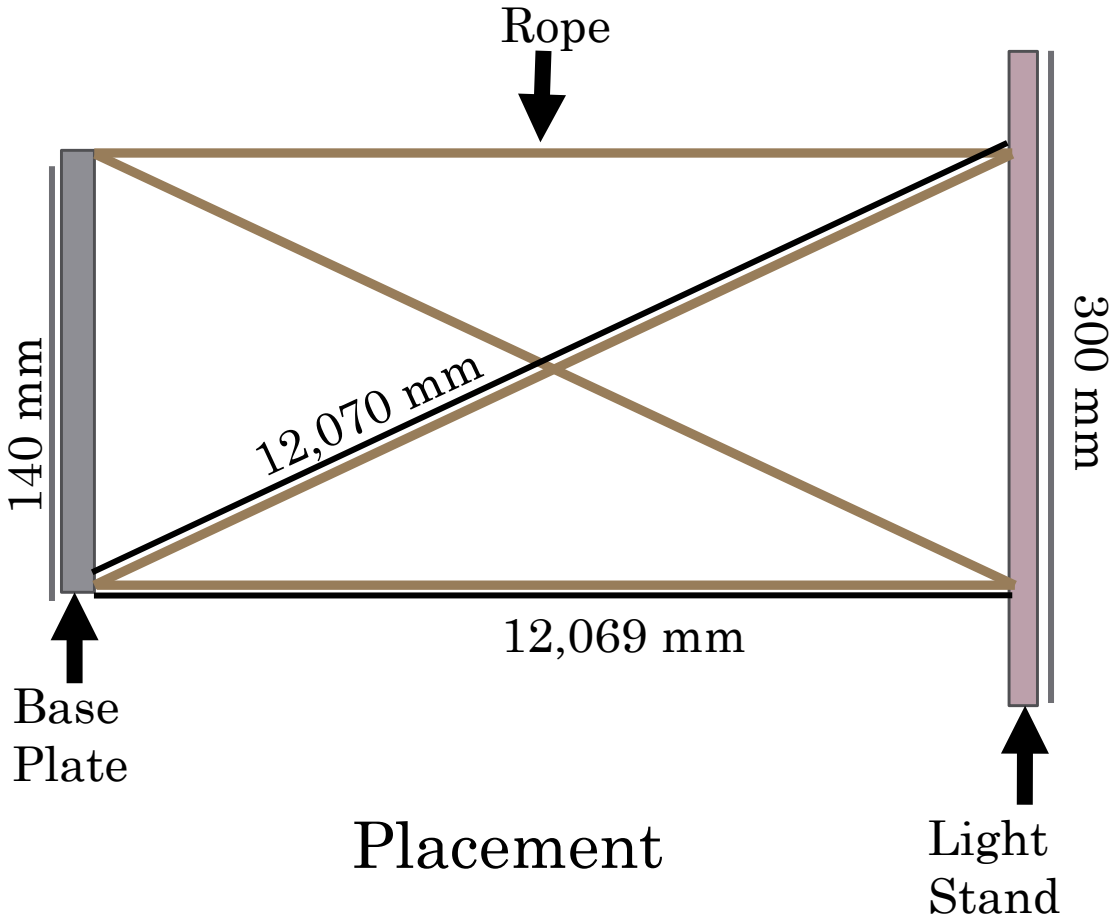
Conclusion - Manufacturing

Part	Machine/process	Time remaining	Completion Date
Top Fixture	CNC Mill	0 hrs	2/2
Middle Fixture	CNC Lathe	0 hrs	1/30
Bottom Fixture	CNC Lathe	0 hrs	1/23
Top Baffle Section	CNC Mill	17 hrs	3/3
Middle Baffle Section	CNC Lathe	4 hrs	2/17
Bottom Baffle Section	CNC Lathe	4 hrs	2/17
Vanes (x3)	CNC Mill & Lathe	1.5 hrs each	3/3
Baseplate	CNC Mill	3 hrs	3/3
Motor Mount	Hand Mill & Metal Bender	0 hrs	1/31
TOTAL		**32.5 hrs**	**All Complete By: 3/3**

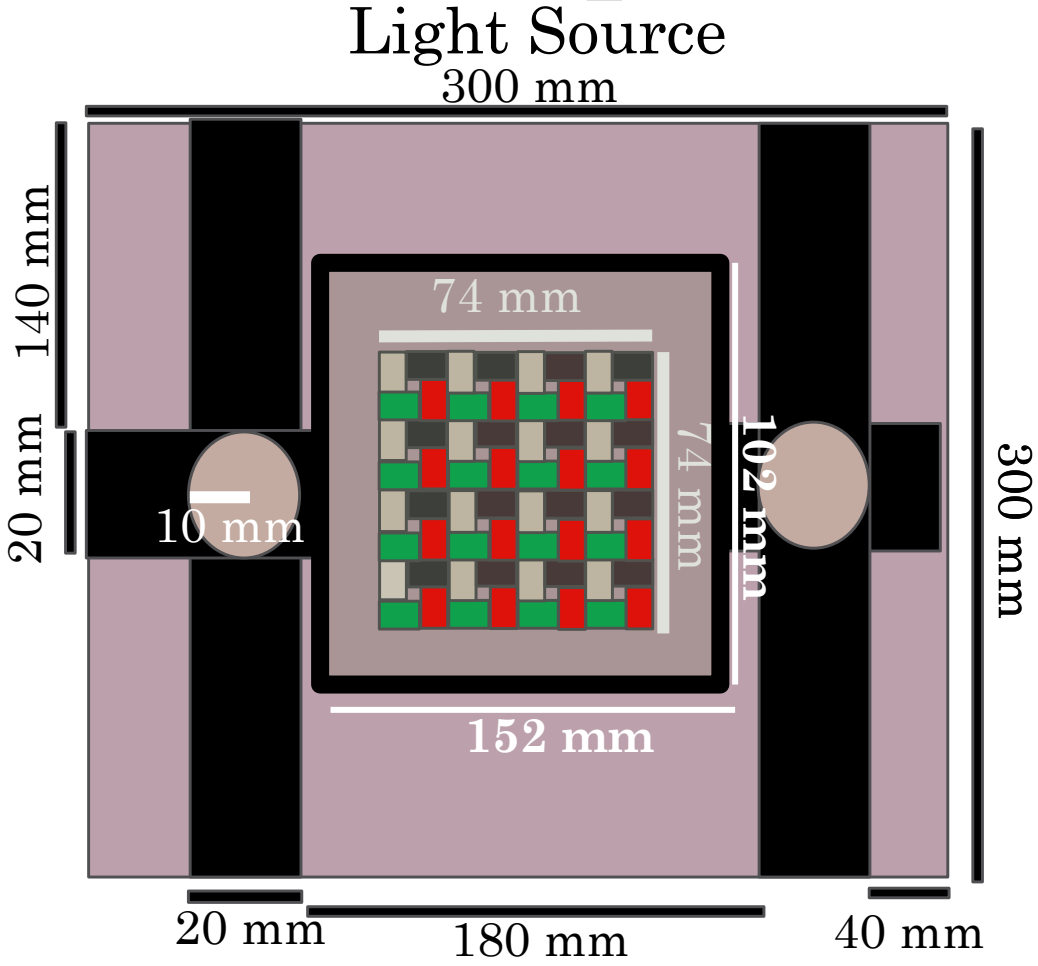
Testing Overview – Light Attenuation



Placement/Orientation Set-up



Placement



Orientation

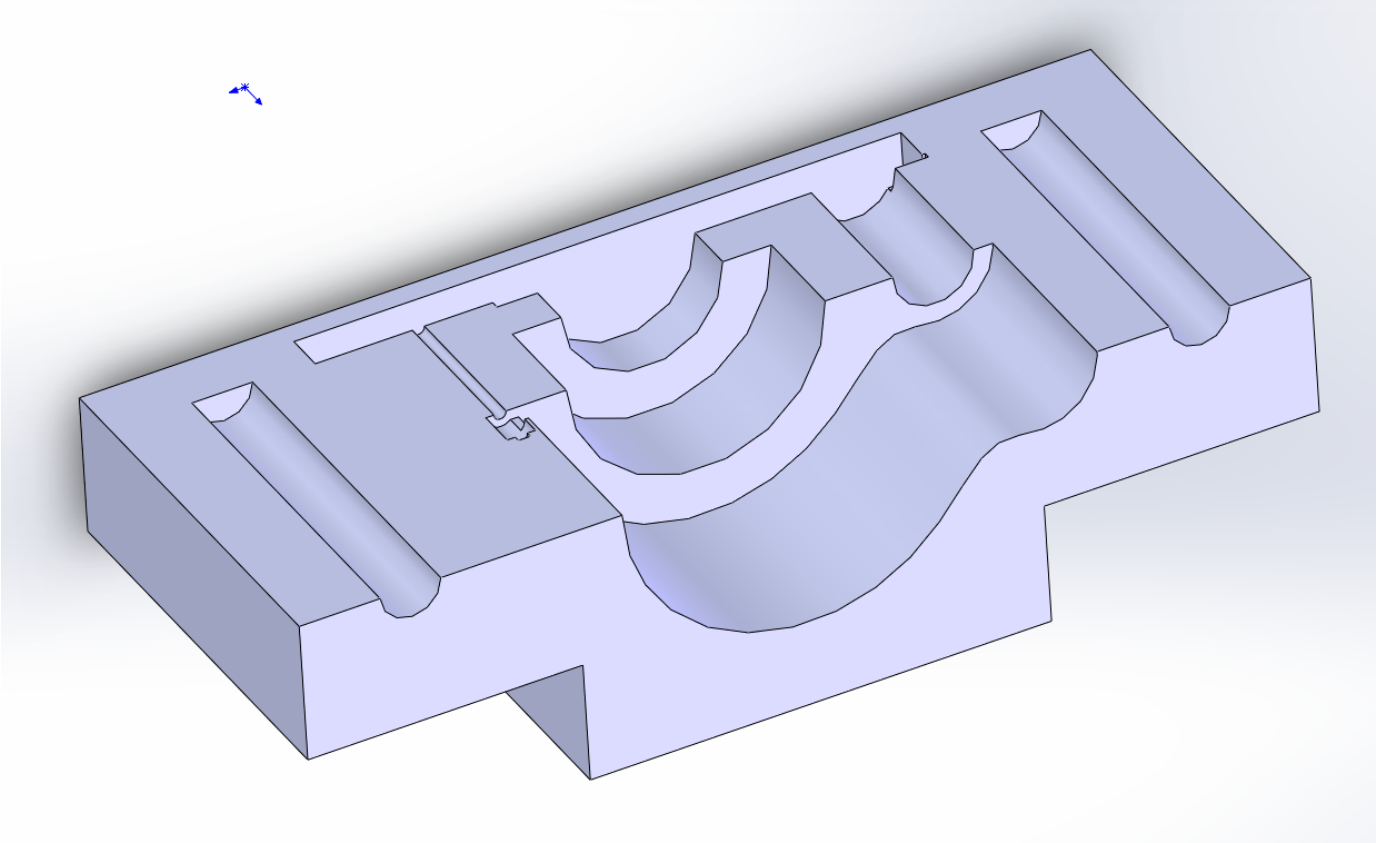
Calibration Test Tolerances

Part	Tolerance	Requirements
Rope (Distance)	$\pm 200mm$ changes sun's arc length by <0.01°	Apparent sun diameter = 0.5° Error: <2%
Laser (Orientation)	$\pm 20mm$ + Manufacturing Error changes Results Angle by 0.27°	Light Attenuation: Pre-obscuration Margin: 1.1° Obscuration Margin: 9.3°

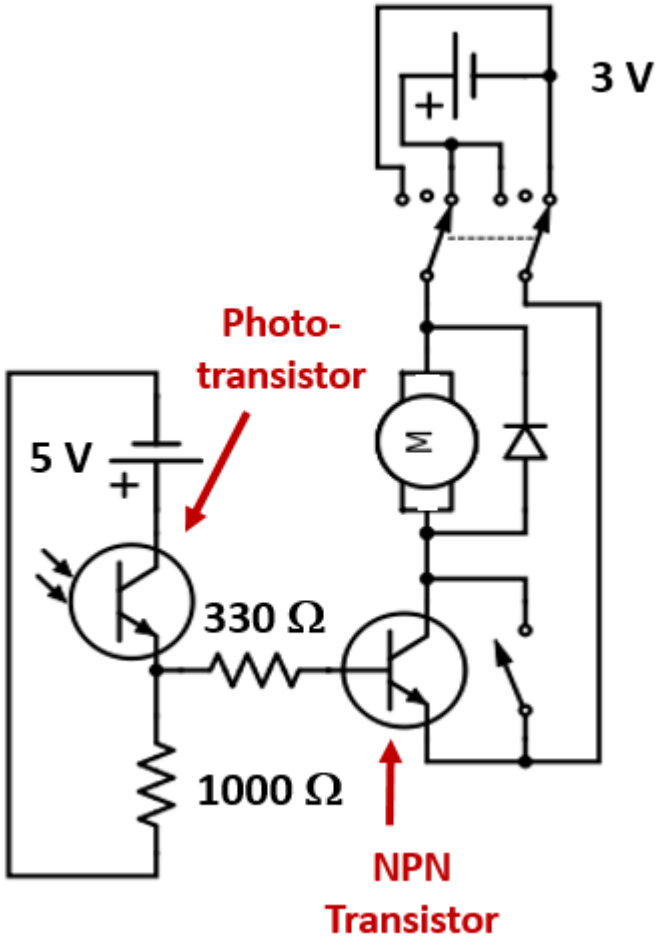
Negative Support Structure

- Support Baffle Structure

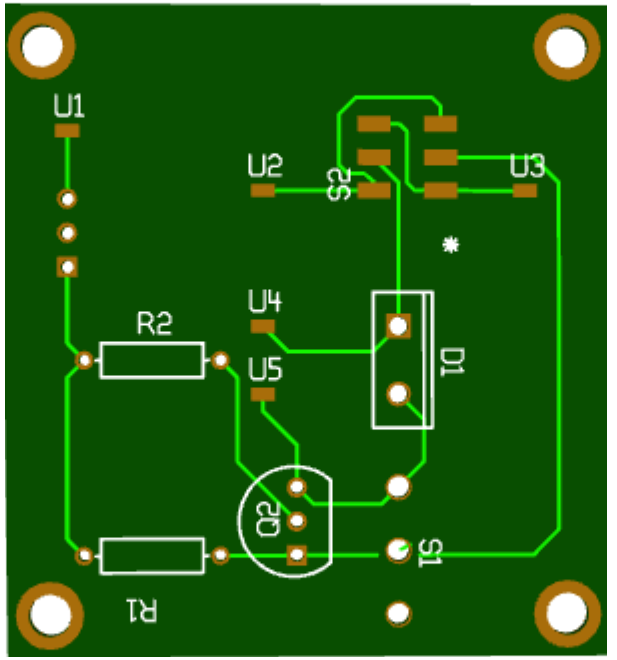
- 4 Total Negatives
  - 2 Symmetrical
  - 2 Asymmetrical



Motor Controller Circuit

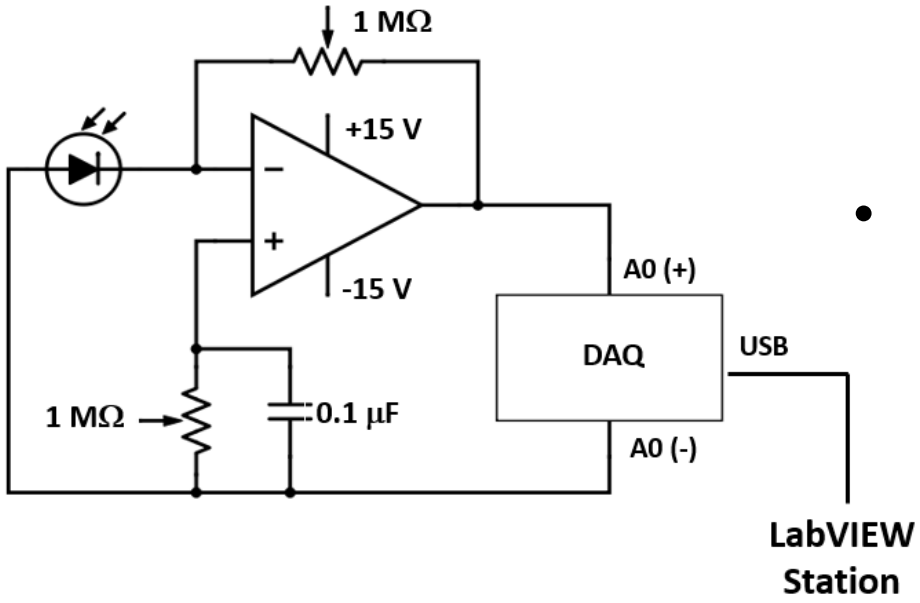


- **PCB Dimensions: 46 x 49 mm**
- **One HW5P-1 Phototransistor for BC337 NPN transistor base biasing**
- **One Jameco 22841 DPDT center-off switch and one 76523 SPST switch for baffle deployment reset**

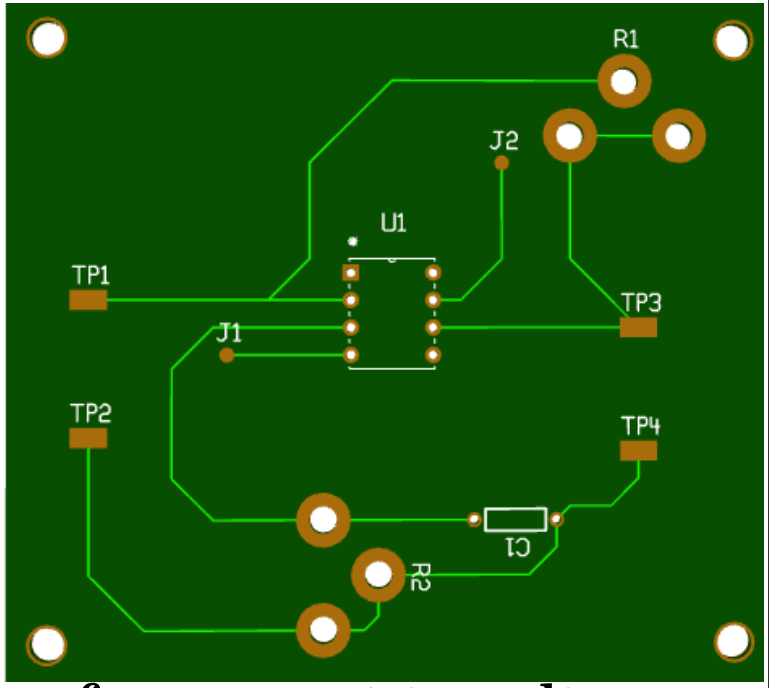


- **One IN4007 flyback diode for NPN transistor protection from inductive kickback**

Photodiode Amplifier Circuit

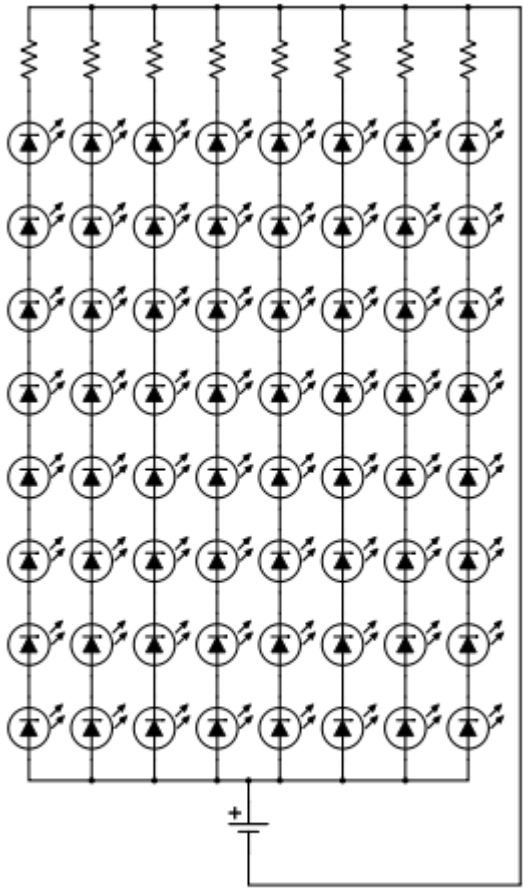


- **PCB dimensions: 72 x 64 mm**

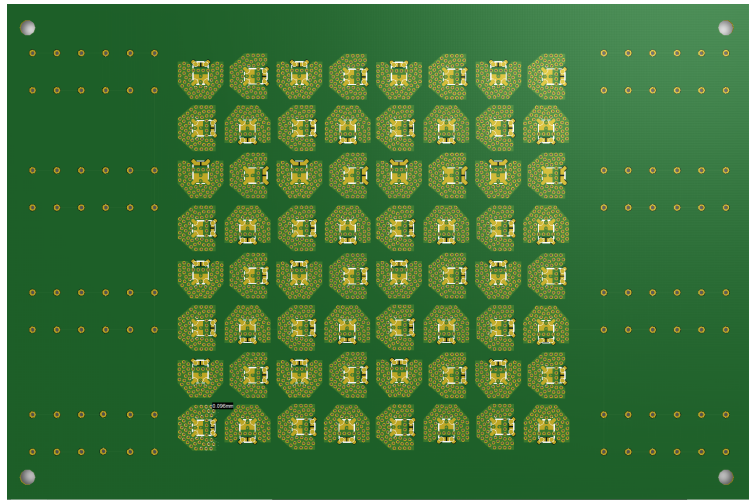


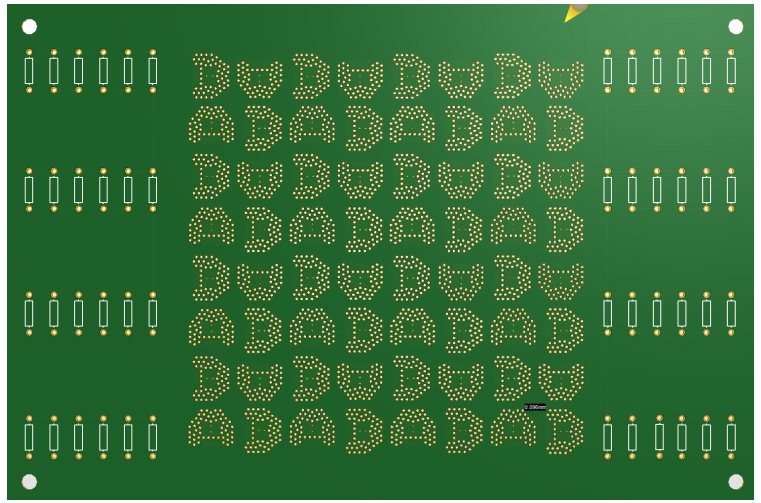
- **Single 18 x 18 mm Hamamatsu S1337-21 Photodiode for light detection**
- **Two 1MΩ Variable Resistors and one 0.1µF capacitor for amplification tuning and noise filtering**
- **Copper pours for additional noise reduction**
- **LM741 Op-Amp for current-to-voltage amplification**
- **NI USB-6009 DAQ connected to computer station running a LabVIEW voltage module for data collection**

LED Circuit



- **PCB Dimensions:**
  152 x 102 mm
- **64 surface mounted Luxeon Rebel Color LEDS arranged in an 8 x 8 array**
- **LED Array Dimensions:**
  74 x 74 mm
- **Forty-eight 2W, 2W resistors for power dissipation**
- **Enlarged thermal pads for heat dissipation (suggested by the manufacturer)**





Electronics Summary

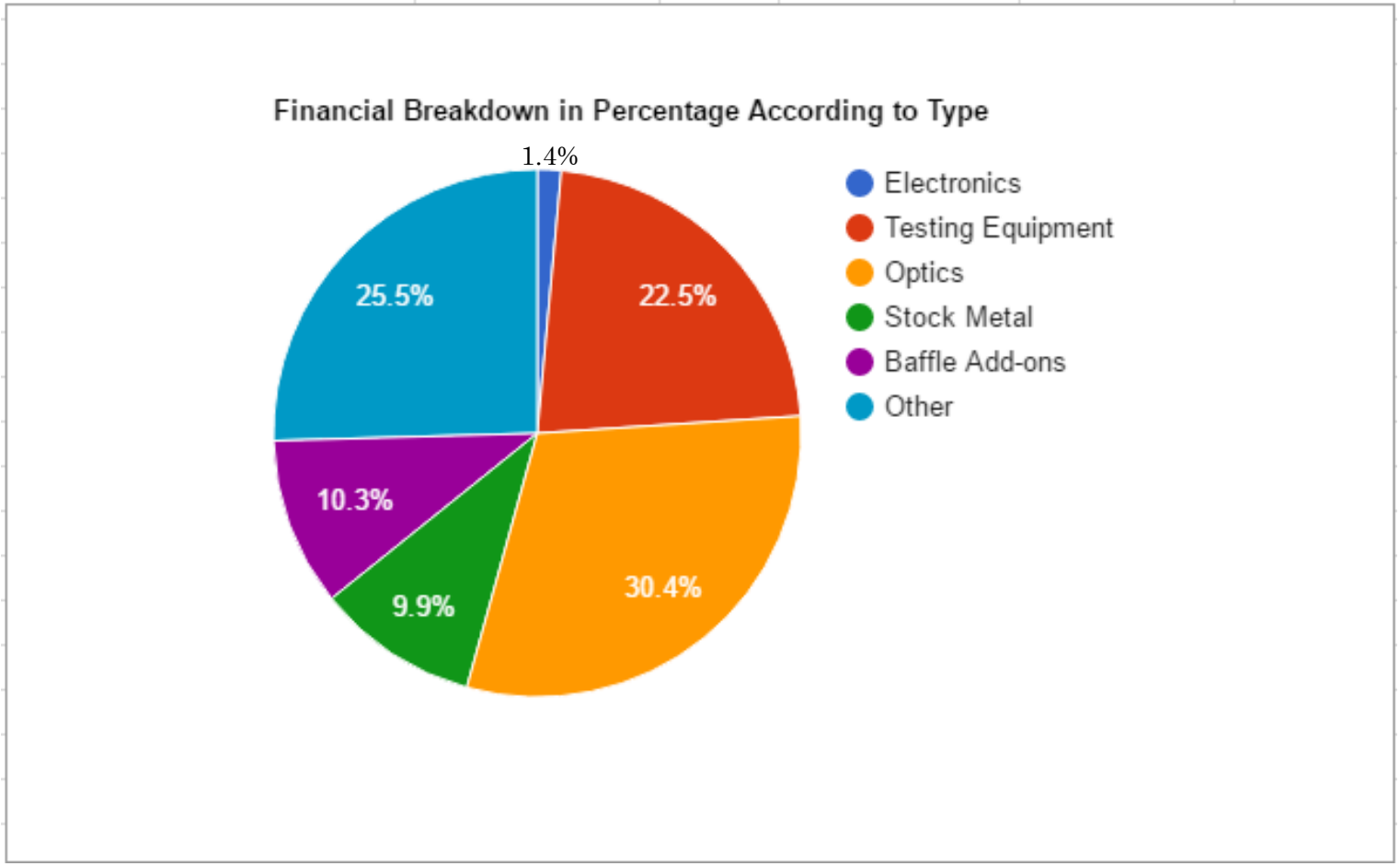
	Motor Controller Circuit	Photodiode Amp Circuit	LED Array
PARTS	Waiting on Hamamatsu photodiode – expected to ship end of February	All parts acquired	All parts acquired
CONCERNS	Small size of phototransistor makes breadboard testing difficult	None	**Heat Dissipation -** Mitigated by expanded thermal pads and short-duration power application **Design Rule Check violations -** Possible mitigation by recreating footprints manually – potentially very time consuming. Alternative solutions being investigated
PLAN	Print PCBs via Advanced Circuits once breadboard testing complete and all DRCs pass. Expected cost $33/board. Expected turnaround 5 business days from order placement.		

Conclusion - Testing

Part	Machine/ Process	Time To Complete	Completion Date
PCB & Laser Support	Hand Mill	1 hr	3/10
Light Stand	Mill	2 hr	3/10
Leveling Plate	Mill	2 hr (CNC) 4 hr (Hand)	3/10
3-D Support (x4)	CNC Mill	4 hrs	3/17
Motor Controller Circuit	Outsourcing	5 hrs	3/3
Photodiode Amplifier Circuit	Outsourcing	5 hrs	3/3
LED Circuit	Outsourcing	5 hrs	3/3
TOTAL		**38 hrs**	**3/17**

Budget

Overall Budget



Electronics - $37.94
Testing Equipment - $587.19
Optics - $792.00
Stock Metal - $258.80
Baffle Add-Ons - $269.32
Other - $664.20

Sum - $2,609.45

Margin - $2,390.55

Financial Status

- All items (except 3) have arrived and are currently in team locker
  - The Si Photodiode, RapidEdge Filter, and the Aeroglaze Coating have all been ordered and will arrive within the month
- Future cost include:
  - Re-ordering items/stock material if necessary
  - Application of coating on baffle
  - Batteries for laser
  - Material for black felt tunnel
  - Material for 3-D support
    - High density foam from bottle rocket excess supplies

Questions?

Backup Slides

Project Assumptions & Levels of Success

- Design is proof of concept
  - Need not be space grade
- Focus on attenuating light from Sun
- Spacecraft will be in L.E.O.
- From spacecraft bus:
  - Voltage available: 28 V
  - Current available: 2.5 Amps
  - Power available: 70 Watts

	TIER 1	TIER 2
DEPLOY BAFFLE (FR1)	Manual Deployment	Electronic deployment with a wired connection
STOWED BAFFLE VOLUME (FR2)	Constrained by: 175 mm width 175 mm length 50 mm height	Constrained by: 125 mm width 125 mm length 50 mm height
BAFFLE MASS (FR3)	<500 grams	<300 grams
BAFFLE LIGHT EXCLUSION (FR4)	40 degree light exclusion angle	30 degree light exclusion angle

Requirements

- **FR1: Baffle shall be deployable**
  - DR1.1: Deployable using 28V
  - DR1.2: Full deployment ground testing shall be conducted
- **FR2: Baffle shall fit within volume constraints**
  - DR 2.1: Fit within 125x125x50mm box
- **FR3: Baffle shall adhere to mass constraints**
  - DR 3.1: Weight less than 300g
- **FR4: Baffle shall attenuate light**
  - DR 4.1: Ground testing shall be done to determine light obscuration
    - DR 4.2: 99.9% light attenuation at 30 degrees
  - DR 4.3: Baffle shall have a Pre-Obscuration angle of $\geq 10^{o}$

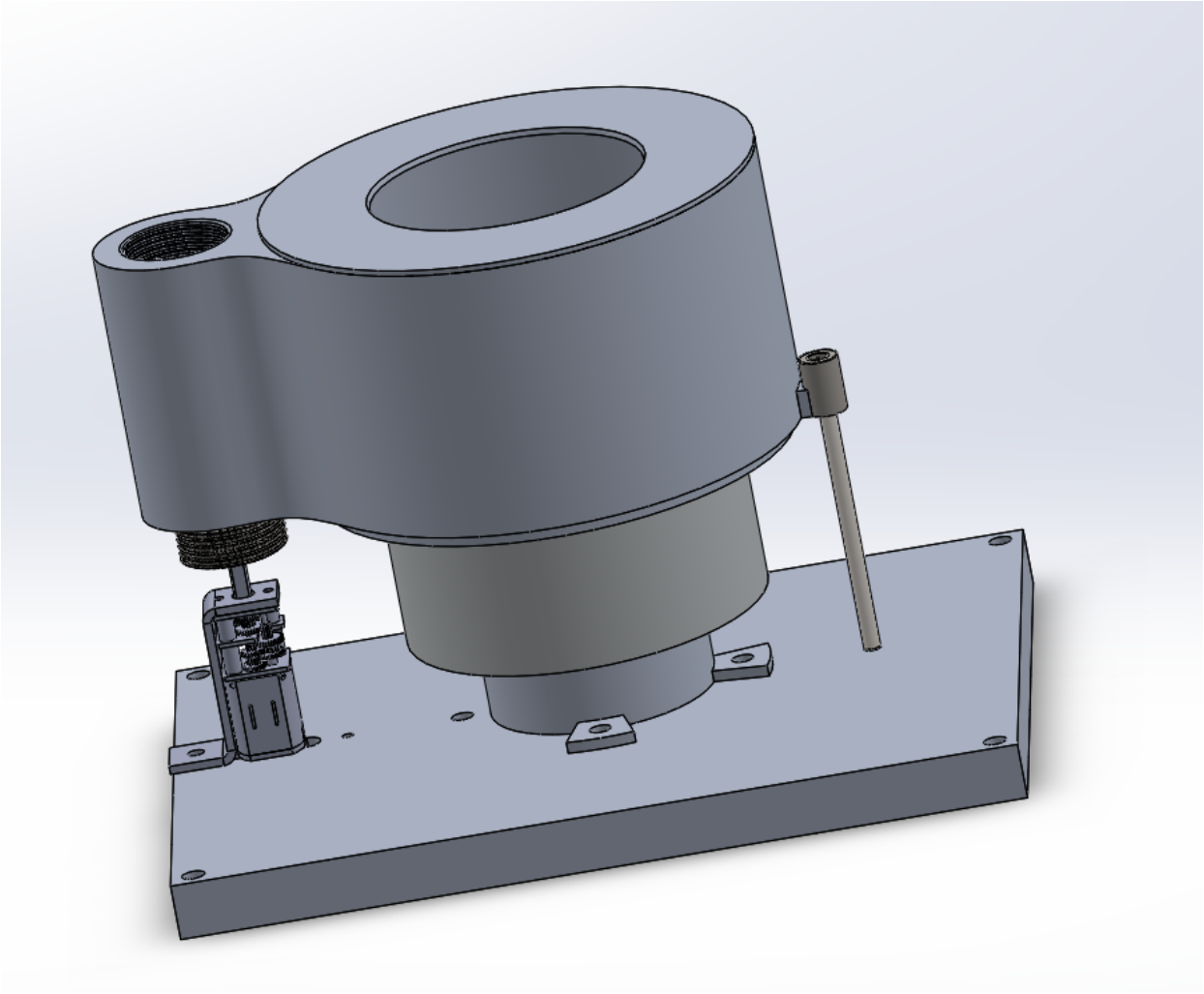
Manufacturing Safety Status

- Risk Mitigation for Machine Shop
  - Personal protective equipment
  - Proper clothing
  - Proper disposal of materials
  - Clean up after machine use
  - Supervision of machining where necessary

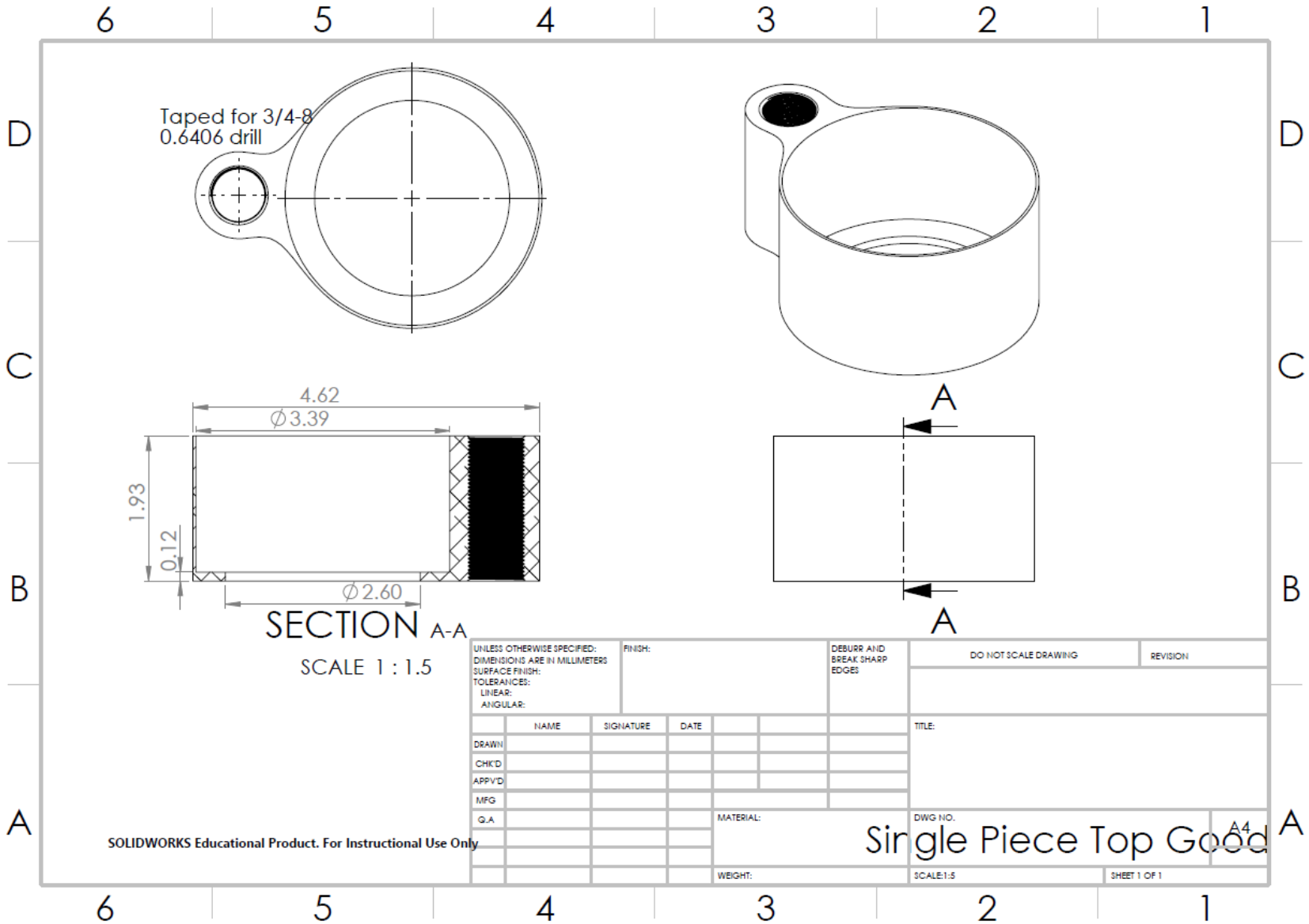
Category Breakdown

- Electronics
  - Includes PC board, resistors, and other small components
- Testing Equipment
  - Includes LEDS, lasers, and rotary table
- Optics
  - Includes filter and photodiode
- Stock Metal
  - Includes Aluminum 2024-T4
- Baffle Add-Ons
  - Includes thread tap, bearing, shaft, motor, and gear
- Other
  - Includes epoxy, adhesive, and shipping costs

Full Baffle



Top Tier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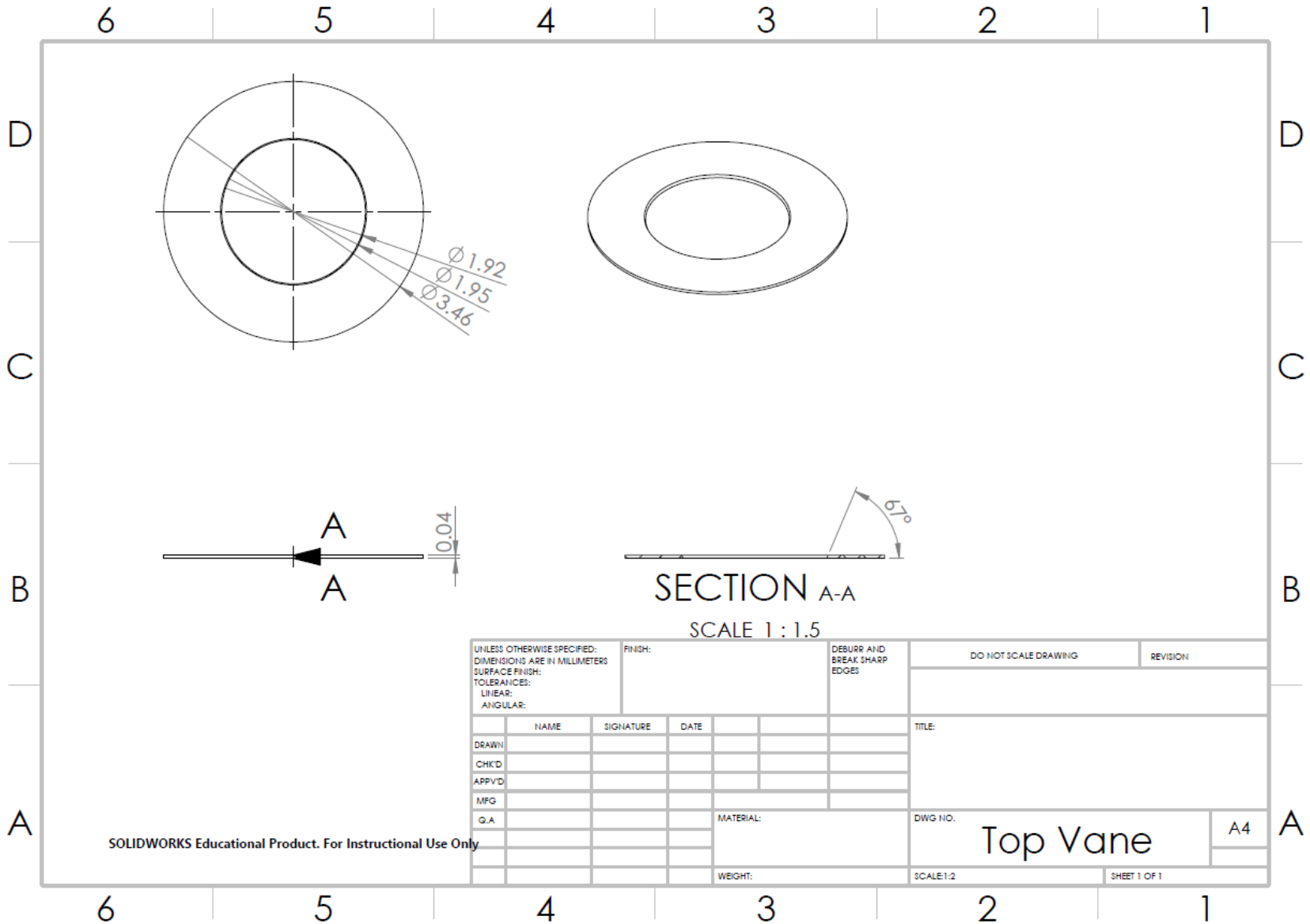
Top Vane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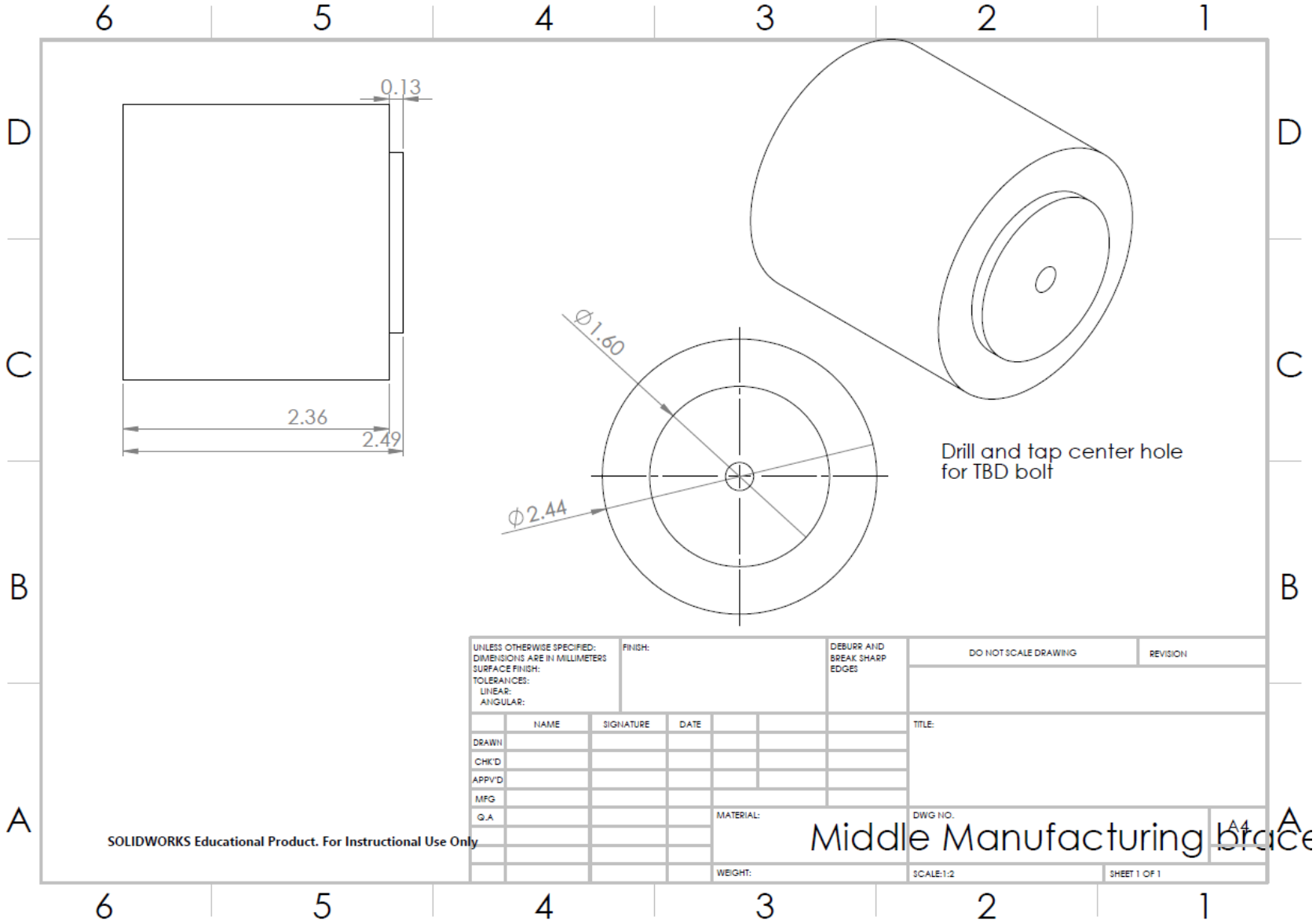
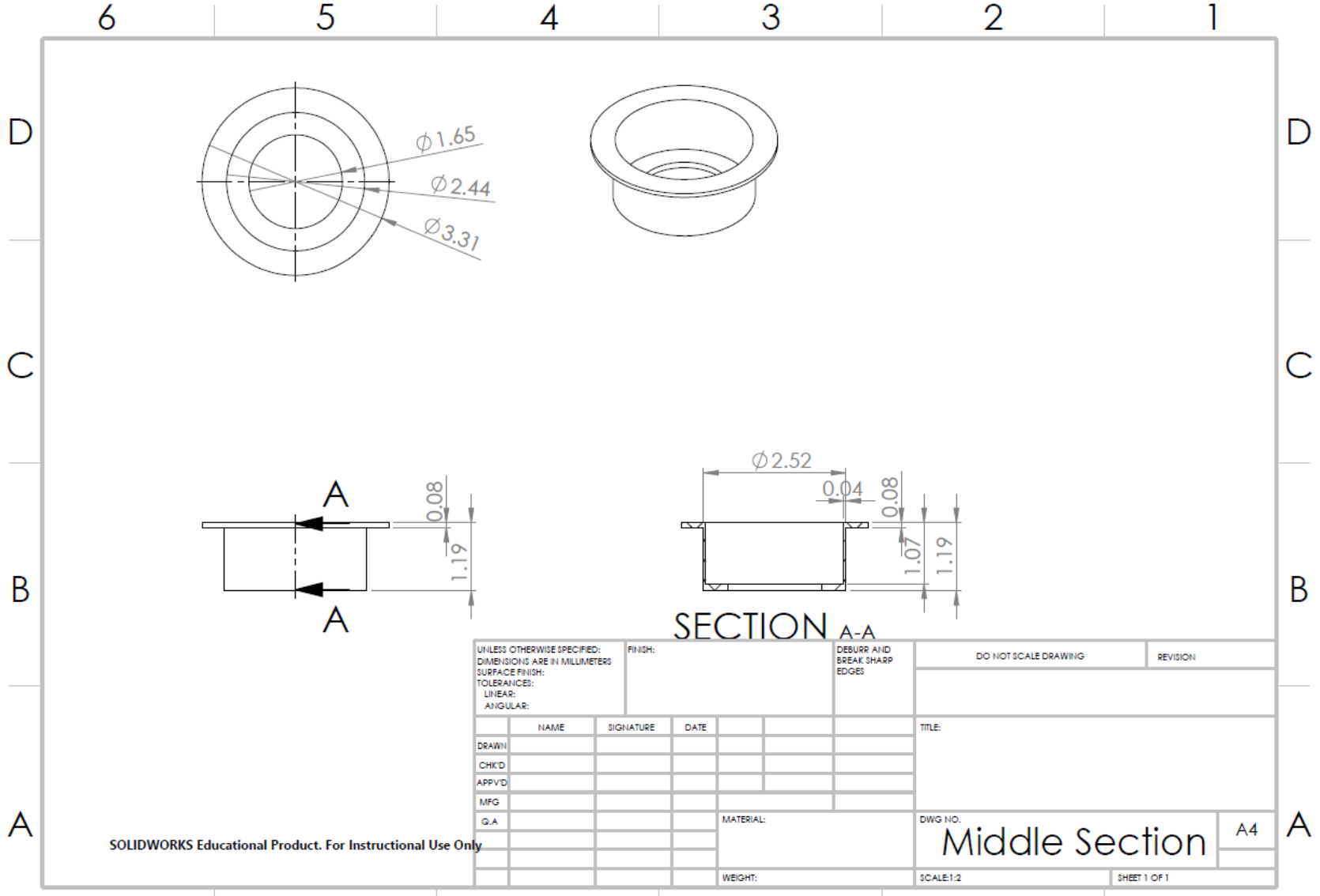
Middle Manufacturing Brace



Middle Tier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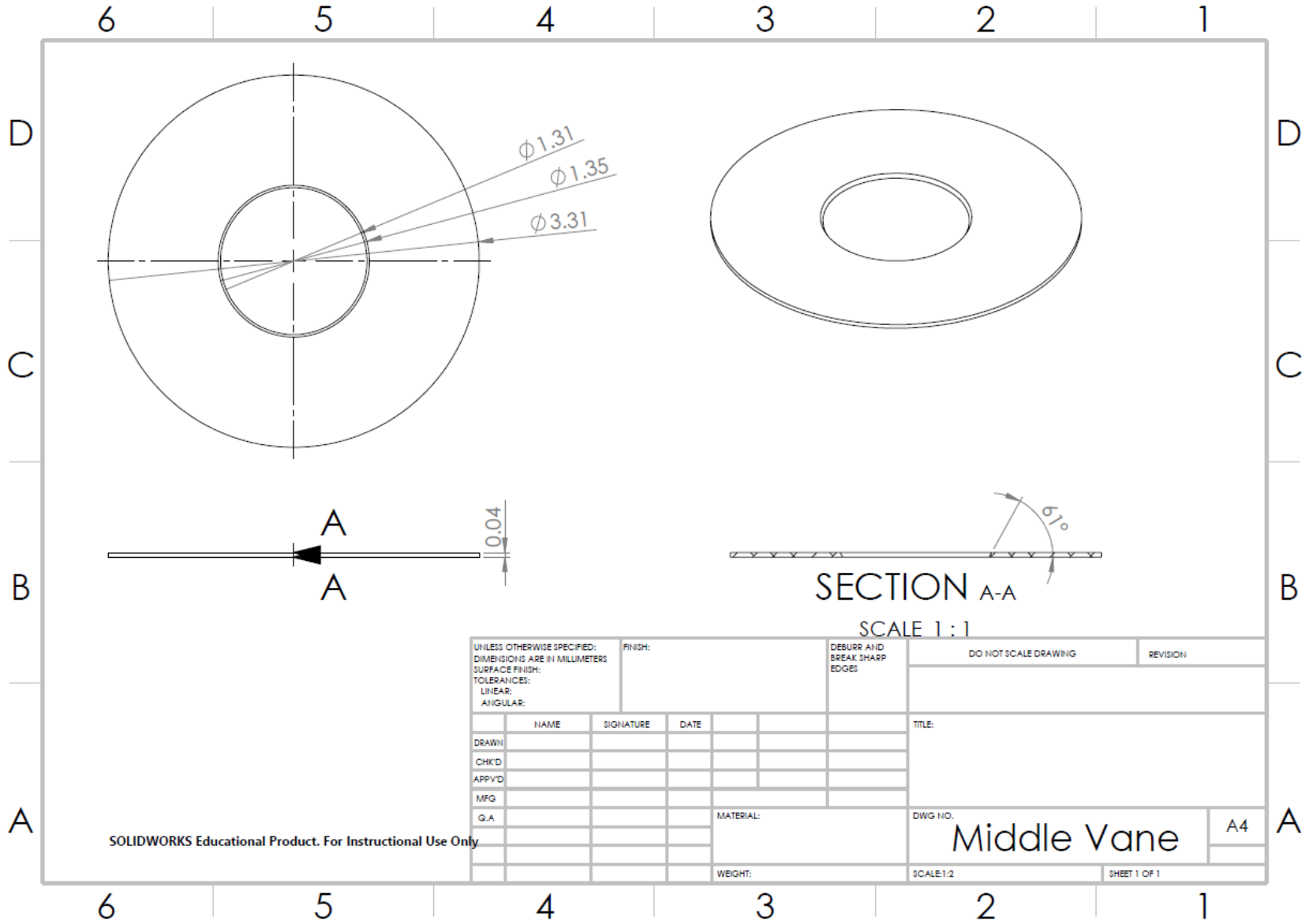
Middle Vane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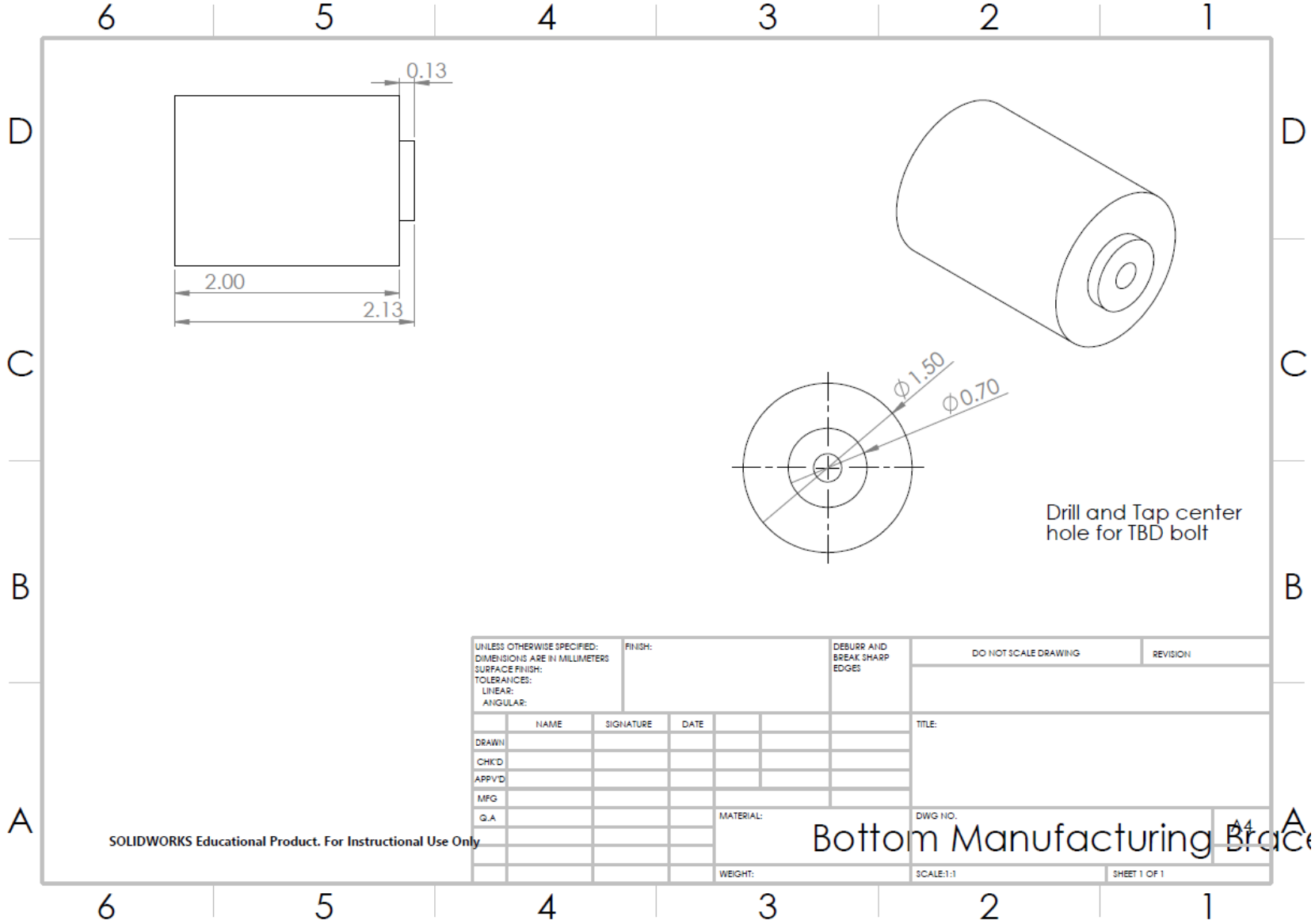
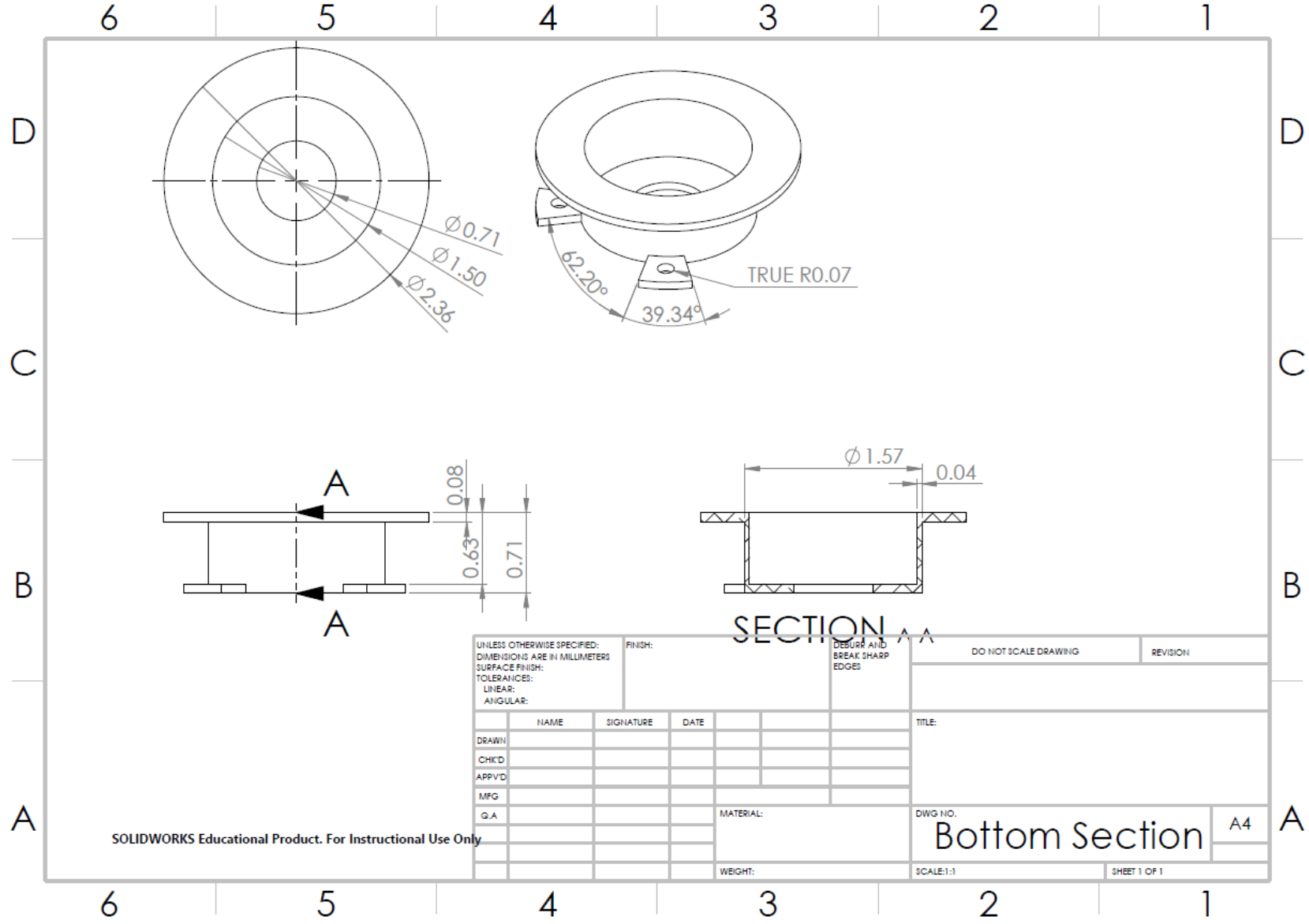
Bottom Manufacturing Brace



Bottom Tier


Ø0.71
Ø1.50
Ø2.36
62.20°
39.34°
TRUE R0.07
A
A
0.08
0.63
0.71
Ø1.57
0.04
SECTION A-A
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
Bottom Section
A4
WEIGHT:
SCALE:1:1
SHEET 1 OF 1
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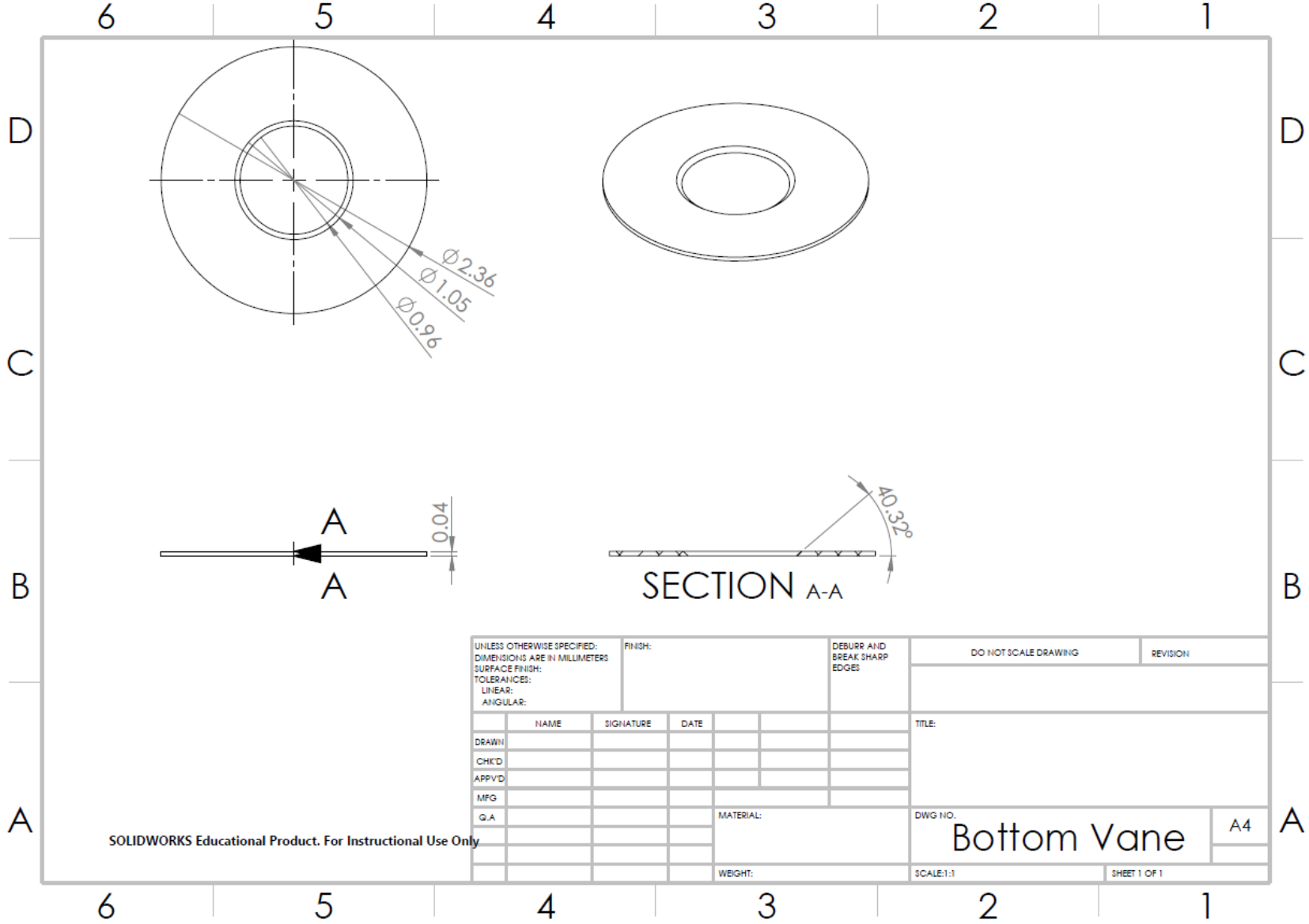
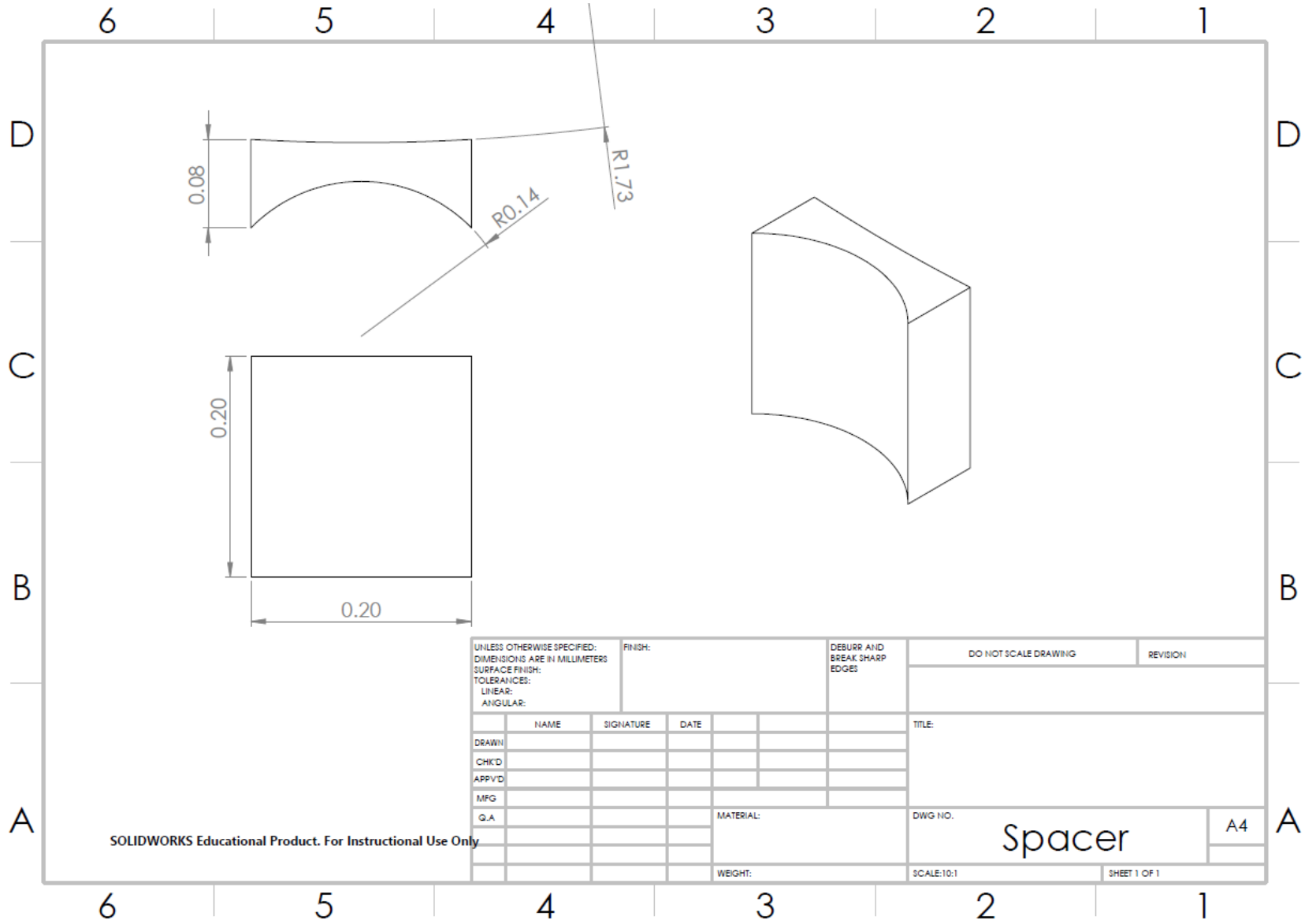
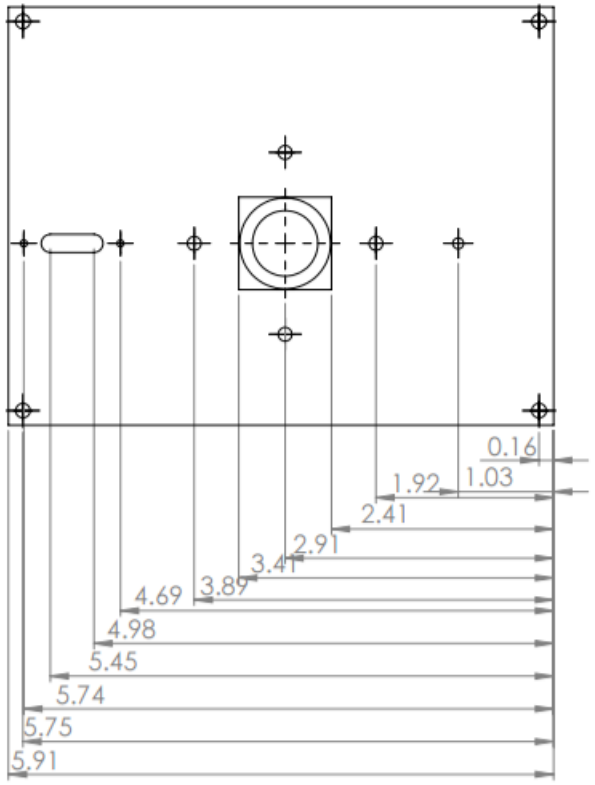
Bottom Vane

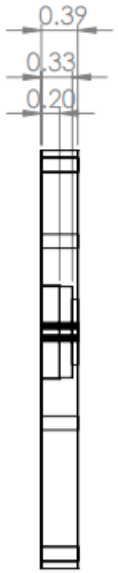

6
5
4
3
2
1
D
C
B
A
Ø2.36
Ø1.05
Ø0.96
A
A
0.04
40.32°
SECTION A-A
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
Bottom Vane
A4
WEIGHT:
SCALE:1:1
SHEET 1 OF 1
SOLIDWORKS Educational Product. For Instructional Use Only

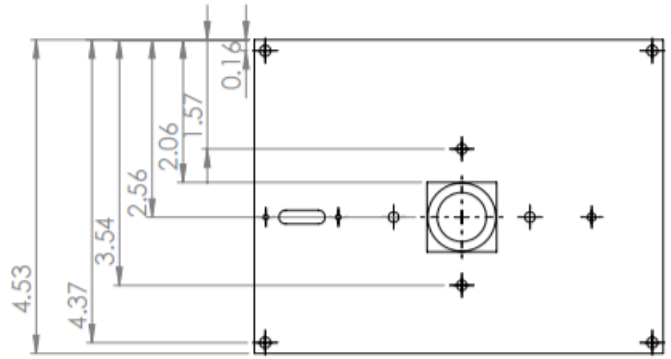
Spacer for Linear Bearing



Base Plate







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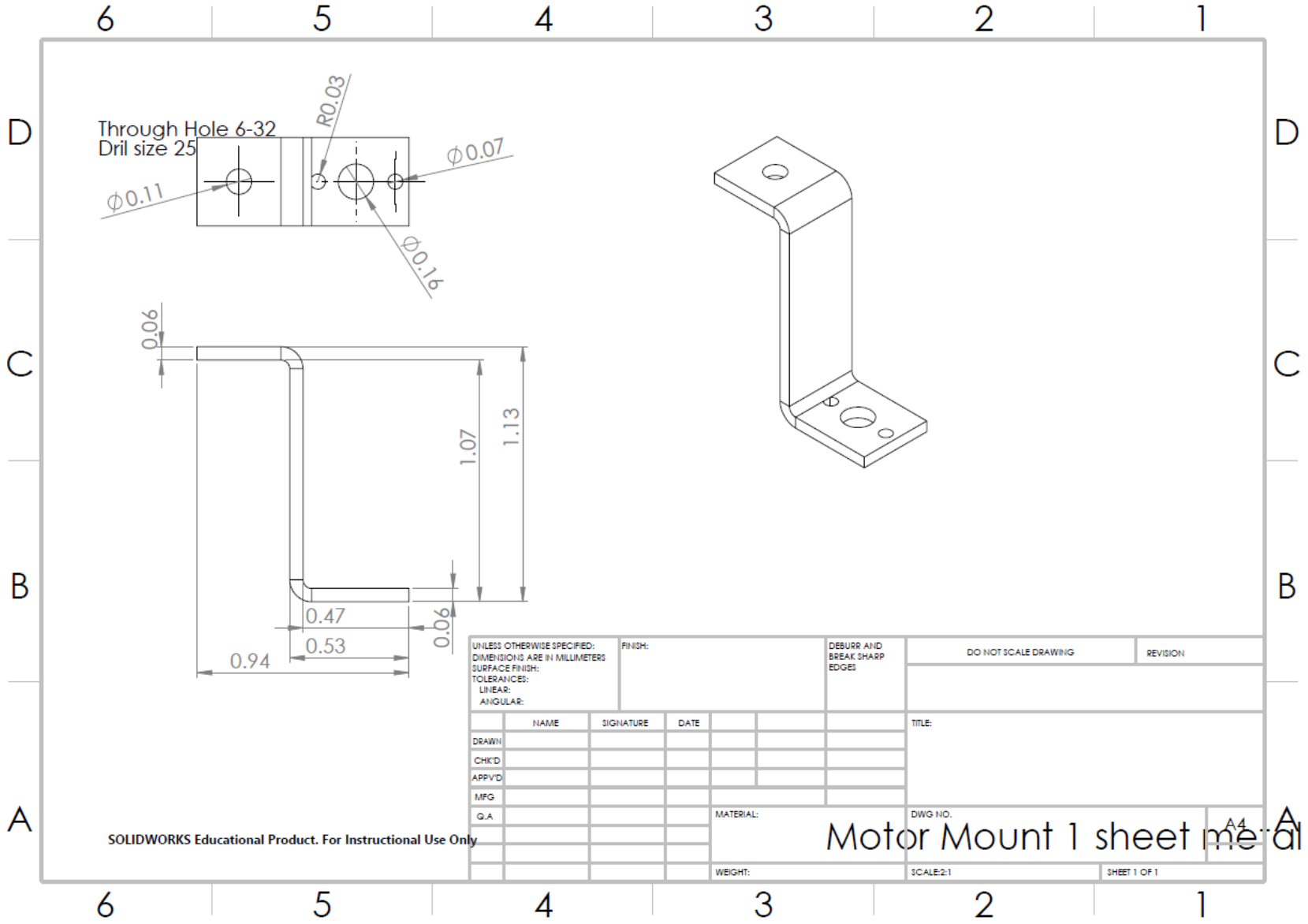
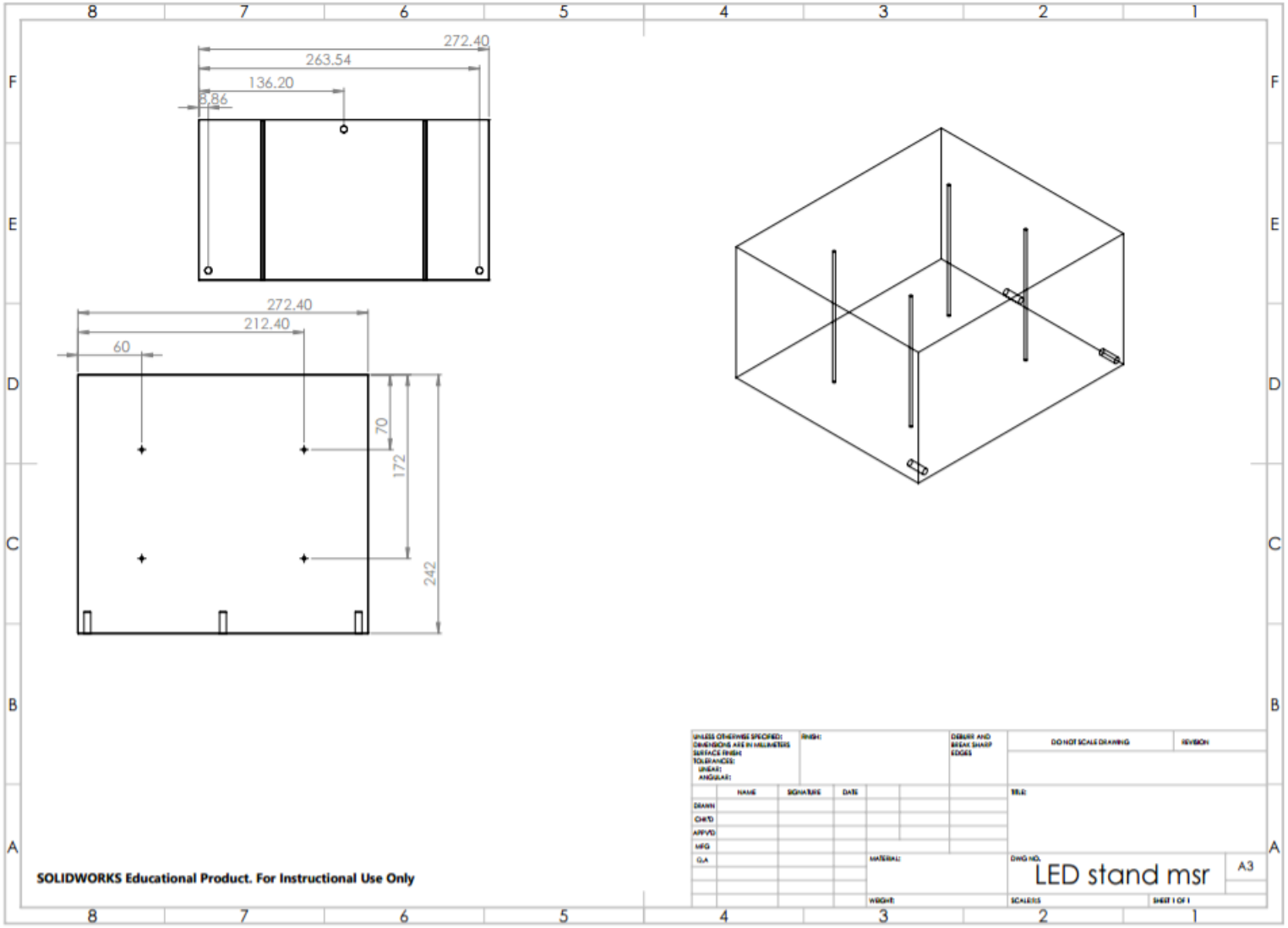
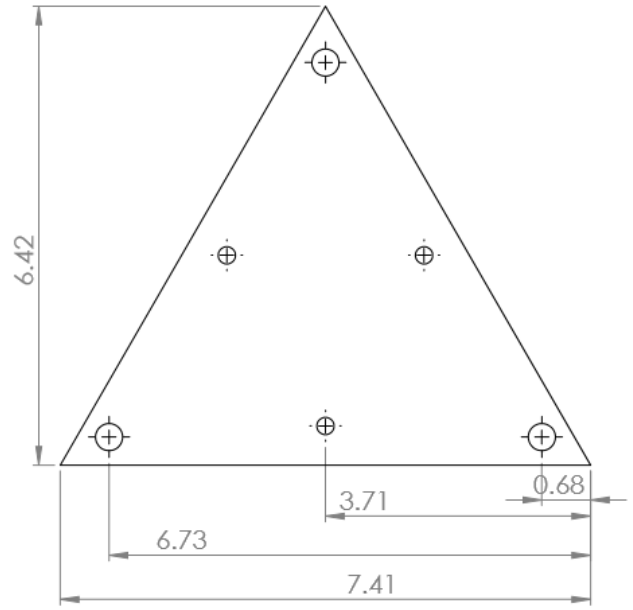
Sheet Metal Motor Mount

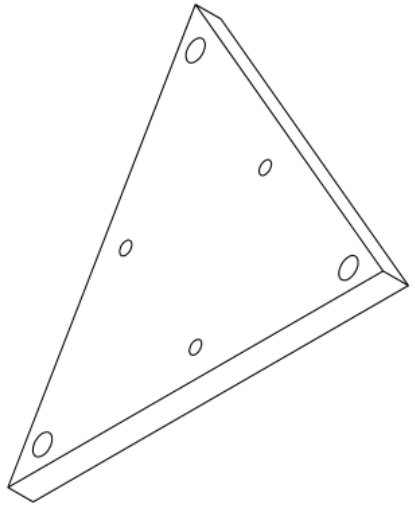


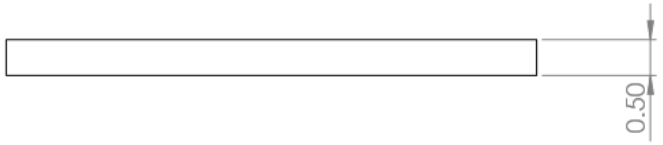
LED Stand


272.40
263.54
136.20
8.86
272.40
212.40
60
70
172
242
SOLIDWORKS Educational Product. For Instructional Use Only
LED stand msr
A3

Rotary Table Level Table







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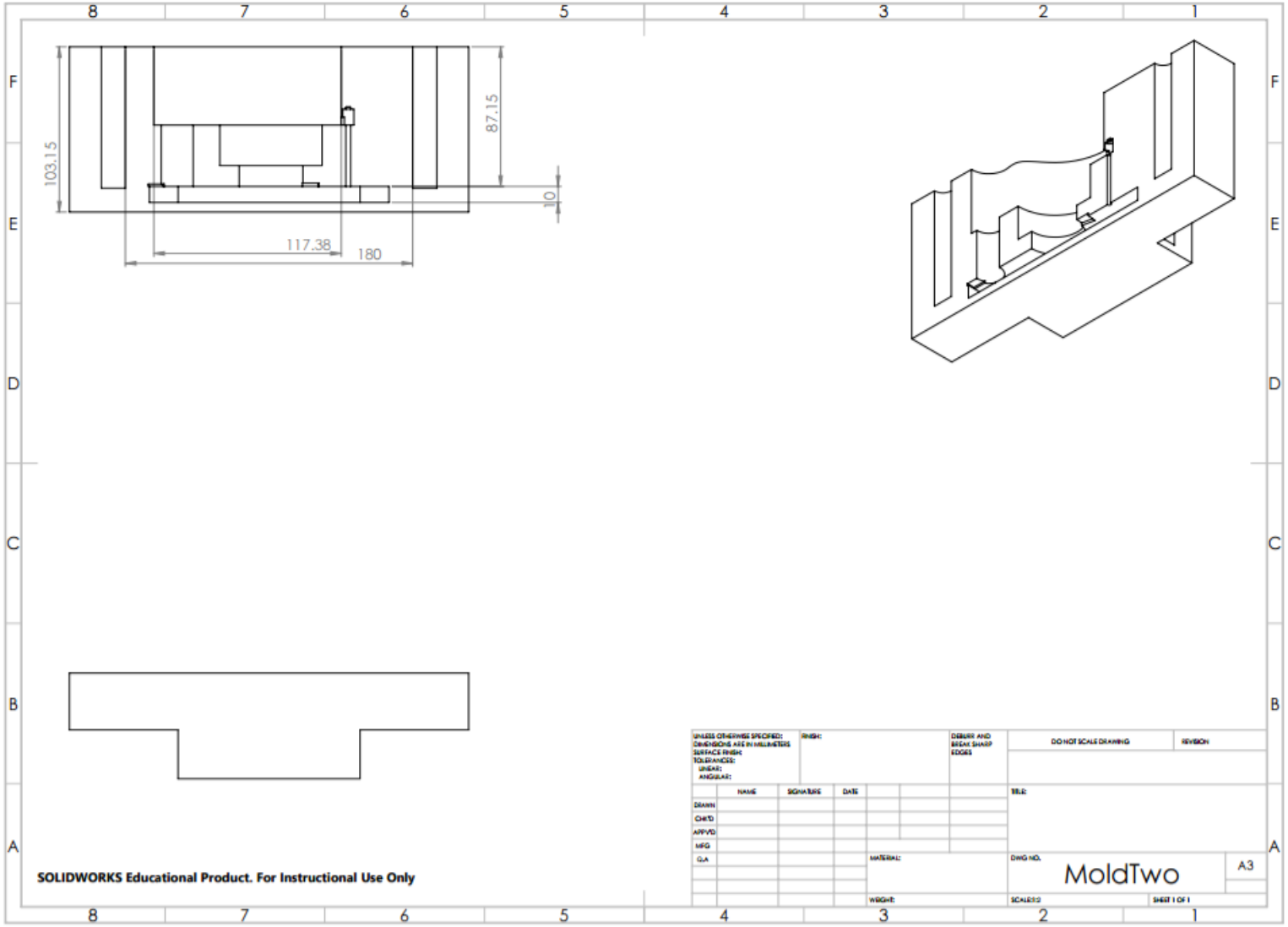
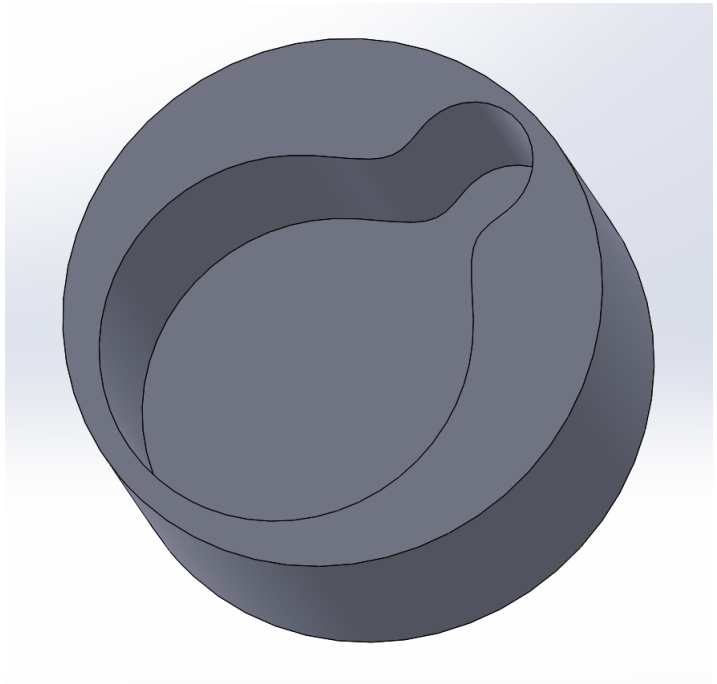
CAD Negative



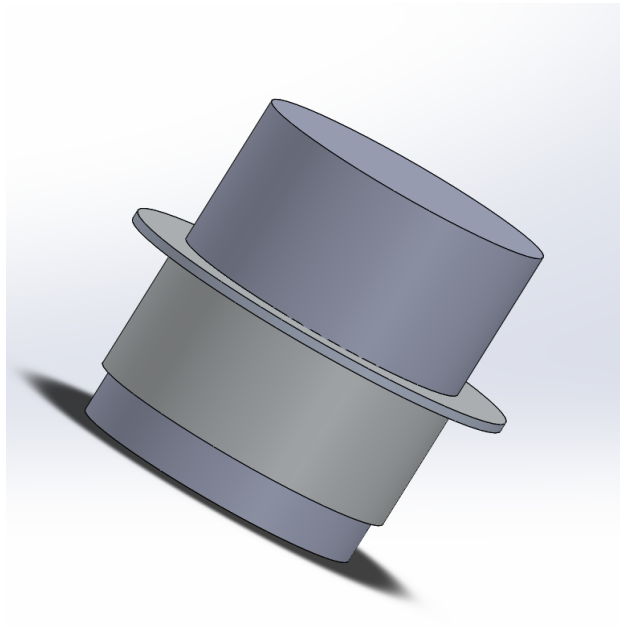
Baffle Fixtures

Top Section



Machine	Time Remaining
CNC Mill	0 hrs

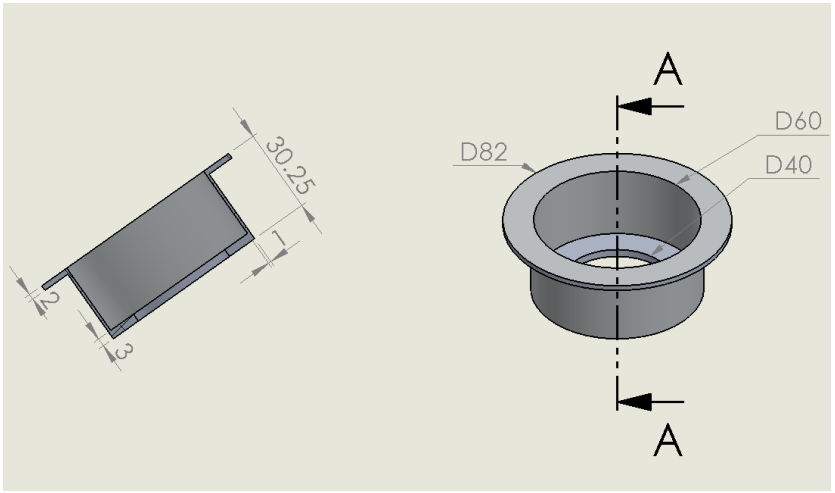
Middle & Bottom Sections



Machine	Time Remaining
CNC Lathe	0 hrs

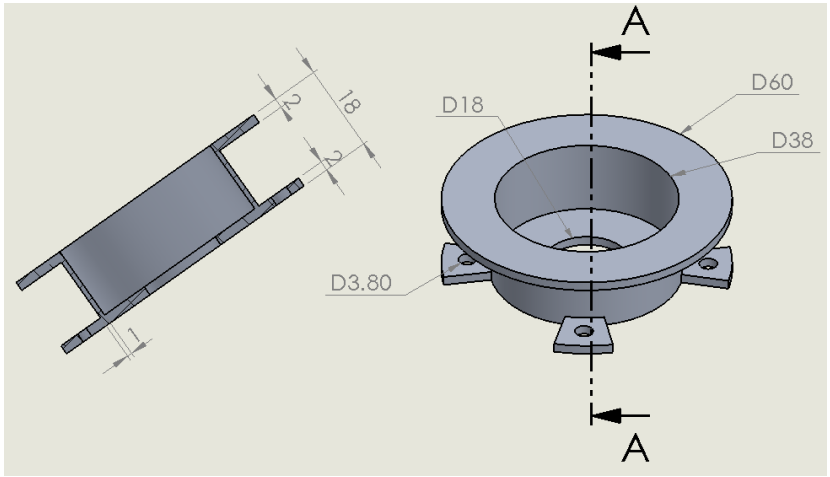
Baffle Sections

Middle Section



Machine	Time Remaining
CNC Lathe	4 hrs

Bottom Section



Machine	Time Remaining
CNC Lathe	4 hrs

Baseplate & Motor Mount

Baseplate

Machine	Time Remaining
CNC Mill	3 hrs

Motor Mount

Machine	Time Remaining
Hand Mill & Metal Bender	0 hrs

Light Stand & PCB & Laser Support

Light Stand

Machine	Time Remaining
	2 hrs

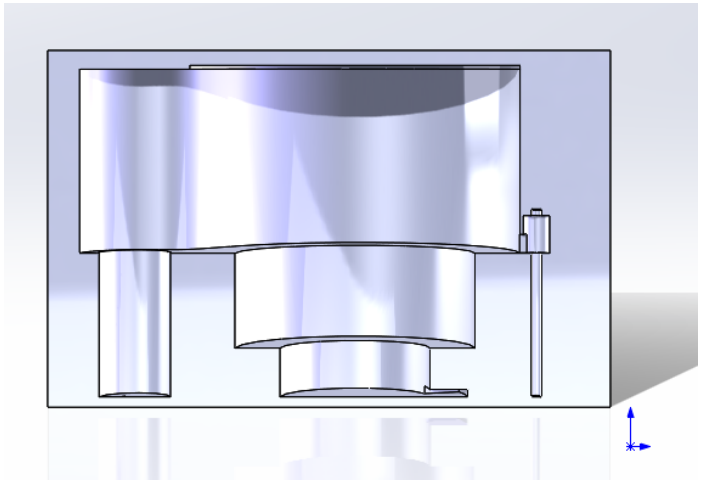
PCB & Laser Support

Machine	Time Remaining
Hand Mill	1 hr

Leveling Plates & 3-D Supports

Leveling Plates

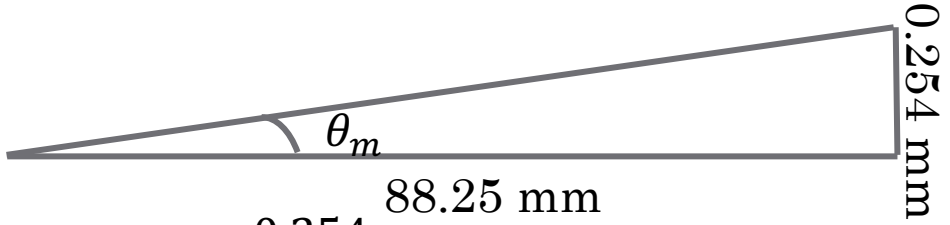
3-D Supports (x4)



Machine	Time Remaining
	hrs

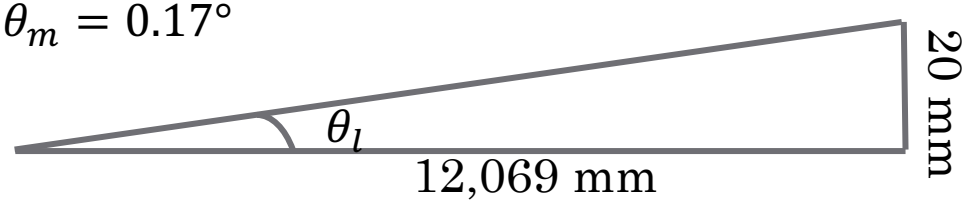
Machine	Time Remaining
	hrs

Orientation Verification



$$\theta_m = \tan^{-1}\left(\frac{0.254}{88.25}\right)$$

$$\theta_m = 0.17°$$



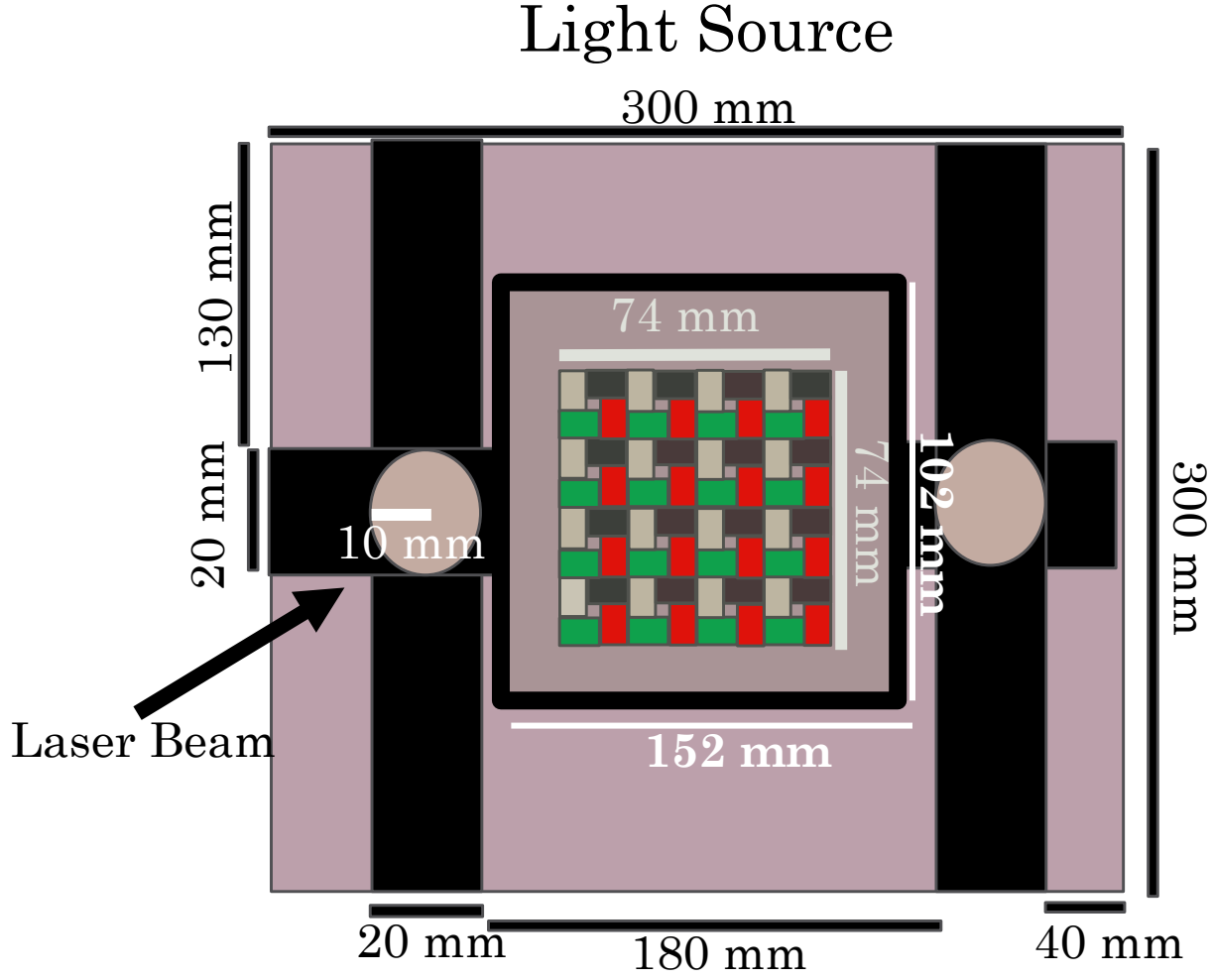
$$\theta_l = \tan^{-1}\left(\frac{20}{12069}\right)$$

$$\theta_l = 0.10°$$

$$\theta = \theta_l + \theta_m$$

$$\theta = 0.10° + 0.17°$$

$$\theta = 0.27°$$



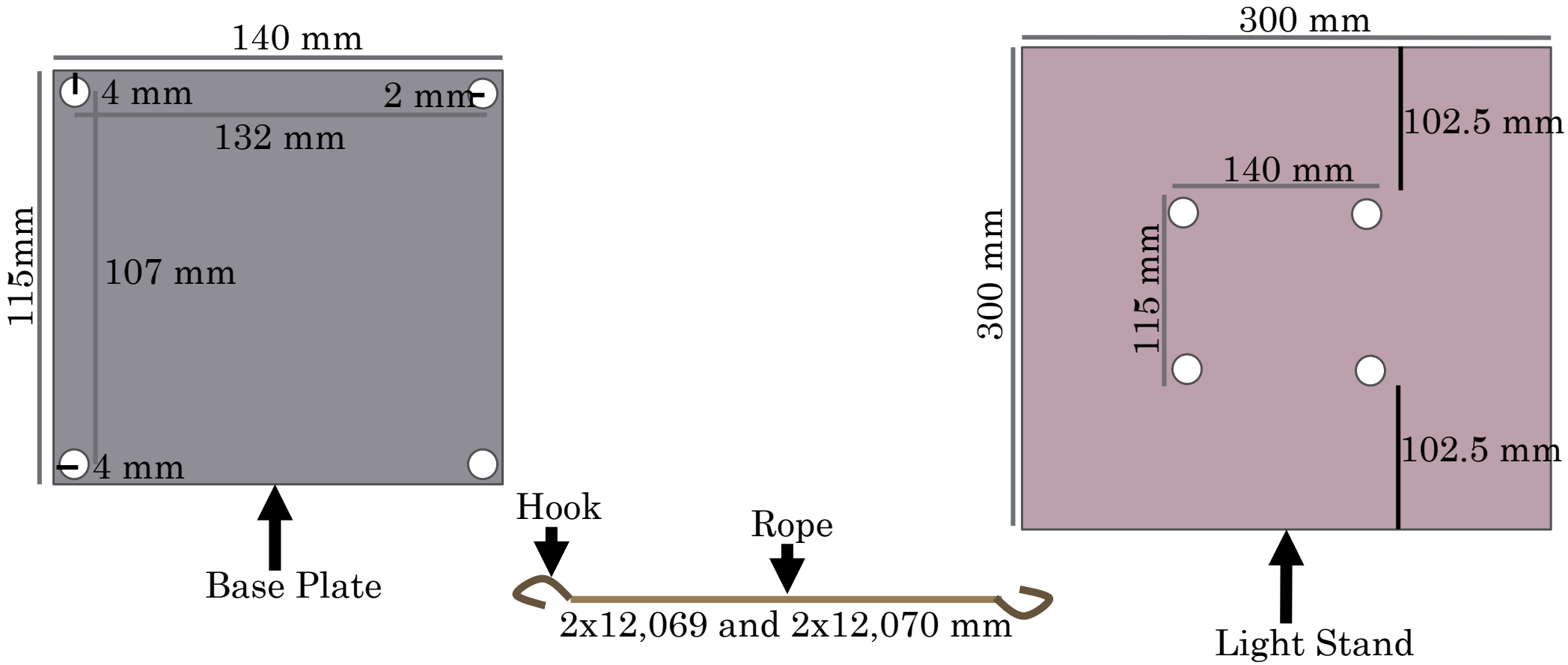
Need for Black Felt Room

Problem:
Dark room has many reflective surfaces

- Floor/Ceiling
- Walls
- Pipes

Solution:
Covering Dark room surfaces in black felt, which will help block the reflectiveness of the surfaces underneath

Placement Set-up



Testing Safety Status

Health and Safety	Equipment and Lab Failure
15% Complete, still compiling hazards	10% Complete, lab design is still changing

Further Steps to Take:

- Continue compiling hazards to health and safety as well as equipment and our lab hallway.
- Assemble checklists in parallel with testing procedure.
- Delegate out requests for input on failure modes as time demands.
- Be pessimistic.
- Regularly reach out to the PAB.

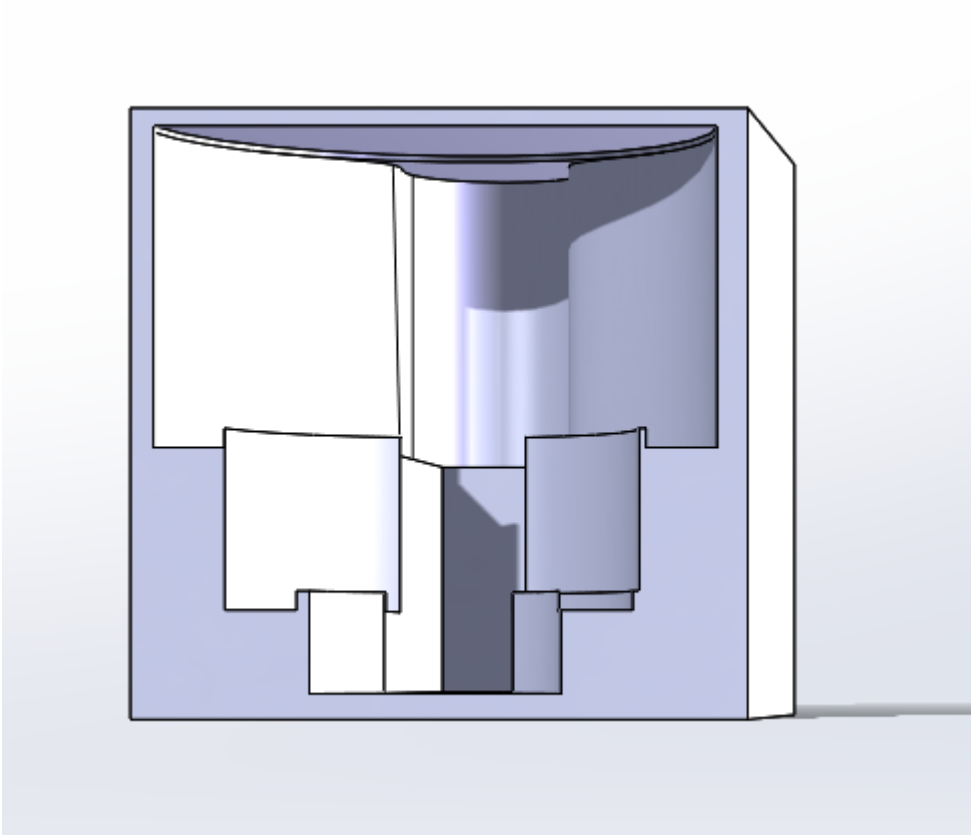
Negative Support Structure

-The purpose of this structure is to hold the baffle in position for optical testing

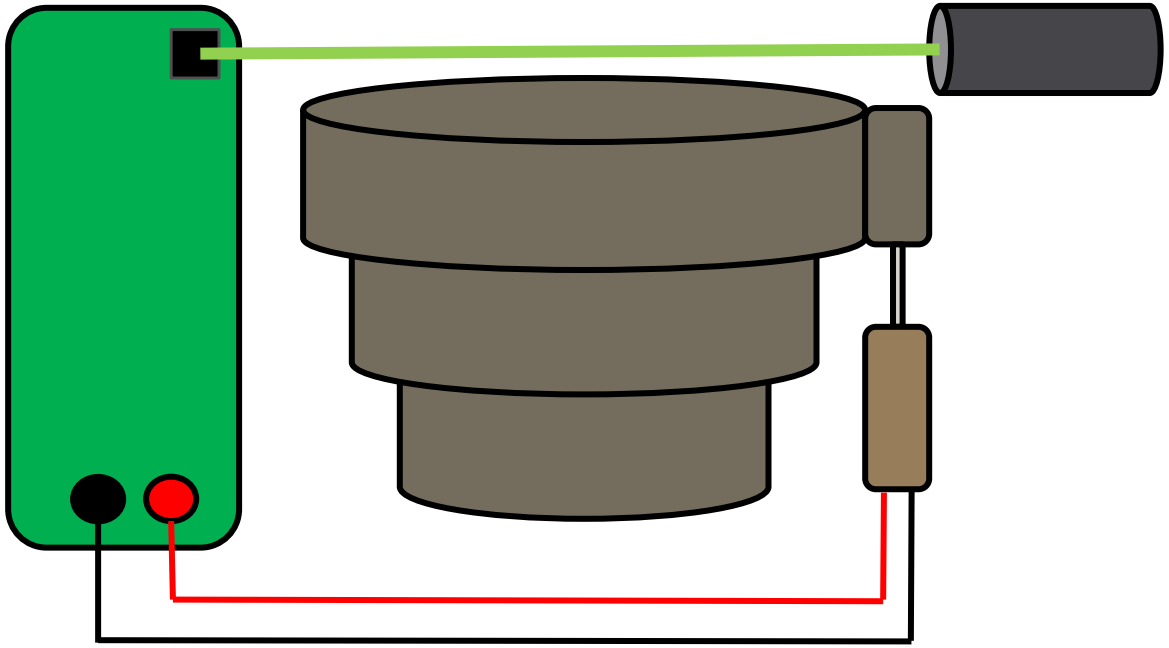
-Two Support structure manufacturing methods will be explored

1) A 3D printed design, the Solidworks file was made from the CAD of the baffle itself will include pieces that must be cut away
2)A high density foam block cut away to fit the baffle and hold it in place

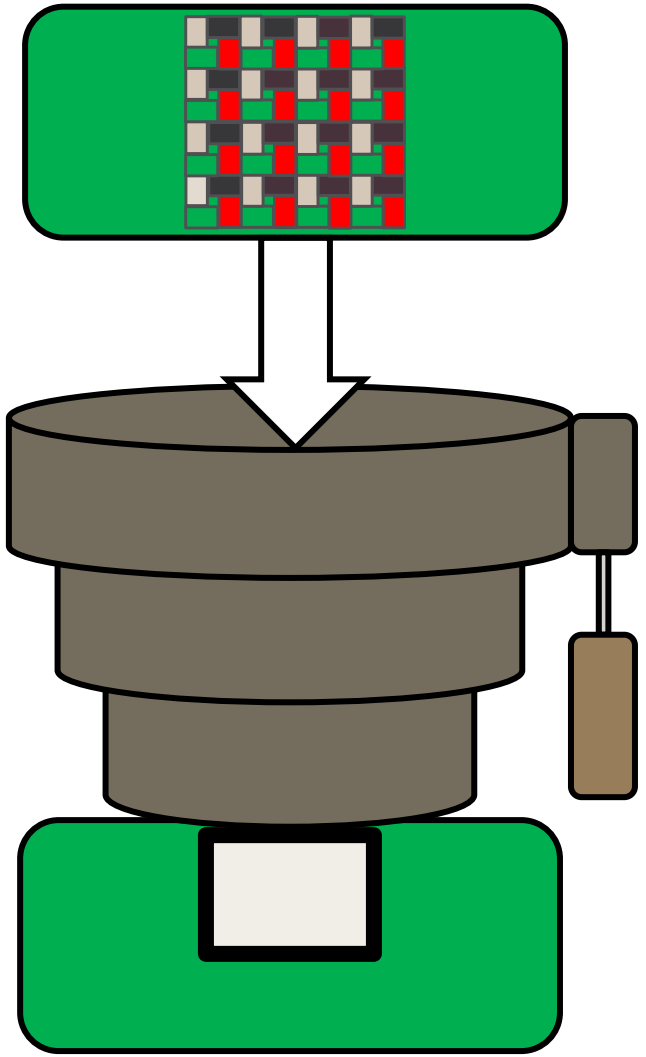
Once one of each is made and checked for accuracy, one of the methods will be chosen to make the remaining 3 support structures



Electronics Overview

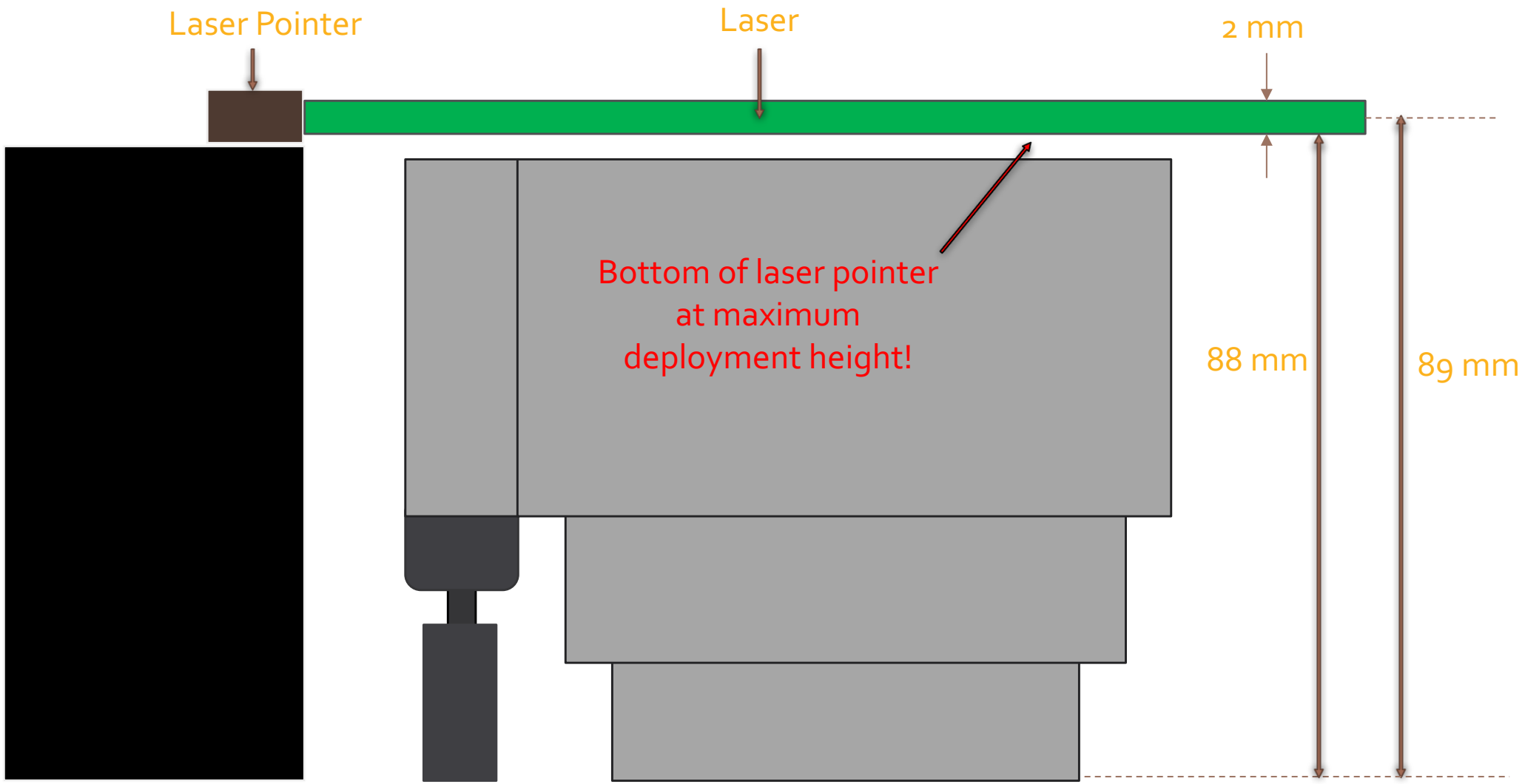


Motor Controller Circuit



Photodiode Amplifier and LED Circuits

Maximum Deployment



Deployment Test Set Up