Spectral Forest Presentation 2

ME 476C Section 02

Team: Tyler Lerew, Torrey King, & Derrick Doan

Project Description

Build a robust spectrometer housing to protect the internal components of the spectrometer. The range of wavelengths of light that the client is interested in is 350-1000 nm, this product could help change the trajectory of forests research and conservation efforts.

Insights into plant health, leaf makeup and thickness, water concentrations in soil and in trees, temperature differences due to water conspiring up the tree, this data will be put into prediction models to analyze the forests' health

The unit will be placed in a specific understory position to continuously monitor a location. Later the device will be attached to a drone and can analyze the forest from above. The lab application is to view the optical and energy properties of semiconductors like energy transfer and light reflection and absorption

Use single aperture with or without mirrors to direct the light into the linear array being used to decipher the light and collect the data

Sponsors: Alexander Shenkin (Assistant Research Professor) and Carlo da Cunha (Assistant Professor) - SICCS

Black Box

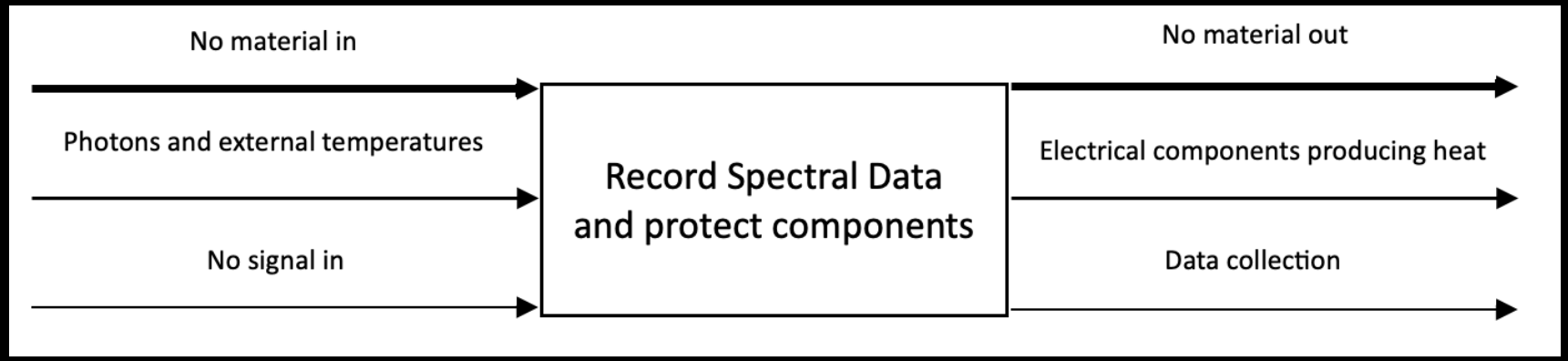


Figure 1: Black Box Model

Functional Model Decomposition

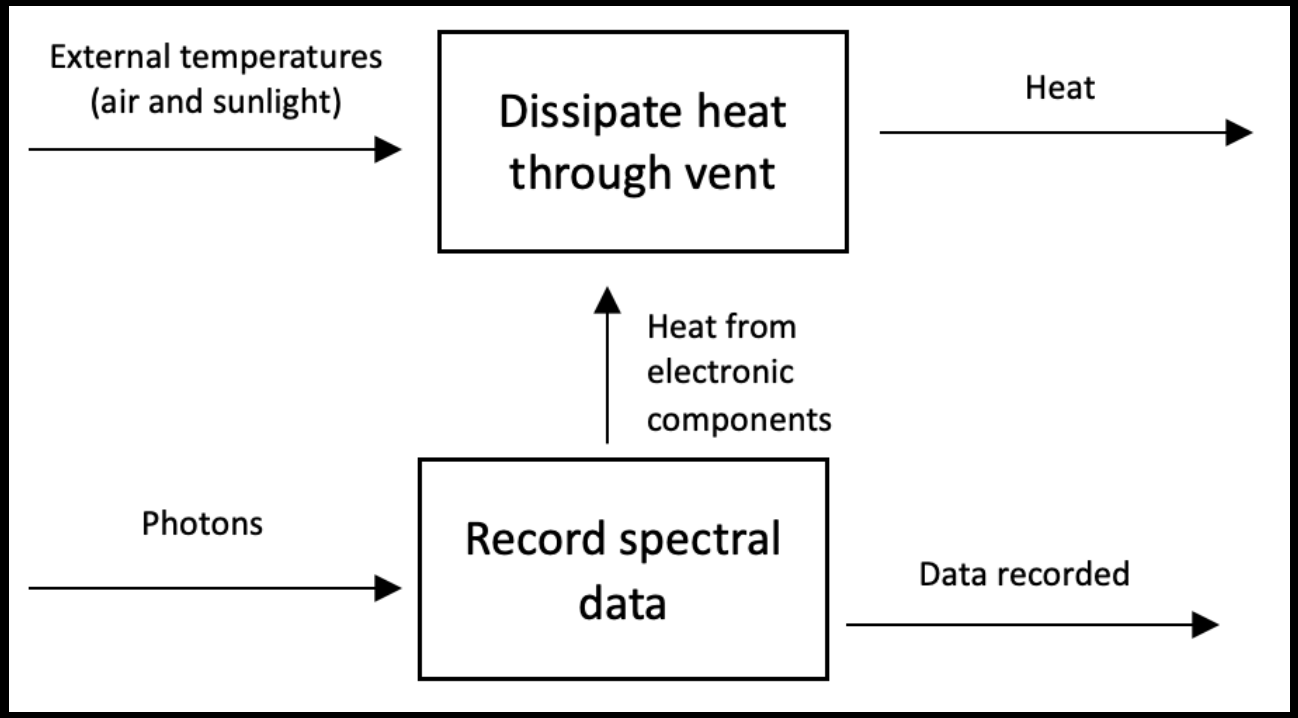


Figure 2: Functional model

Engineering Calculations -Tyler

- FEA on camera mount attached to housing
- Purpose: design the housing to easily be attached to a standard camera mount and it will not fail when attached
- thrust = thrust-to-weight-ratio × total drone weight
- Aurelia X4 Standard
  - Payload up to 3.3 lbm
  - Total weight of drone with battery and housing attached = 10.68 lbs
  - Thrust to weight ratio = 2:1
  - Thrust = 21.36 lbf
  - Strength of sleeve nut is 105 x 10^3 psi

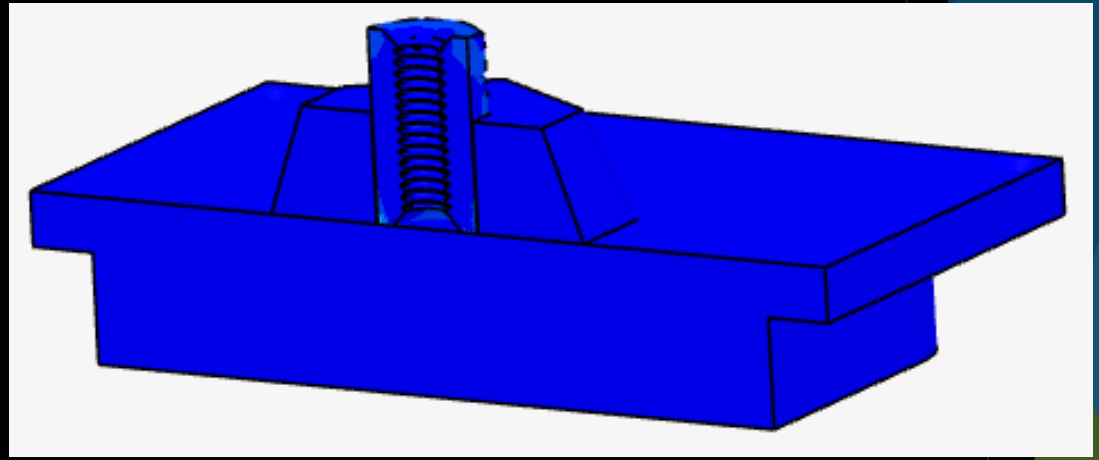


Figure 3: FEA Solution Field

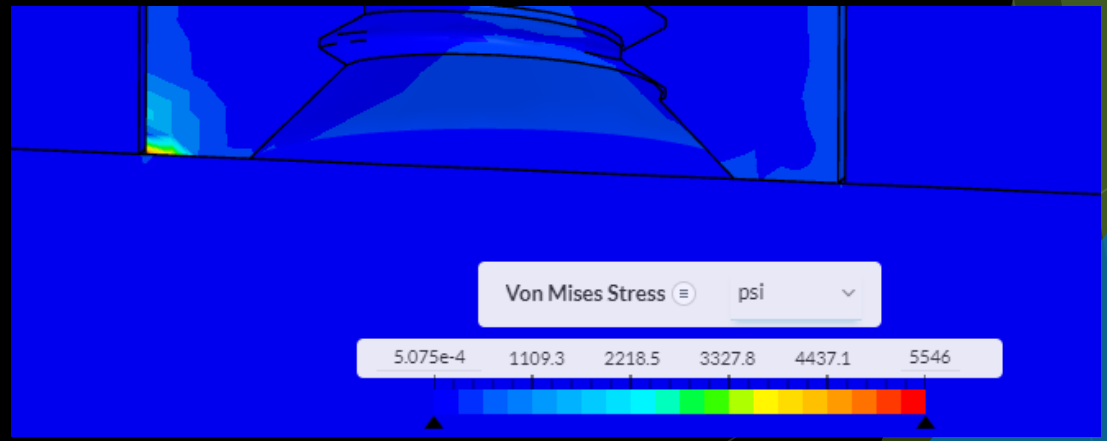


Figure 4: Highest stress concentration

Engineering Calculations - Torrey

Gore weather-resistant vent: 4000 ml/minute at 70 mbar pressure

$$\dot{m} = \rho A V$$

Mass flow rate equation

$$\rho = P/RT$$

Ideal gas law

Engineering Calculations - Derrick

- Cosine Correction – Making light spectrum spectrally flat across all arrays (Ex: eyes)

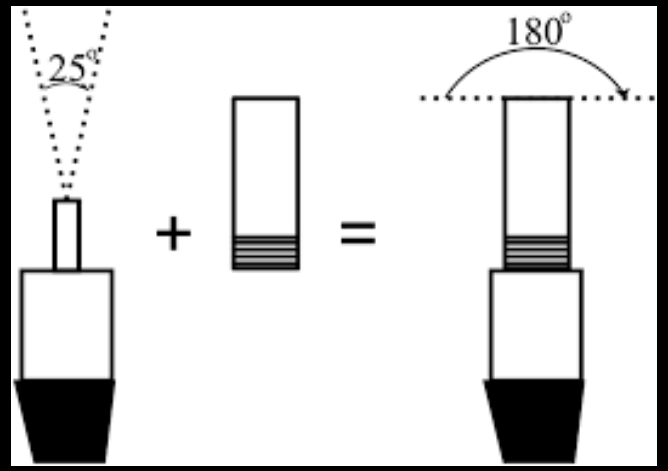


Figure 5: Cosine Corrector Example

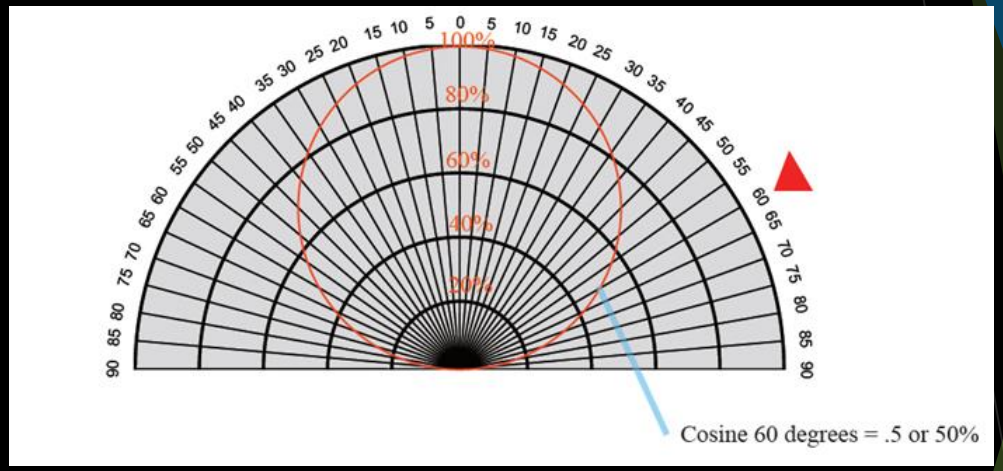


Figure 6: Cosine Correction for Oblique Angle Light

Lambert's Law:
$L_\theta = L_0 \times \cos \theta$

Light Intensity at Angle θ = Light Intensity on Reflected Surface x Cosine of Oblique Angle θ

Concept Generations: Morph Matrix

- Morph matrix was used to generate concepts by researching the most common practices and ranking them based on feasibility for application to our project
- Green is the most relevant option followed by yellow and orange

Table 1: Morphological Matrix

Morph Matrix						
Subsystem	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6
Optics	Linear array	fiber optic	camera	Linear array	Linear array	Linear array
Shape	Cylinder	Rectangular prism	Cone	Rectangular prism	Rectangular prism	Rectangular prism
Cosine corrector	silica/quarts glass	PTFE film	Microscope slide	silica/quarts glass	PTFE film	silica/quarts glass
Pressure equalizer	latex balloon	Breather vent	hole	inverted balloon	Breather vent	Breather vent
O-ring	Silicone	FKM	FFKM	FKM	FFKM	Silicone
Material	ABS	Onyx	Polycarbonate	Onyx	Onyx	Onyx
Insulation	yes	no	yes	yes	yes	no
Mirrors	yes	no	yes	no	yes	no

Concept Generation

Table 2: Concepts Advantages and Disadvantages

Concept advantages and disadvantages			
Subsystem	**Most relevant**	**Advantages**	**Disadvantages**
Optics	Linear Array	Cheap, can collect data in the range of wavelength that we are interested in	Must direct the light into the array
Shape	Rectangular Prism	Easy to 3d print, easier to mount to a drone	Difficult to 3d print and difficult to mount to a drone
Cosine corrector	Silica/quarts glass	Large range of transmissibility, chemically and thermally resistant	None
Pressure equalizer	Breather vent	Can withstand pressures at 2m under water	Slowly equalizes pressures
O-ring	FFKM	Resistant to acids, solvents, extreme temperatures, water, weather, and sunlight	Expensive
Material	Onyx	Smooth surface finish, strong, 3d printable	May not be waterproof, needs to be tested
Insulation	None	Keeps electronics from shifting and at consistent temperature	Components are inaccessible
Mirrors	None	Ensure the light is perfectly aligned with the array	Hard to fasten and keep in the exact same place

Torrey, Spectral Forest, F23toSp24_10

Concept Evaluation: Pugh Chart

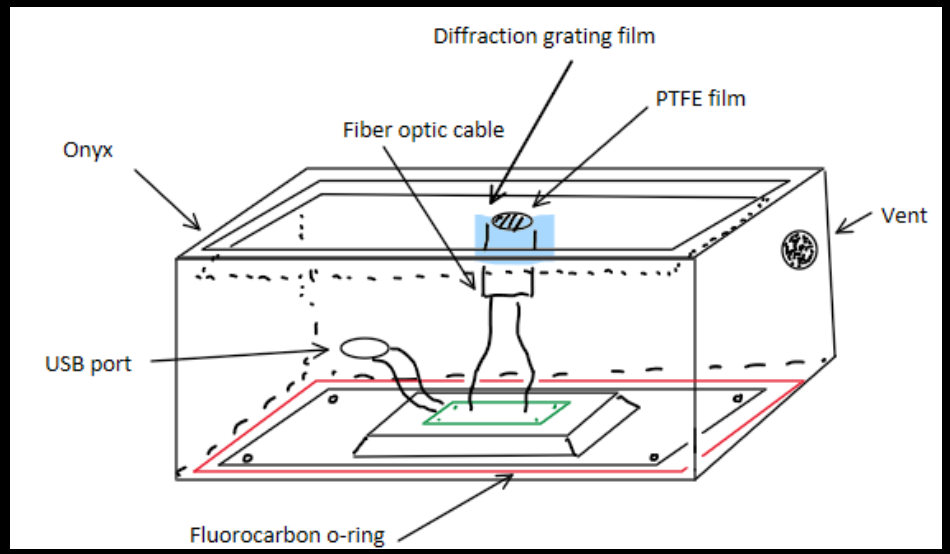
Table 3: Pugh Chart

Pugh Chart						
Criteria	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6
Durable	-	=	=	=	D	-
Vents ensure semi-constant conditions	+	=	+	+	A	=
Unit is sealed	-	=	-	=		=
Ease of access	-	+	-	=	T	+
Reliable	-	+	-	+		=
UV resistant	-	=	+	=	U	=
Affordable	+	-	-	-	M	=
S+	2	2	2	2		1
S-	5	1	4	1		0
S=	0	4	1	4		6

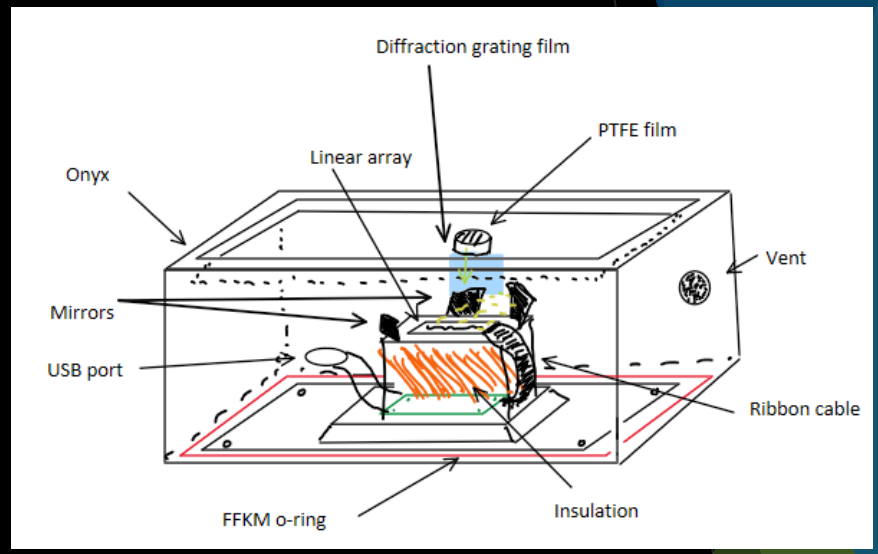
The team will move forward with **Designs 2, 4, & 5**

Concept Evaluation: Decision matrix

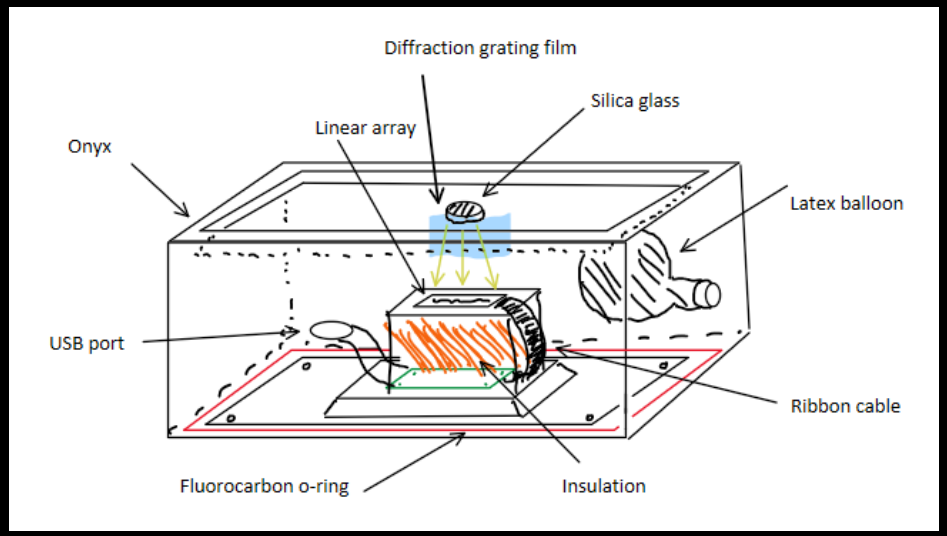
Design 2



Design 5



Design 4



Figures 7, 8 & 9: Top 3 Design Alternatives

Concept Evaluation: Decision matrix

Table 4: Decision Matrix

Design #:	-	Design # 2		Design # 4		Design # 5	
Criteria	**Weight**	**Unweighted**	**Weight**	**Unweighted**	**Weight**	**Unweighted**	**Weight**
Durable	0.15	85	12.75	90	13.5	80	12
Vents ensure semi-constant conditions	0.15	90	13.5	100	15	90	13.5
Unit is sealed	0.2	95	19	95	19	95	19
Ease of access	0.05	100	5	50	2.5	50	2.5
Reliable	0.2	95	19	100	20	90	18
UV resistant	0.2	90	18	90	18	90	18
Affordable	0.05	0	0	100	5	90	4.5
Total	1	Sum	87.25	Sum	93	Sum	87.5
Relative Rank	N/A	3		1		2	

Concept Evaluation

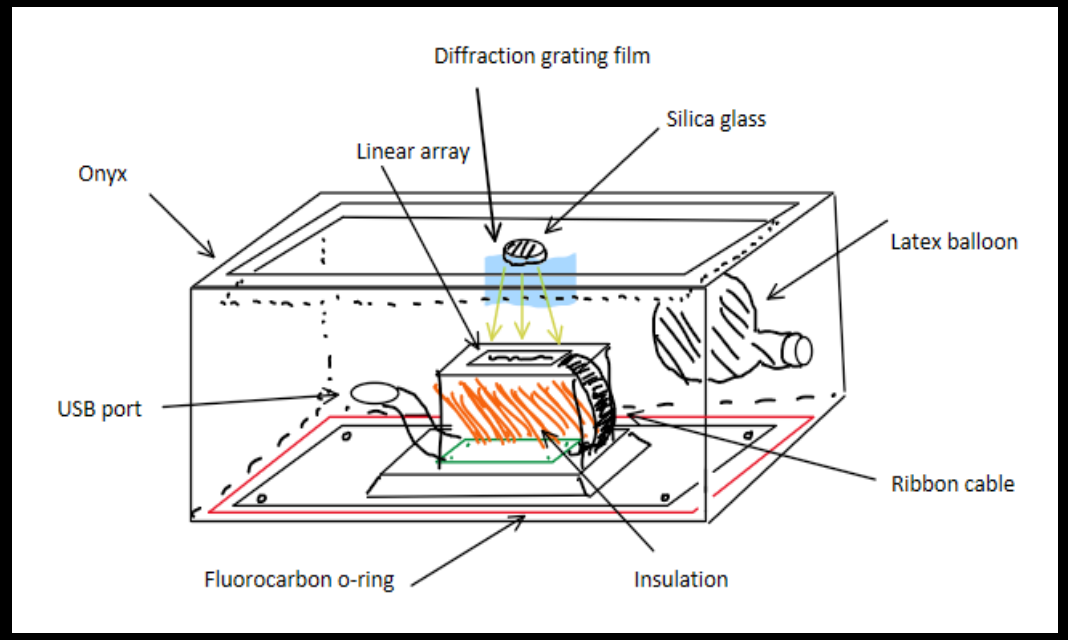


Figure 8 :Design #4

- No mirrors, latex balloon may be an issue if the quality is not high enough
- Silica glass has a higher transmissibility than PTFE
- Insulation may be removed if ribbon cables cannot be obtained

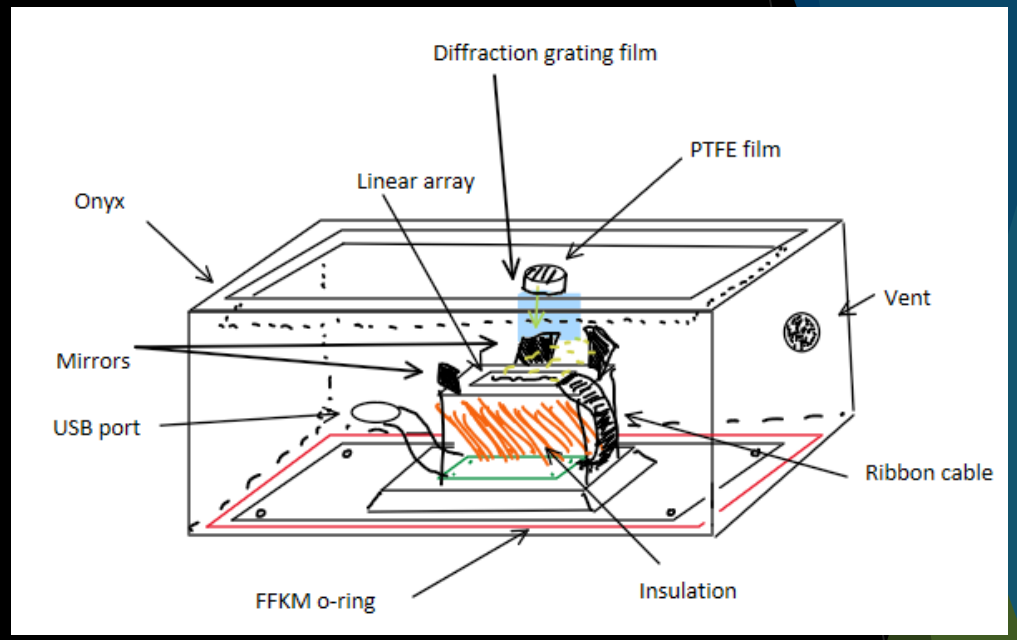


Figure 9 :Design #5

- Contains mirrors, which are difficult to deal with when attached to a drone
- PTFE comes in a thin film, will be an issue if it gets punctured

Concept Evaluation: CAD

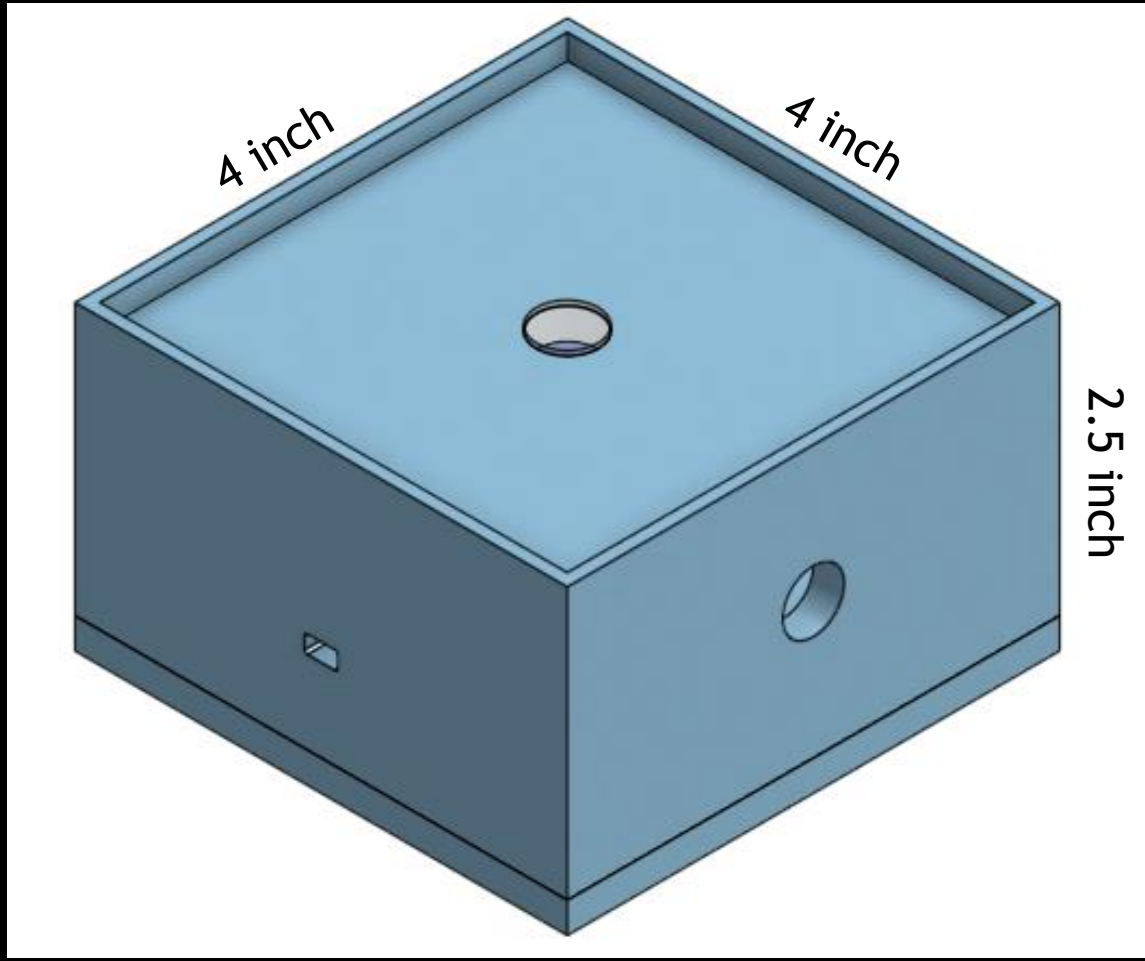


Figure 10: ISO CAD View

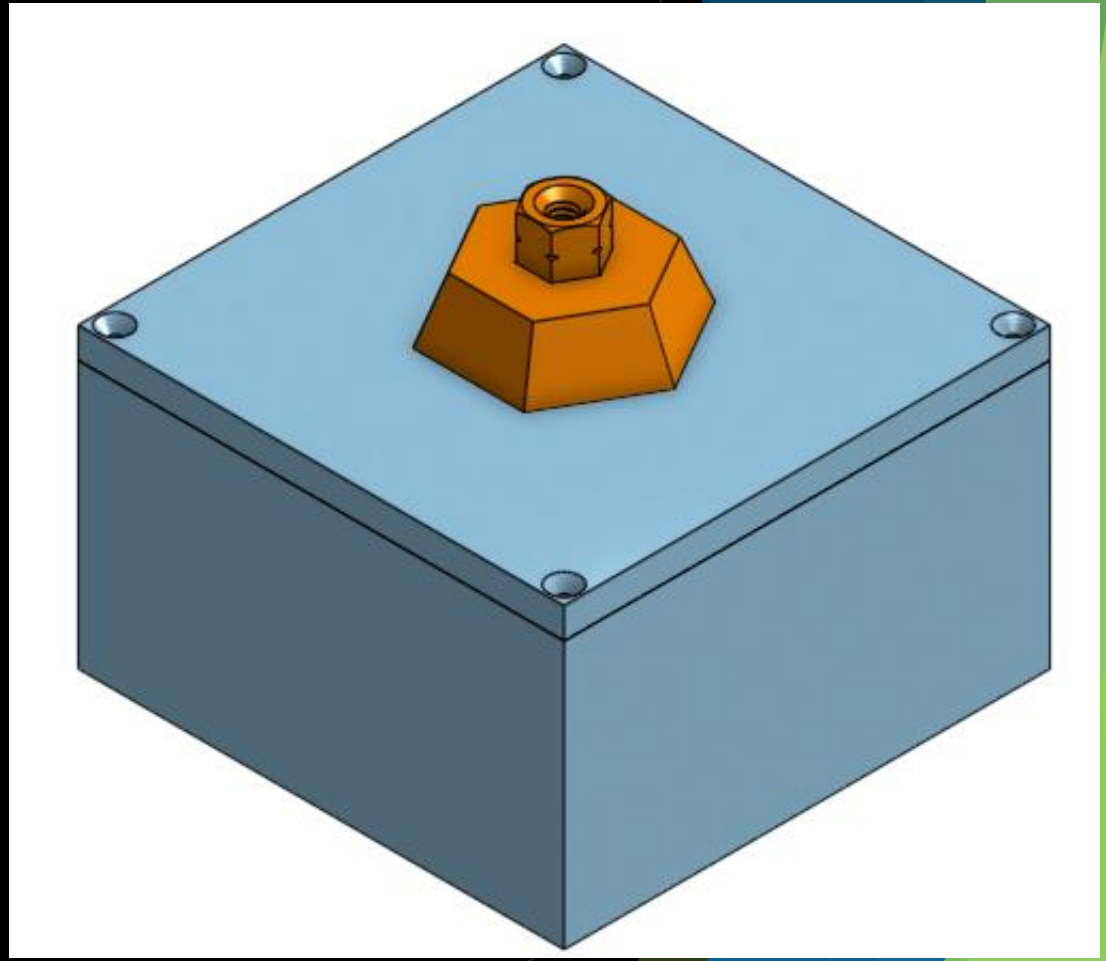


Figure 11: Bottom ISO CAD View

Concept Evaluation: CAD

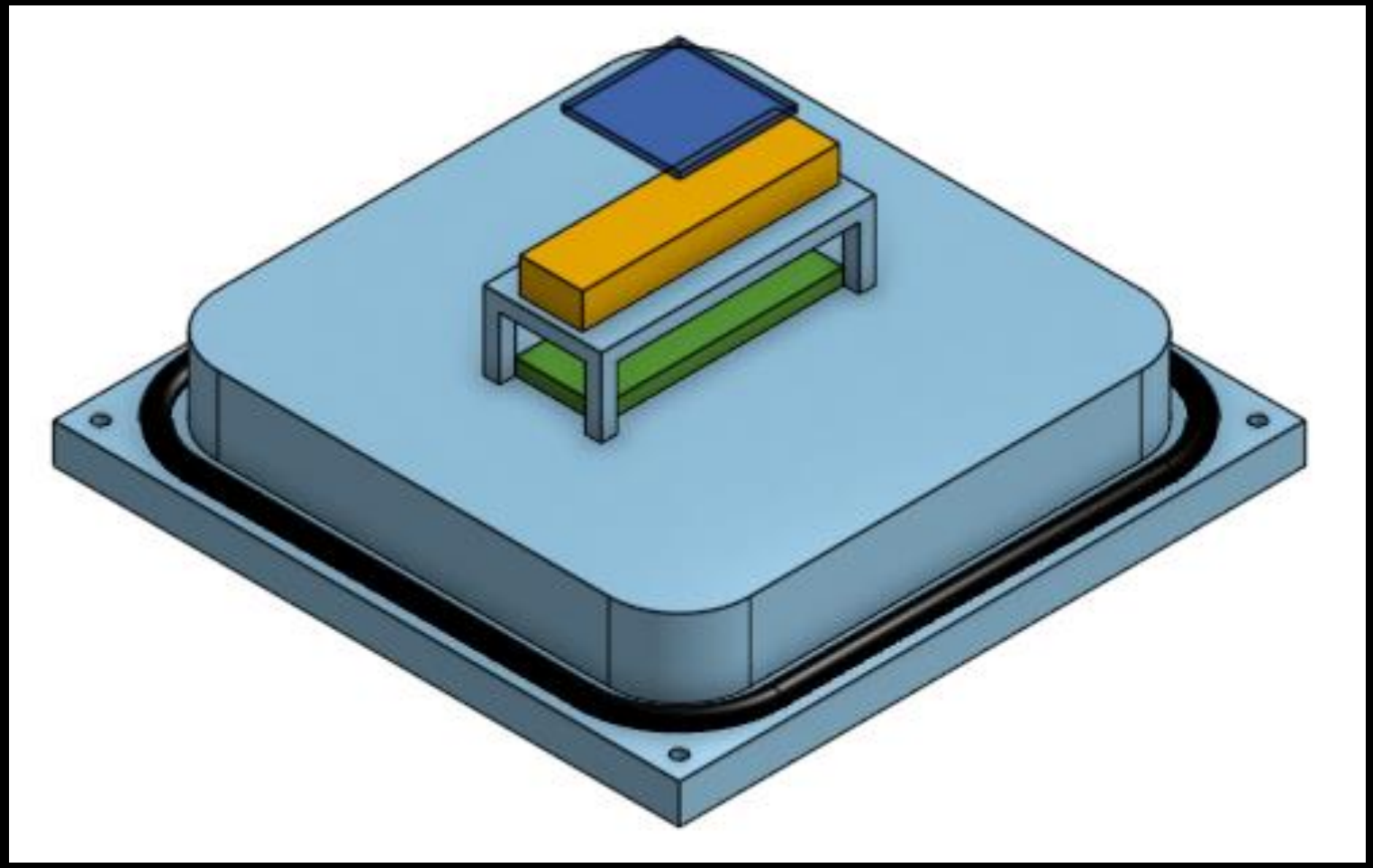


Figure 12: Internal CAD View

Schedule – Gantt Chart

- On Schedule
- Designated roles for upcoming weeks
- Torrey working on website
- Derrick and Tyler on prototyping and CAD modeling
- Collaborate on Reports and Presentations
- Gantt Chart provided in next slide:

Spectral Forest Gantt Chart

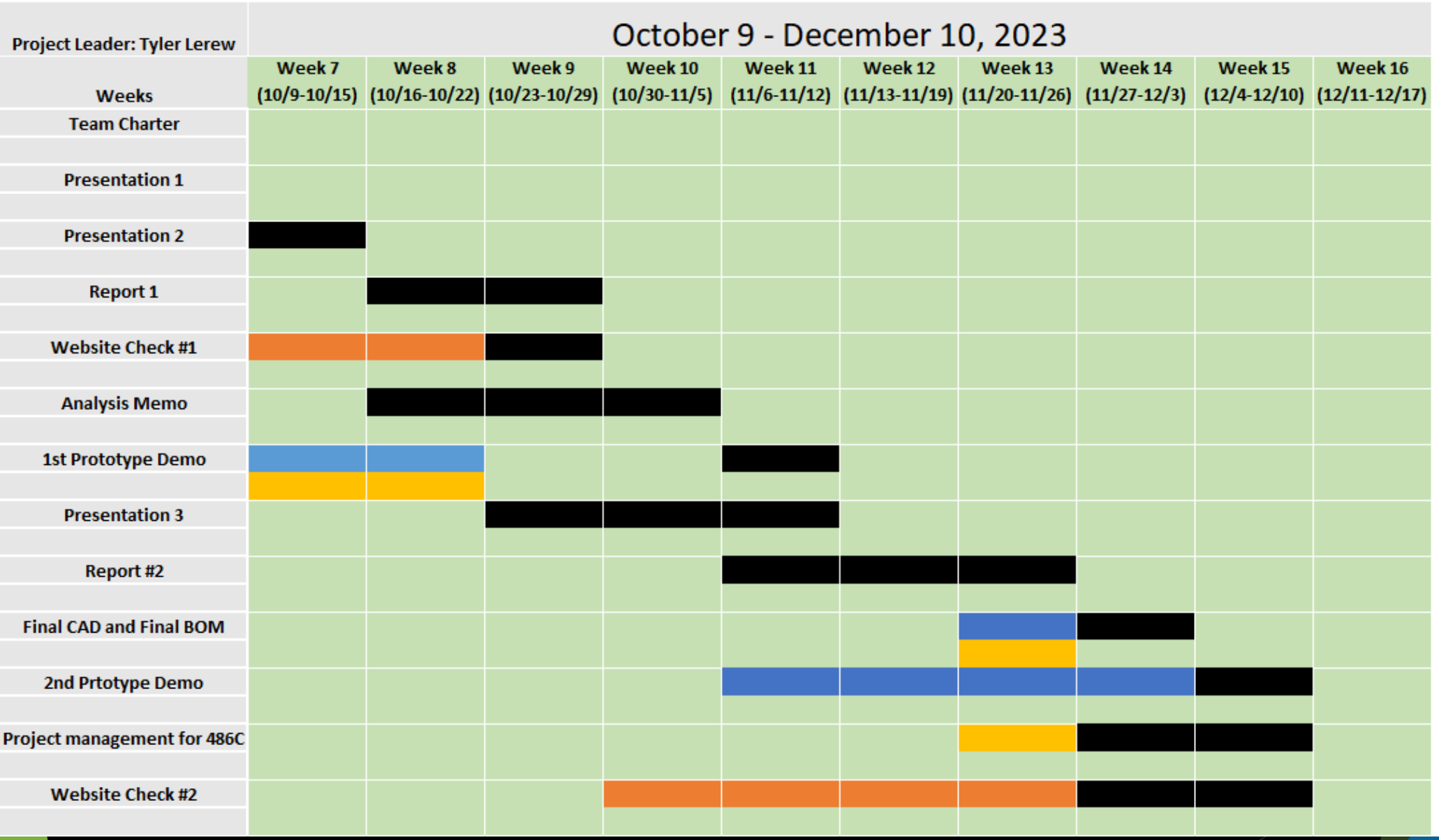


Figure 13: Gantt Chart

BoM

- Contains potential items and costs
- Constantly adding and replacing parts
- Most of budget going into printing filament, cosine corrector and the optic

Item #	Item	Item Description	Vendor	Quantity	Cost $	Cost Per unit $
1	Onyx filament	Micro carbon fiber filled nylon (12 m)	Markforged	1	96	.24/cm^3
2	Fasteners	Han-compact fixing screw	DigiKey	8	1.20	.15
3	O-ring	Fluoropolymer sealing ring	DigiKey	1	.47	.47
4	Cosine Corrector	CC-S-DIFFUSE Spectralon Diffuser	OceanInsight	1	75	75
5	Diffraction Grating Film	LAPPING FILM SIL CARBIDE 11X8.5"	DigiKey	2	5.94	2.97

Figure 14: Bill of Materials

BoM cont.

6	Silicone	Chip Quik Electronic Grade Silicone	DigiKey	1	4.95	4.95
7	PCB with Components	UNIVERSAL PROTO-BOARD PCB 6CM	DigiKey	1	1.95	1.95
8	USB-C Rubber Seal	Würth Elektronik CONN COVER FOR USB-C	DigiKey	1	.63	.63
9	Conductive Silver Tape	Electrical Shielding Tape Conductive Acrylic Adhesive Silver 1/4" X 180'	DigiKey	1	3.94	3.94
10	Black Oxide Paint	Golden® Fluid Acrylics, Carbon Black 1 oz.	Michaels	1	8.49	8.49

Figure 15: Bill of Materials Cont.

Budget

- $500 for each ME and EE teams $1000 total, can be moved around
- Anticipated expenses:
  - Prototyping ($50), Linear Array ($30-$200), final product parts ($150-200), misc. ($50)
  - Total according to BOM: $198.57 or $200
- Total expenses to date: None
- Total balance: $500
- We will raise $50 ourselves, which is 10% of the allotted budget
- Client working with Hamamatsu (Chips) and Chris Edwards' Space Grant Consortium (>$5K)

Thank you!

Questions?

References

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