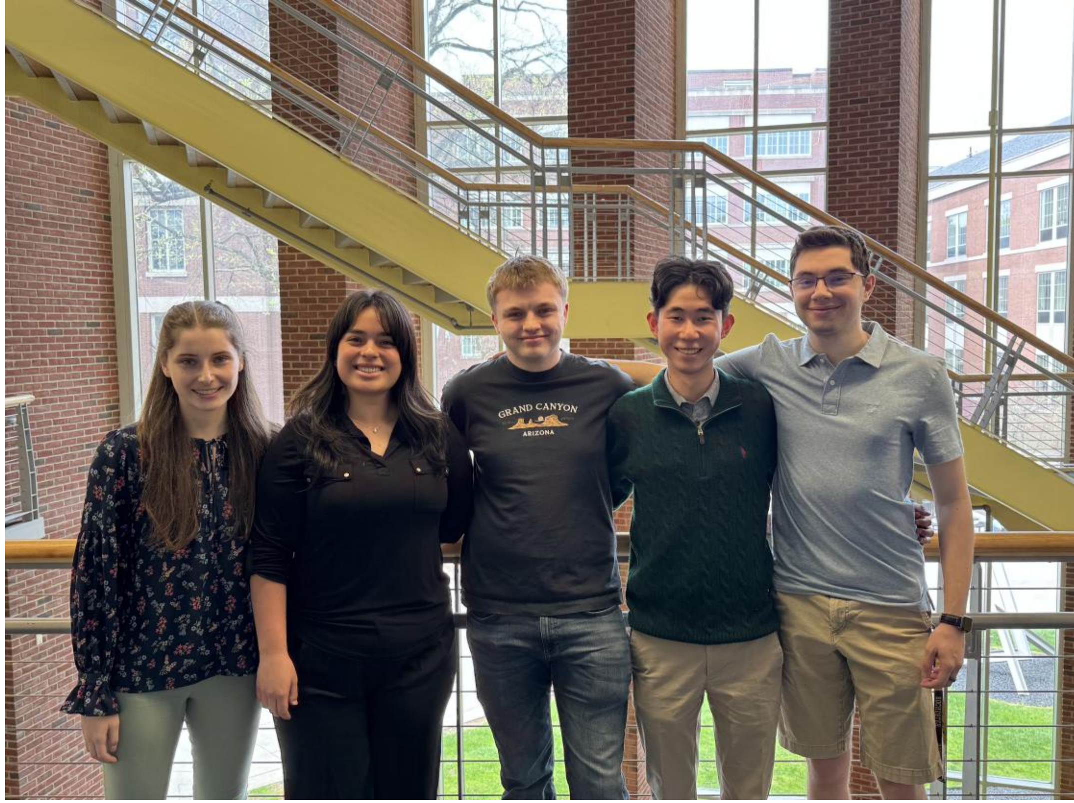
L3Harris 2025 SMSS Final Design Review

Team Members: Kaitlyn Bartlett, Angel Bermudez, Stanley Huang, Joshua Nova-Yingst, and Matthew Stead

April 29, 2025

L3Harris Secondary Mirror Support Structure



Team Members
Kaitlyn Bartlett
Angel Bermudez
Joshua Nova-Yingst
Stanley Huang
Matthew Stead

Customer
L3Harris

Project Overview

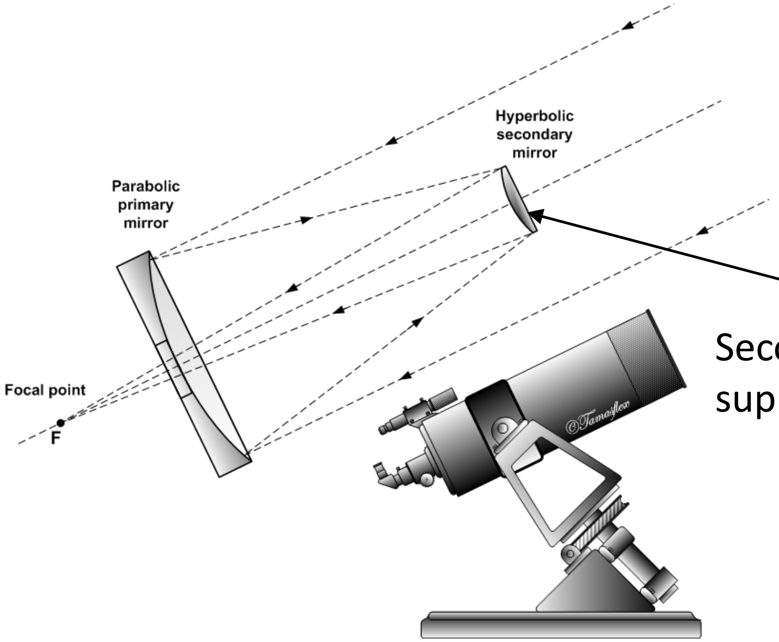
This project aimed to redesign the Secondary Mirror Support Structure (SMSS) for satellites using 3D metal printing. The goal was to reduce manufacturing time and cost, while maintaining strength and precision. The team has developed and tested lightweight designs with internal lattices, helping L3Harris improve production efficiency for satellite components, advancing the global accessibility of technology.

Problem Statement

Secondary Mirror Support Structure (SMSS) is a mount used in some large telescopes for holding optical mirrors. These structures must be highly durable and require precise manufacturing methods. Increased durability and precision come at the cost of increased expenses and time, and as such, L3Harris is looking into additive metal manufacturing to potentially reduce manufacturing time while increasing production capacity.

SMSS

Secondary Mirror (SM)



Secondary Mirror is supported by SMSS

Deliverables, Requirements and Specifications

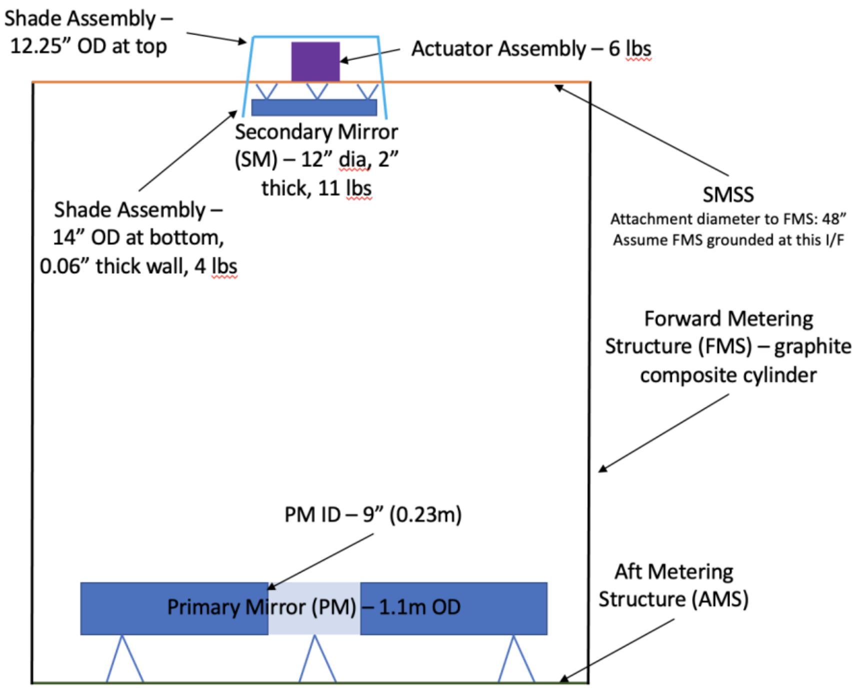
The deliverables, requirements and specifications define what will be done
and how to be objective about what it means to have a “successful” project.

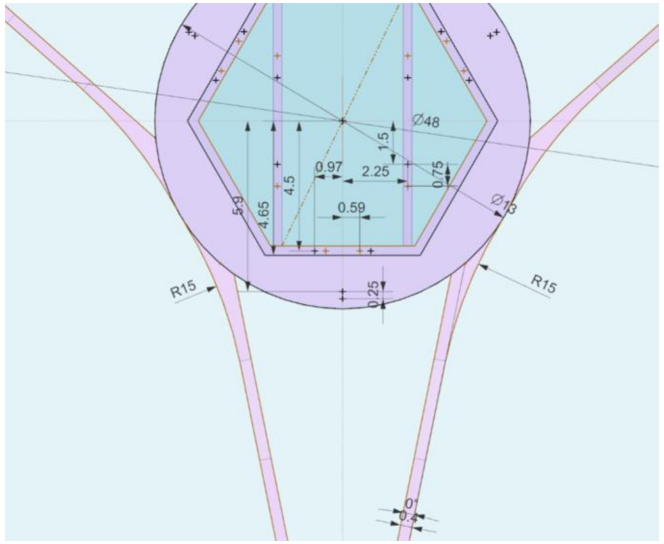
Deliverables:

- *Preliminary Design Review (PDR)*
- *Final Design Review (FDR)*
- *3D-printed scaled SMSS model*

Requirements:

- *Must be 3D-printable in titanium or invar*
- *Must be able to hold 23 pounds of equipment*
- *Shall interface to the Forward Metering Structure (FMS) at three locations 120 degrees apart.*
- *Shall provide interfaces with and support for all necessary hardware*
- *Must be considered cleanable*
- *The following factors of safety shall be used:*
  - *Yield Stress: 2.0*
  - *Micro-Yield Stress: 1.0*
  - *Ultimate Stress: 2.5*
  - *Buckling Stress: 4.0*



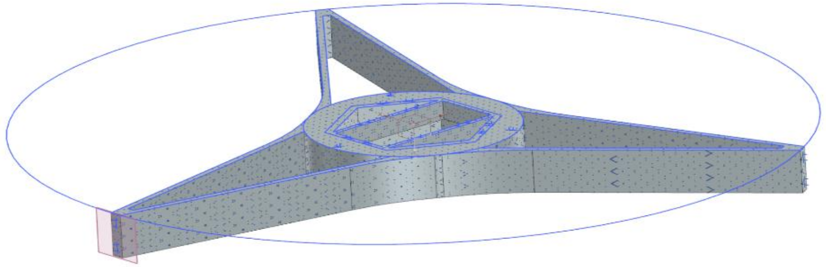


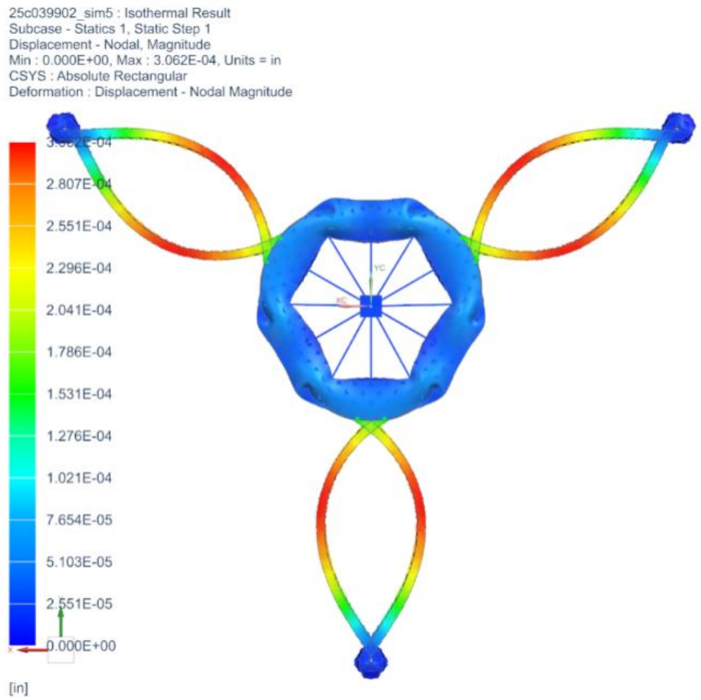
Deliverables, Requirements and Specifications

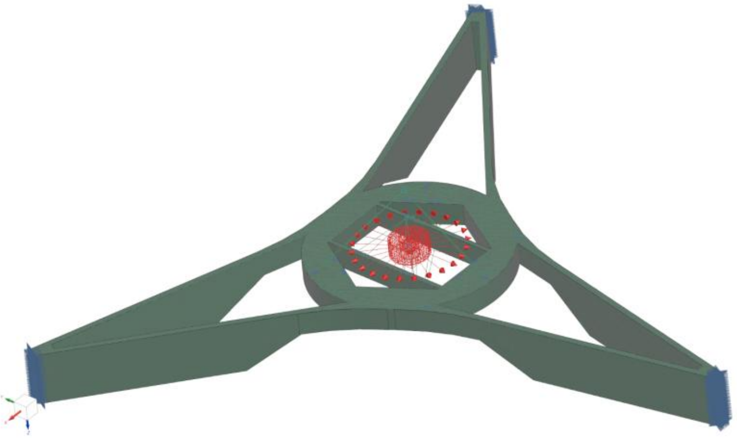
The deliverables, requirements and specifications define what will be done and how to be objective about what it means to have a “successful” project.

Specifications:

- *Outer diameter shall be 48 inches*
- *First mode shall be 120 Hz or greater*
- *Mass shall be 18 lbm or less*
- *Shall have positive margins of safety against yield and ultimate failure when exposed to load of 12 G laterally and 18 G axially, with lateral swept 15-degree increments*
- *Shall have positive margins of safety in a 5ºC to 35ºC temperature range*
- *Shall not obstruct more than 14% of Primary Mirror (PM) aperture area*
- *Average motion under a 1ºC isothermal load should be 0.66 micro-inches translation or less*
- *Average motion under a 1ºC isothermal load should be 0.037 micro-radians rotation or less*







Work Breakdown Structure and Critical Path Management

Secondary Mirror Support Structure

3D Printed Prototype

Scaled Model
- Research 3D printing vendors
- Obtain quotes for 3D printing model
- Modify size and material based on price
- Order scaled 3D printed prototype

Material Testing Data
- Research 3D metal materials
- Purchase coupons from vendor
- Determine key material properties to test
- Test coupons

Design Progression

Concepts
- Research current SMSS concepts
- Create initial sketches

Initial CAD Model
- Create initial model with infill structure that had optimal performance from material testing

Final CAD Model
- Perform final optimization
- Obtain approval from sponsor
- Create 2D drawings

Model Analysis

Finite Element Model (FEM)
- Research lattice designs and boundary conditions
- Create FEM model for solid structure
- Design and implement boundary conditions to represent FMS interfaces

Structural Analysis
- Determine critical stress states using given loads

Thermal Analysis
- Perform thermal soak analysis using given temperature values and additional specifications

Vibrational Analysis
- Perform modal analysis to determine first modes of frequency

Prototype Test

Stiffness Testing
- Design four-point bend test to determine material properties
- Conduct four-point bend test

Thermal Testing
- Design thermal test to measure thermal displacement
- Conduct oven test

Vibrational Testing
- Design hammer test to measure first mode of vibration
- Conduct hammer test

Model Validation
- Ensure cleanability of model
- Correlate analysis results to test results
- Compare data to ensure tests are within margin of error that validates FEM model

Design Reviews

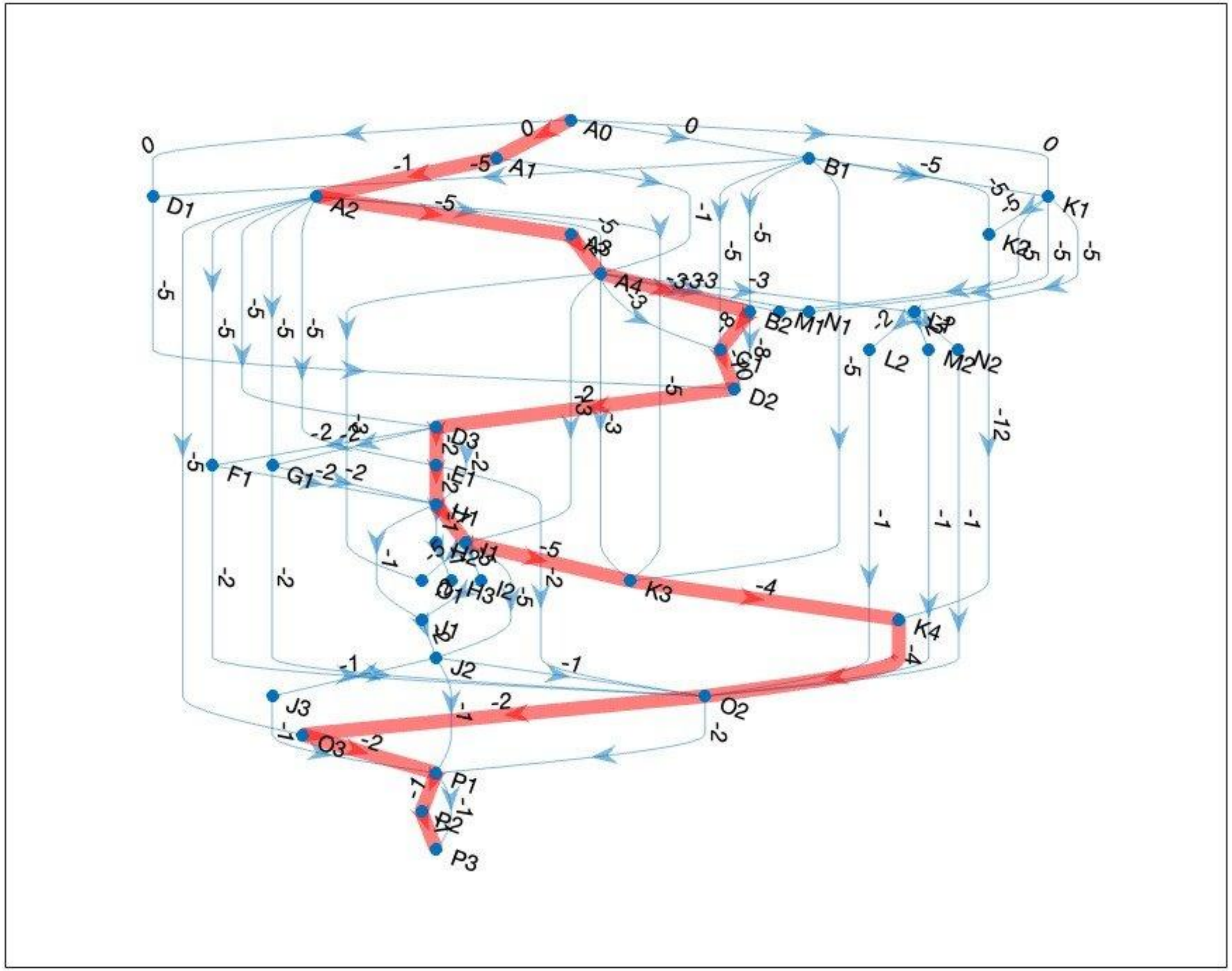
Concept Design Review
- Schedule meeting with sponsor for progress update, questions and approval
- Change design as needed

Preliminary Design Review
- Present feasible design and analysis
- Present initial optimization of final CAD model
- Present initial one-pagers

Final Design Review
- Present test results to sponsor
- Present manufacturing plan
- Present results during Senior Design Day

	Student	$/hr	cost	hrs	
A	Angel	$100	$2900	29	
J	Joshua	$100	$2900	29	
K	Kaitlyn	$100	$2800	28	
M	Matthew	$100	$2800	28	
S	Stanley	$100	$3000	30	$18,800

	Item	Activity	Time (hours)	Skill	Cost
A0		Start	0		
A1	Project Setup	Make Problem Statement	1	J	$100
A2		Make Specs and Recs	5	A	$500
A3		Create Deliverables	2	K	$200
A4		Make WBS and CPM	4	A	$400
B1	Concepts	Research SMSS and Previous Projects	10	M	$1000
B2		Create and Modify Sketchs	14	K	$1400
C1	Initial CAD Model	Develop Initial Model With Optimized	10	S	$1000
D1	FEM	Research Lattice Design and BCs	8	S	$800
D2		Create FEM and Model for Solid Structure	4	M	$400
D3		Design and Implement Boundary Conditions to Represent FMS Interfaces	6	A	$600
E1	Structural Analysis (FEM)	Determine Critical Stress States Using Given Loads	2	J	$200
F1	Thermal Analysis (FEM)	Perform Thermal Soak Analysis Using Given Temperature Values and Additional Specifications	2	M	$200
G1	Vibrational Analysis (FEM)	Perform Modal Analysis to Determine First Modes of Frequency	2	J	$200
H1	PDR	Present Feasible Design and Analysis	3	A	$300
H2		Present Initial Optimization of Final CAD Model	3	K	$300
H3		Present Initial 1-Pagers	3	M	$300
I1	Concept Design Review	Schedule Meeting with Sponsor for Progress Updates, Questions and Approval	5	A	$500
I2		Alter Design as Needed	8	S	$800
J1	Final CAD Model	Perform Final Optimization	6	J	$600
J2		Obtain Approval	1	K	$100
J3		Create 2D Drawings	2	S	$200
K1	Material Testing Data	Research 3D Metal Materials (Titanium)	8	J	$800
K2		Develop Models for Simulated Testing	2	M	$200
K3		Determine Material Properties to Test	4	J	$400
K4		Test Models	2	S	$200
L1	Stiffness Testing	Design Simulated Four-Point Bend Test to Determine Material Properties	2	A	$200
L2		Conduct Simulated Four-Point Bend Test	2	J	$200
M1	Thermal Testing	Design Thermal Simulation to Measure Displacement	2	K	$200
M2		Conduct Thermal Simulation	2	A	$200
N1	Vibrational Testing	Design Vibration Simulation to Measure 1st Mode of Vibration	2	J	$200
N2		Conduct Vibration Simulation	2	J	$200
O1	Model Validation	Ensure Model Cleanability	2	A	$200
O2		Compare Analysis and L3Harris Materials Data	2	M	$200
O3		Compare Test Results Fall Within Margins of Error	2	M	$200
P1	FDR	Present Test Results to Sponsor	3	K	$300
P2		Present Manufacturing Plan	3	M	$300
P3		Present Results During Senior Design Day	3	K	$300


A0
A1
A2
A3
A4
B1
B2
M1
N1
K1
K2
D1
D2
D3
L2
M2
N2
E1
F1
G1
H1
I1
H3
I2
J1
J2
J3
K3
K4
O2
O3
P1
P2
P3

Initial Design Progression

Pugh Matrix	Design 1 (Last Year's)	Design 2 (Stanley)	Design 3 (Joshua)
Design Images			
Total Weight	0	-	-
Total Area	0	+	+
1^{st} Vibration Mode	0	+	+
Buckling Eigenvalue	0	+	+
Translation Displacement	0	-	-
Rotational Displacement	0	-	-
Ultimate MS	0	-	+
Yield MS	0	-	+
Optimizable	0	+	+
TOTAL =	**0**	**-1**	**3**

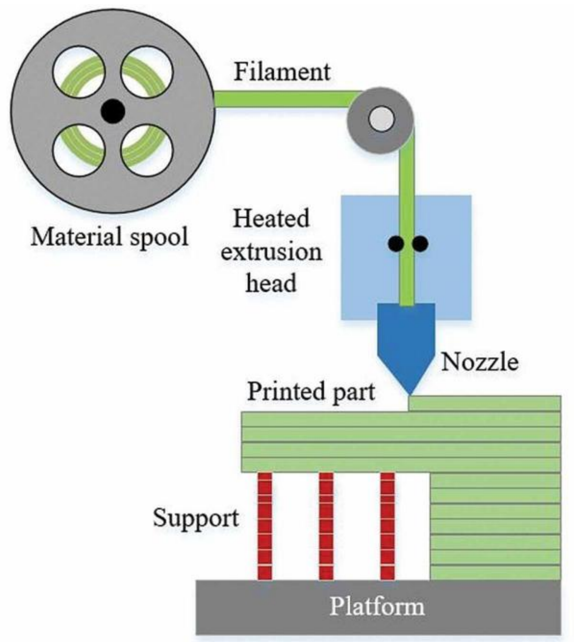
Manufacturing

Manufacturing

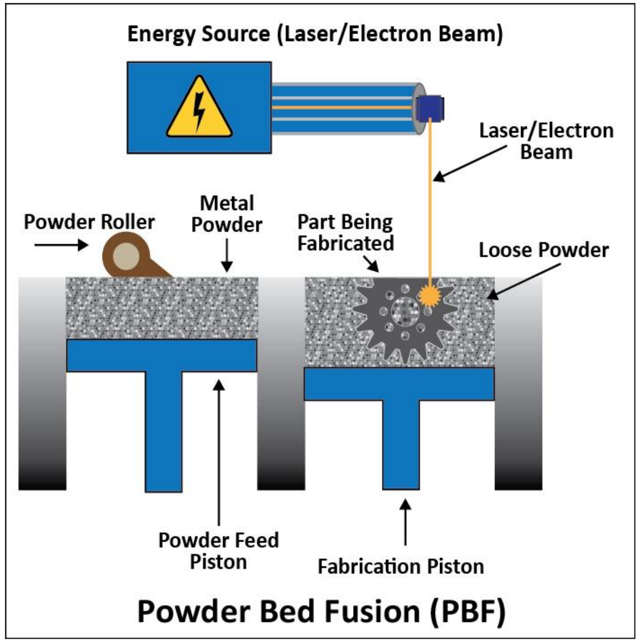
Fused Deposition Modelling (FDM)
- Test coupons – ABS, PLA

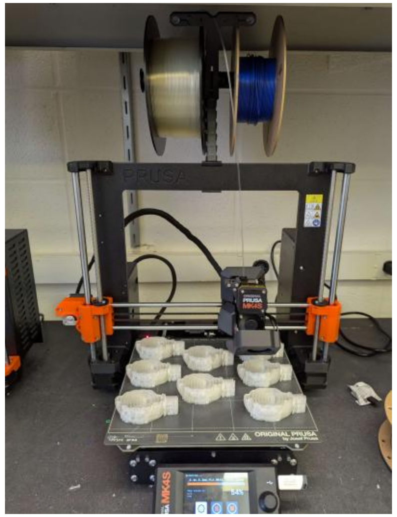
Power Bed Fusion (PBF)
- Test coupons – Aluminium
- Final scale model - Aluminium

FDM



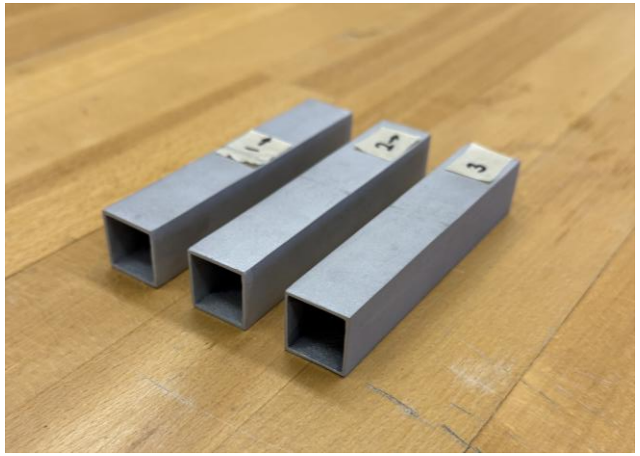
PBF





FDM ABS samples PLA samples

PBF Aluminium samples



Coupon Testing and Results

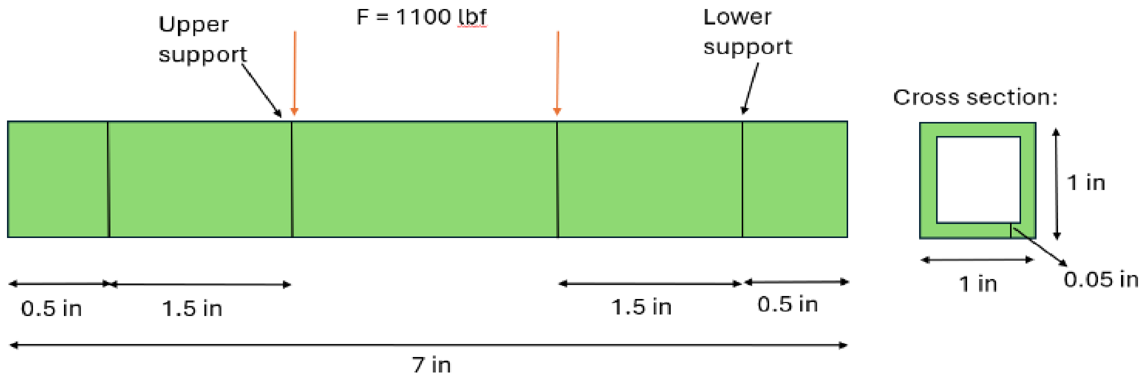
Initial 4-Point Bend Testing Setup

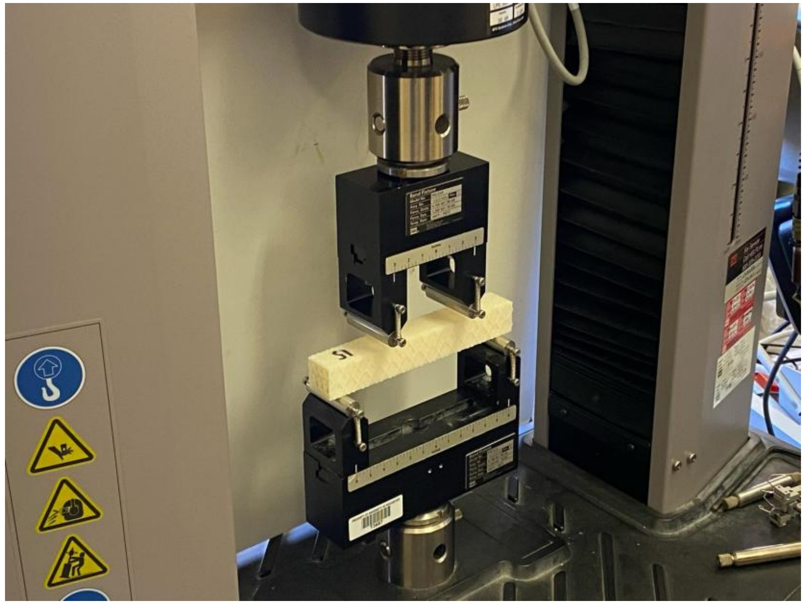
Simulation and Testing Purpose:

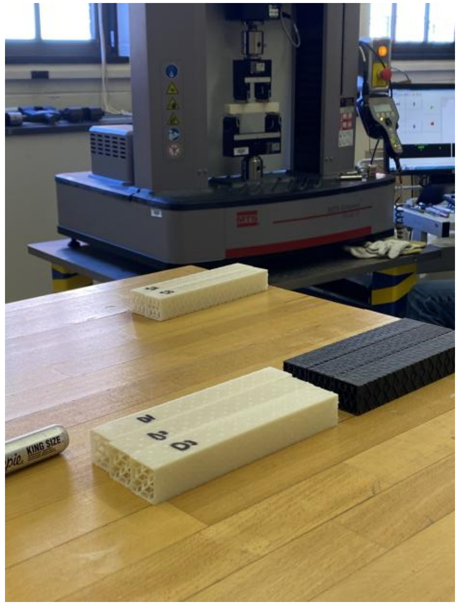
- Conducting 4-point bend tests on 3D printed beam models with lattice infill to determine:
    - If 3D printing with lattice produces results comparable to simulation (low % error) to ensure 3D printing with lattice in the SMSS will have same properties as expected from NX simulations

Initial Testing Parameters:

- Model: 7” in length, 1” x 1” cross section
    - Dodecahedron lattice infill, default parameters (0.05” rod thickness, 0.5” edge length)
- Applied 1100 lbf to top two supports

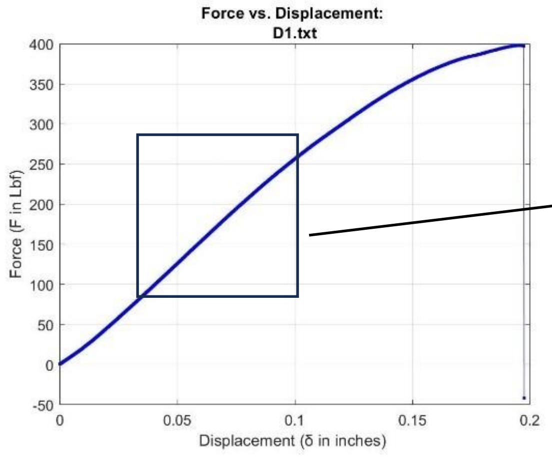


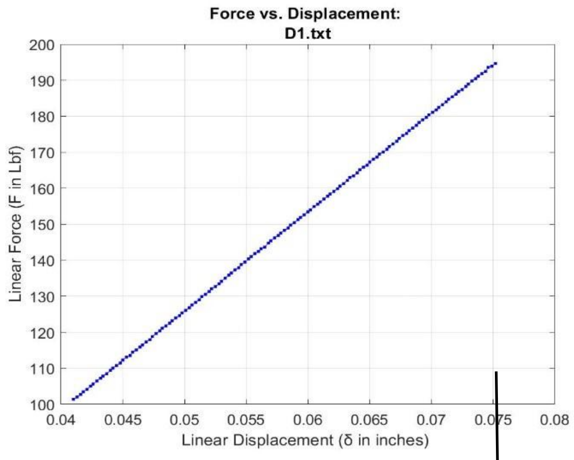




Initial 4-Point Bend Testing Results

Method:
- Stiffness (k) obtained from linear region of force-displacement curves. The process for the first sample, D1, is shown below:





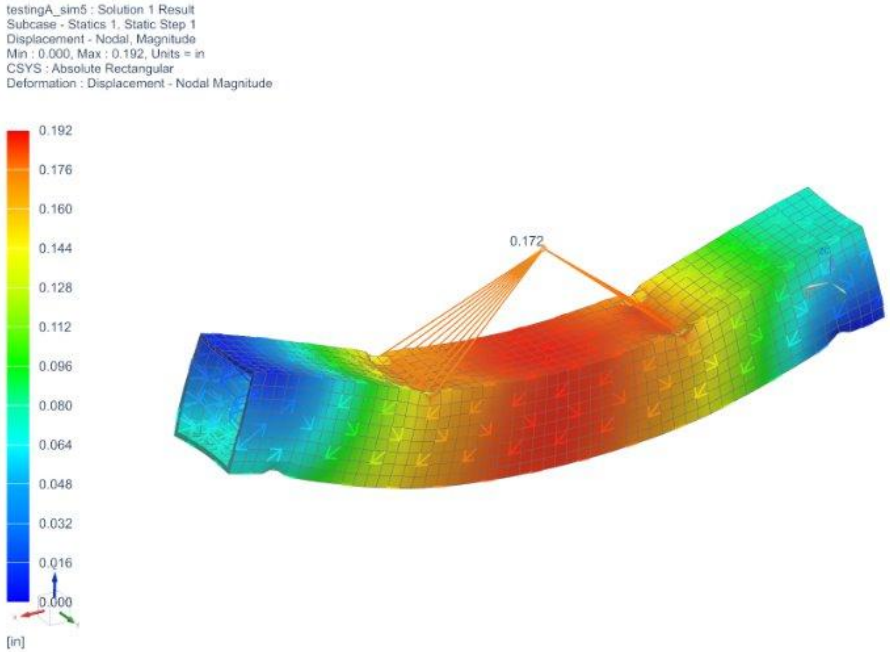

```
"Processing "    "D1.txt"

Enter start index for linear region: 154
Enter end index for linear region: 282
Calculated Stiffness: 2742.847 Lbf/in
```

Observations:
- Simulation had stiffness and mass that were roughly double that of the test models

Sample Tested	Stiffness (Lbf/in)	Mass (oz)
D1	2742.847	1.18
D2	2732.643	1.136
D3	2788.843	1.138
Average from Samples	2755	1.15
Simulated Sample	6395	2.09
Percent Error	56.92%	44.91%

Simulation Result:



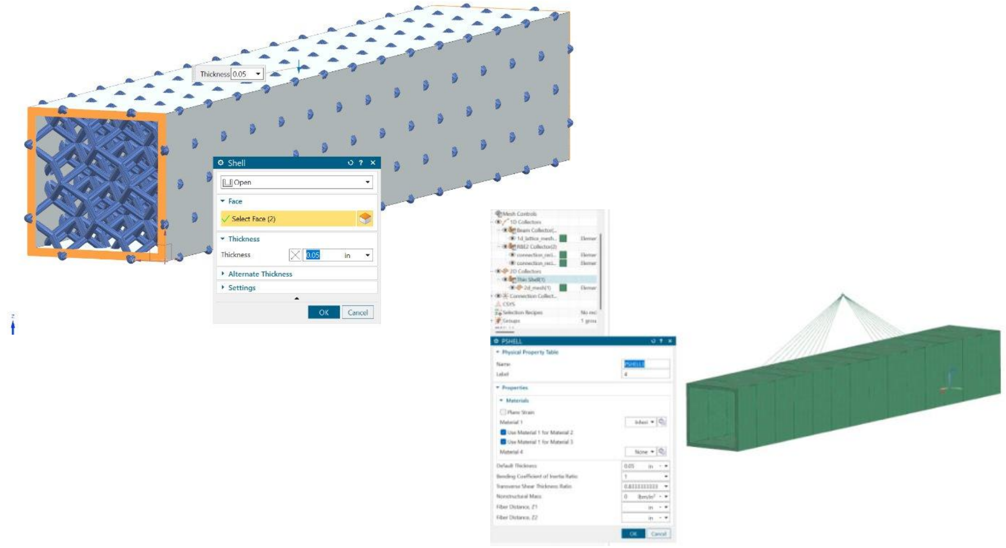
Stiffness of model from simulation:
F = kx
k = 1100 lbf/0.172 in = 6395 lbf/in

Mass of model from FEM solid properties check:
m = 2.09 oz

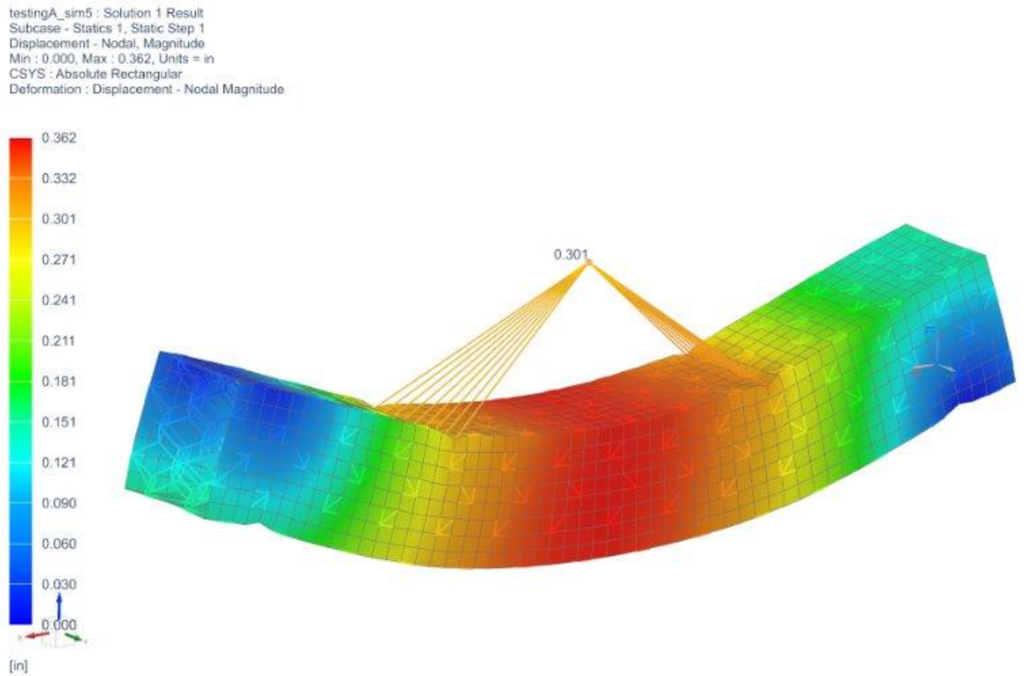
Initial 4-Point Bend Testing Results

Corrected Model

- Determined model was shelled twice—once during the creation of the part, and then again for the 2D thin shell connection in the finite element model



- Editing model so it was only shelled once resulted in:



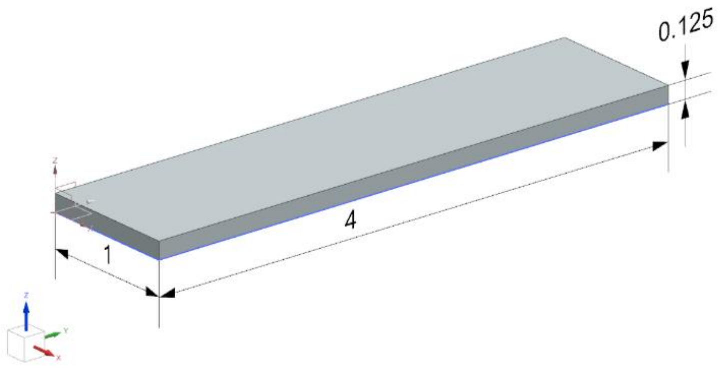
Sample Tested	Stiffness (Lbf/in)
D1	2742.847
D2	2732.643
D3	2788.843
Average Stiffness from Samples	2755
Stiffness of Simulated Sample	3654
Percent Error	**24.61%**

Stiffness of model from simulation:
k = 1100 lbf/0.301 in = 3654 lbf/in

Observations:

- Percent error reduced but still relatively high
- Speculated to be due to a mismatch in Young's Modulus (E) from NX as compared to printer's ABS E value

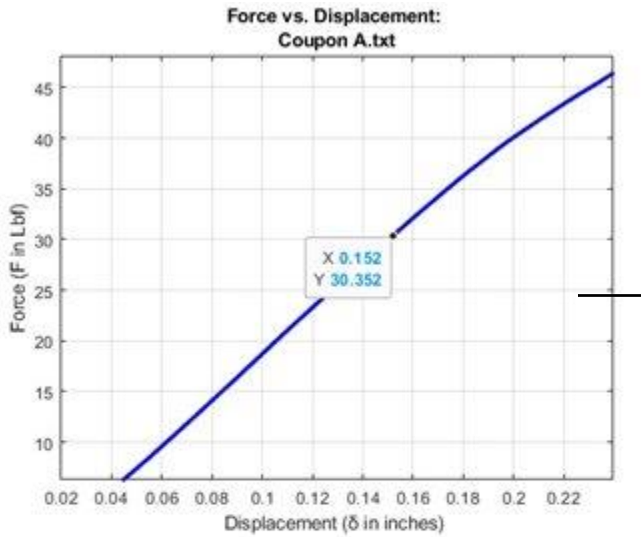
Determining Young's Modulus for ABS



Method:

- 3D printed solid beam model with reduced thickness and tested it with the same four-point bend testing parameters
- Used force-displacement curve from linear region to calculate E of ABS

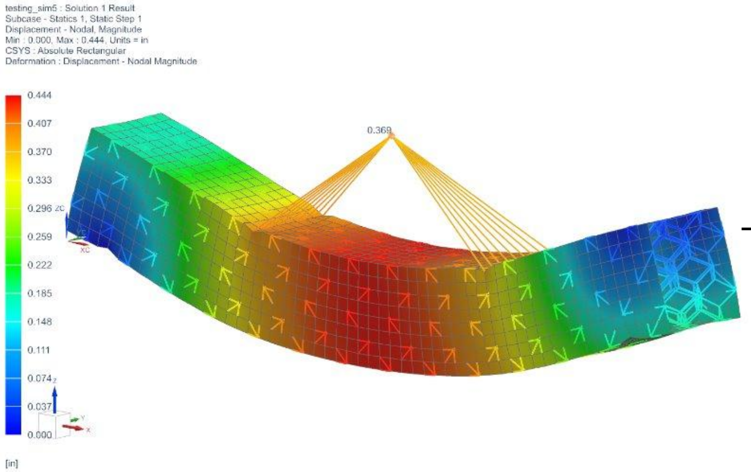
Linear region of force-displacement curve of solid model:



$$E_f = \frac{F}{\delta} \cdot \frac{L_1(3L_{total}{}^2 - 4L_1{}^2)}{48I}$$

From calculation:
E_{ABS}= 1.635e6 kPa

Lattice model recalculated with E_{ABS}= 1.635e6 kPa instead of 2.0e6 kPa:



Stiffness of model from simulation:
k = 1100 lbf/0.369 in = 2981 lbf/in

Comparing simulation to 3D printed lattice models:

Sample Tested	Stiffness (Lbf/in)	Mass (oz)
D1	2742.847	1.18
D2	2732.643	1.136
D3	2788.843	1.138
Average from Samples	2755	1.15
Simulated Sample	2981	1.31
Percent Error	7.59%	12.11%

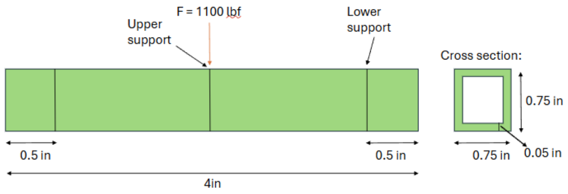
Observations:

- Percent error for stiffness was now in acceptable range (below 10%)

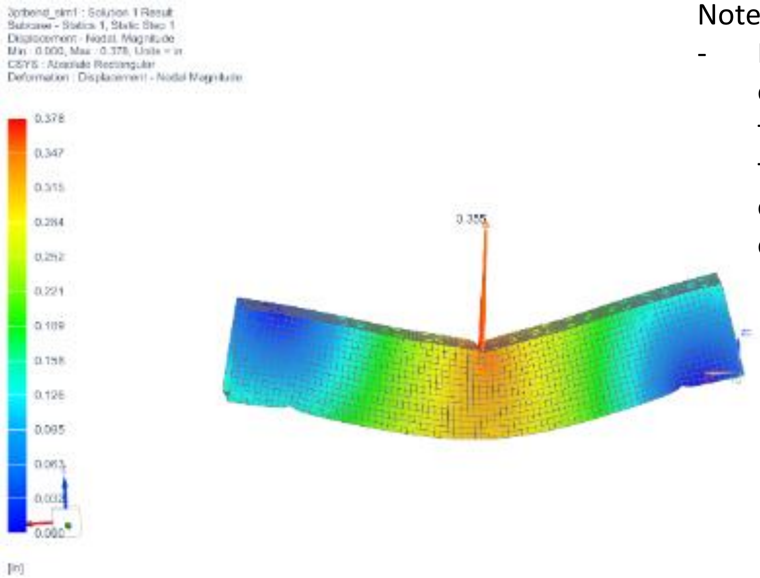
3-Point Bend Testing Results

Method:
- Originally conducted 4-point bend testing on 4-inch samples, however, the top and bottom supports were too close, resulting in shearing instead of bending
- Switched to three-point bend testing

Testing Parameters:
- Models: 4” in length, 0.75” x 0.75” cross section
- Dodecahedron lattice infill, 0.65” edge length for all
    - Three samples had 0.06” rod thickness
    - Three samples had 0.07” rod thickness
- Applied 1100 lbf at top support



Simulation Result:



Note:
- Reduced 2D mesh element size from 0.125” to 0.05” as the 1D mesh-to-face connection was originally spanning over elements

Stiffness of the 0.07” rod thickness model:
k = 1100 lbf/0.355 in = 3098.6 lbf/in

Sample Tested	Stiffness (Lbf/in)
1A (0.06")	2992.345
1B (0.06")	2974.664
1C (0.06")	2959.791
0.06" - Average	2975.6
0.06" - Simulated	3055.56
Percent Error	2.62%

Sample Tested	Stiffness (Lbf/in)
2A (0.07")	3141.882
2B (0.07")	3096.352
2C (0.07")	3111.22
0.07" - Average	3116.5
0.07" - Simulated	3098.59
Percent Error	0.58%

3-Point Bend Testing and Results: Aluminium Samples

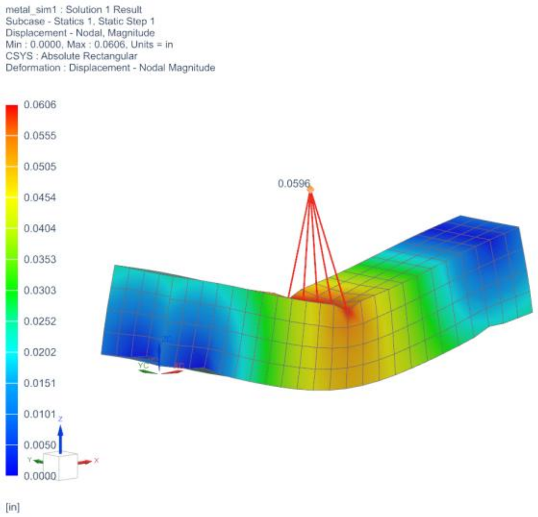
Testing Method:
- Same three-point bend testing, except with 1000 lbf applied instead of 1100 lbf
- Samples were supposed to have dodecahedron lattice but were only shelled, and dimensions were inconsistent—sides were sloped

Testing Samples	Mass (oz)	Maximum Displacement (in)	Stiffness (Lbf/in)
1	0.764	0.0588	1.63E+04
2	0.778	0.0509	1.89E+04
3	0.803	0.0484	1.98E+04

Sample Simulated	Mass (oz)	Maximum Displacement (in)	Stiffness (Lbf/in)
1	0.982	0.0596	1.68E+04
2	1.013	0.0578	1.73E+04
3	1.035	0.0556	1.80E+04

Sample	Mass Percent Error	Stiffness Percent Error
1	22.20%	2.98%
2	23.20%	9.25%
3	22.40%	10%

Simulated Result:

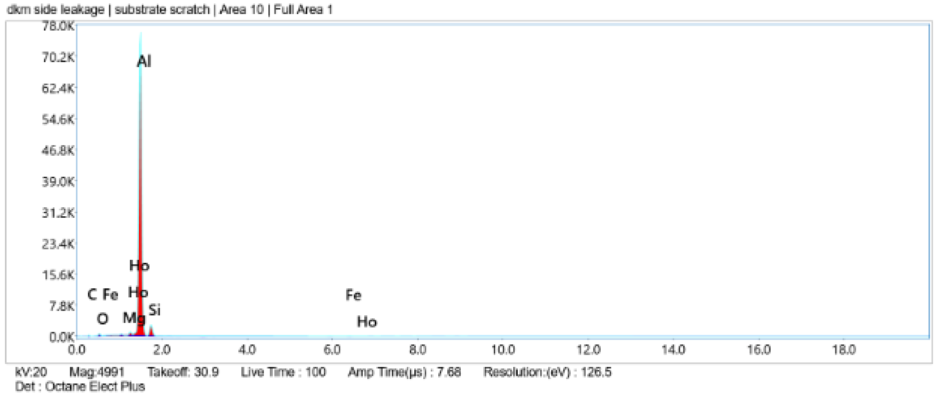


Mass percent errors were higher, likely due to the discrepancy in material between NX and actual metal coupons—coupons were fully aluminum in NX

Mechanical Engineering
University of Rochester

Elemental Analysis of Aluminium Samples

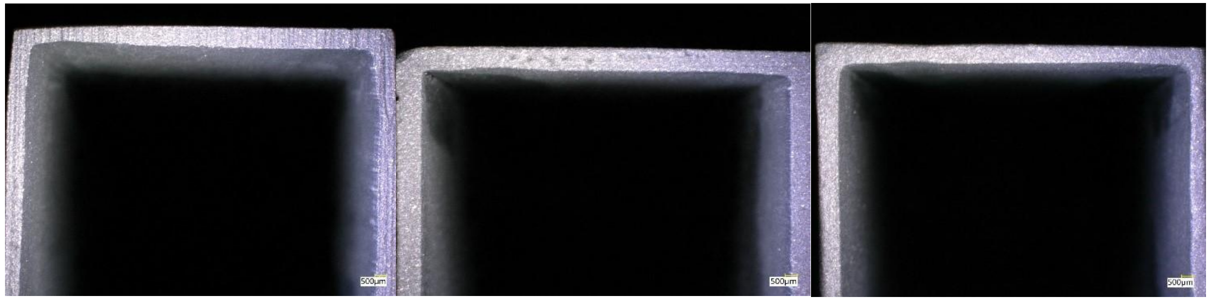
X-Ray Spectroscopy



Element	Weight %	Atomic %	Error %	Net Int.	R	A	F
C K	7.83	15.82	14.20	14.85	0.8875	0.0229	1.0000
O K	3.00	4.54	12.42	34.71	0.8993	0.1102	1.0000
Mg K	0.94	0.94	6.49	65.31	0.9172	0.6566	1.0471
Al K	80.00	71.94	3.66	5552.49	0.9211	0.7432	1.0026
Si K	7.63	6.59	8.67	216.82	0.9248	0.3159	1.0020
Fe K	0.25	0.11	35.17	4.71	0.9607	0.9617	1.0695
Ho L	0.35	0.05	48.29	2.65	0.9668	0.9730	1.0207

Observations:
- Samples were only 80% aluminum

Microscopic Imaging at 20X Magnification

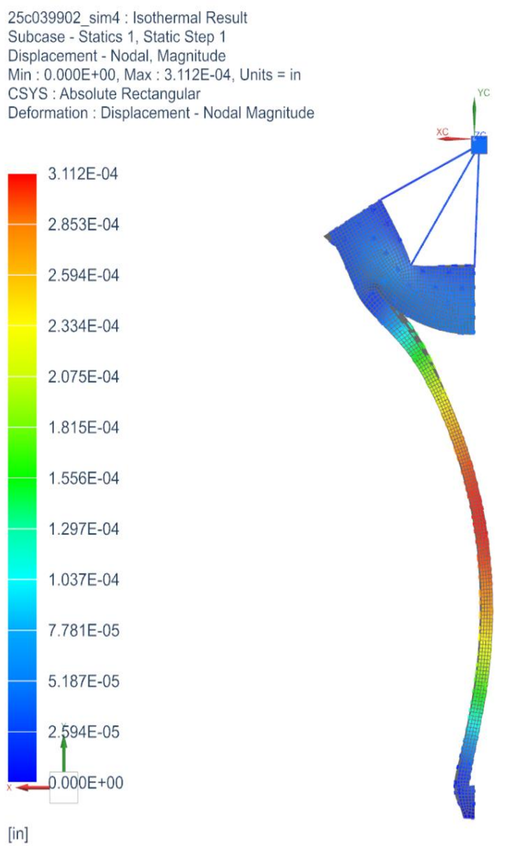


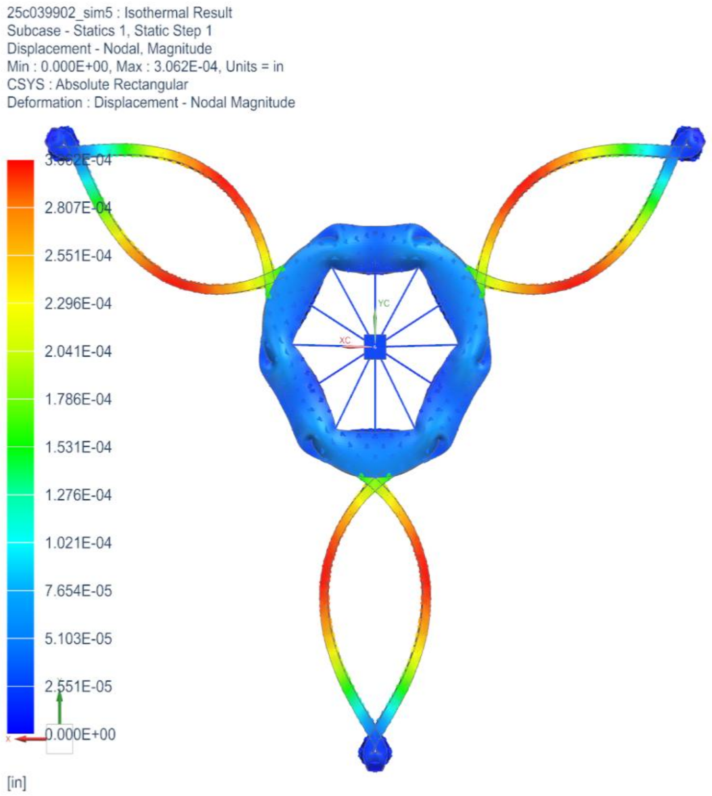
Optimization

Lattice Optimization

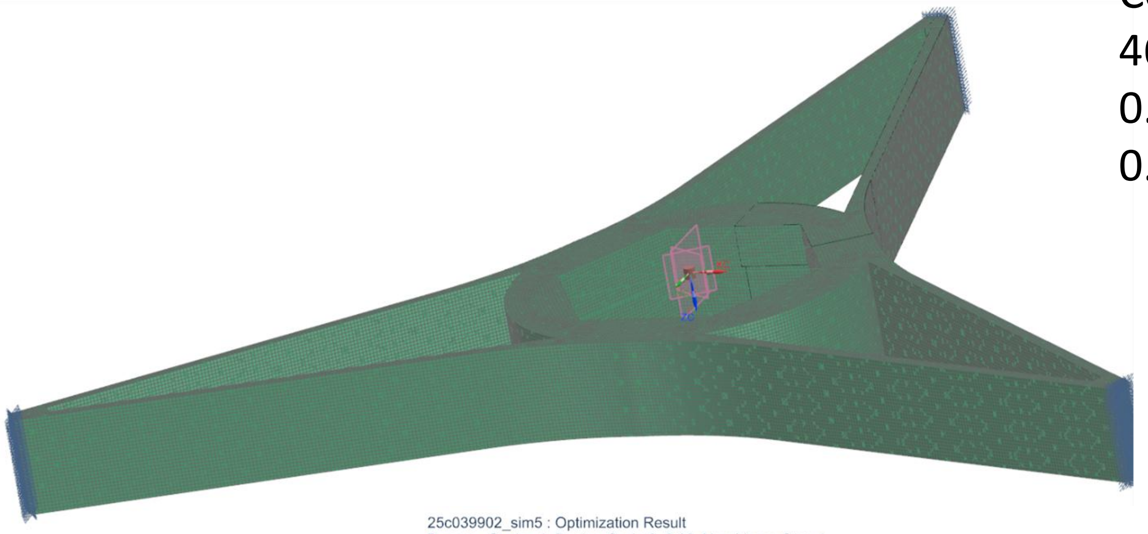
Method and Results:

- Created 1/6th model
- Set up Solution 200 to minimize weight
    - Lattice range = 0.045 - 0.1 inches
    - Shell range = 0.045 - 0.2 inches
    - Loads = 46119 psi and 1C
- Assuming symmetrical geometry, lattice and shell thickness don't effect 1C displacement
- Under minimum FS load, lattice = 0.045 inches, shell = 0.0765 inches





Lattice Optimization

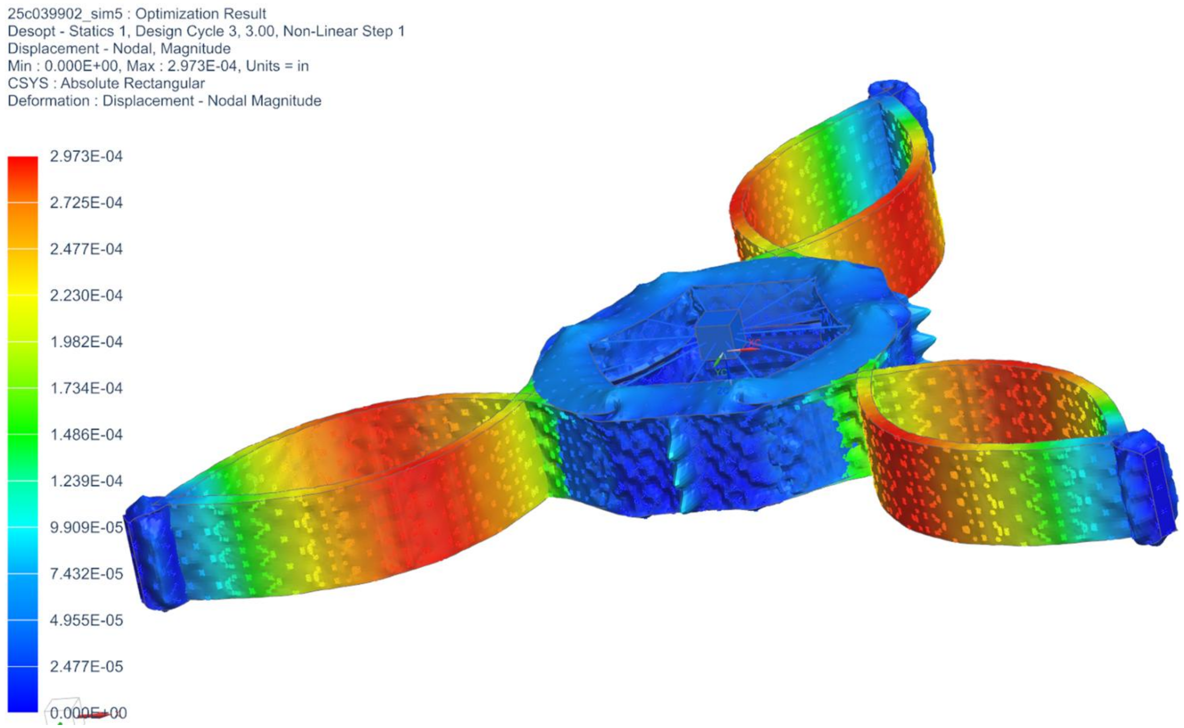


Constraints:
46119 psi
0.66E-06 Inches
0.37E-07 Radians

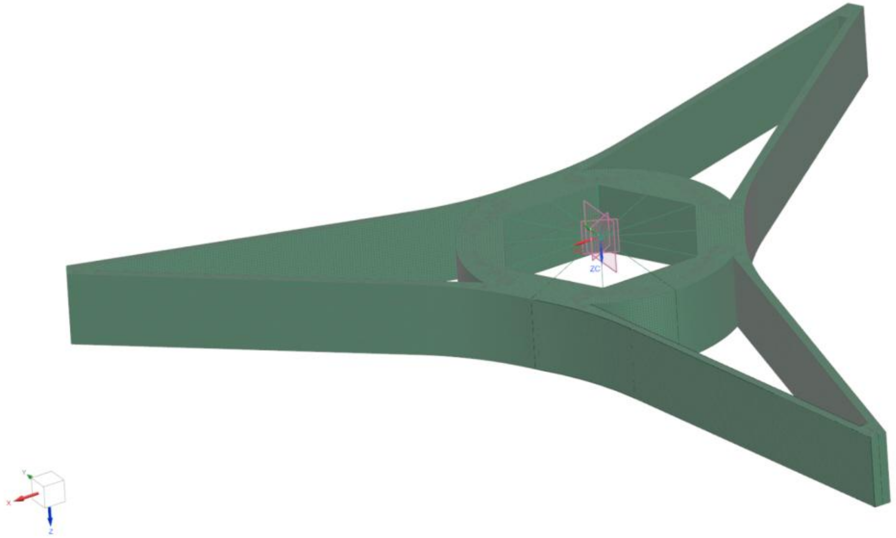
A	B
$gmax	5.00E-03
$	
Cycle	Design Objective
	Value
INITIAL	1.24E-01
1	9.41E-02
2	7.04E-02
3	7.04E-02

DVID	10	11
Label	RODTHICK	SHLTHICK
INITIAL	5.00E-02	1.00E-01
1	4.00E-02	5.00E-02
2	3.00E-02	1.00E-02
3	3.00E-02	1.00E-02
End of Data		

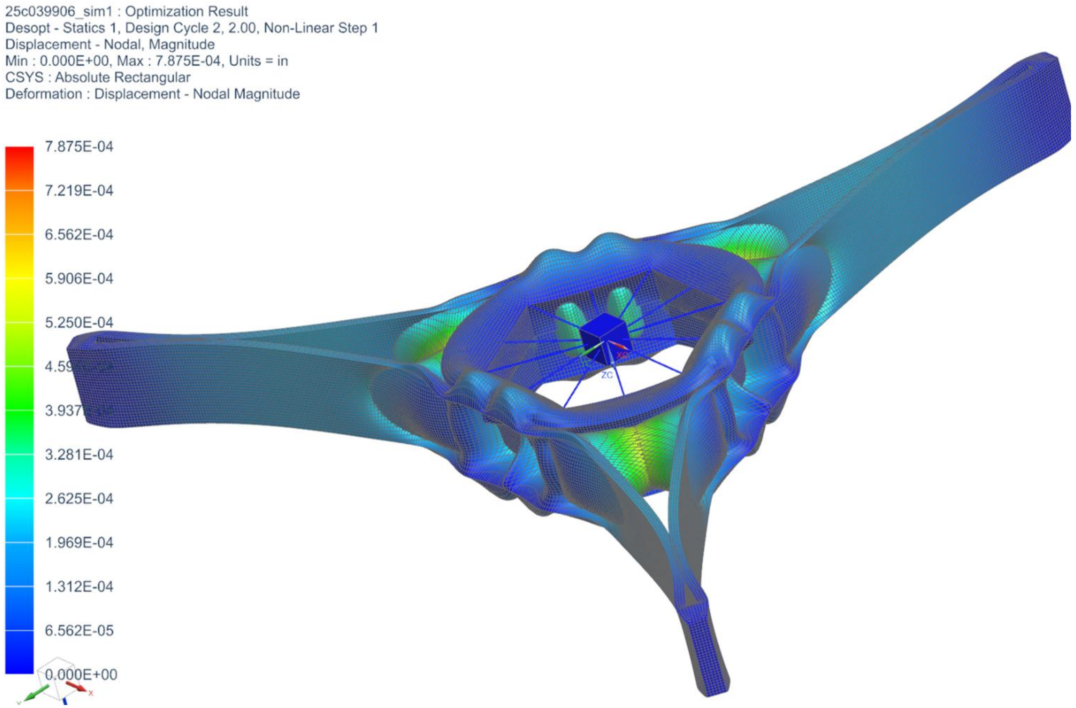
CQUAD4 0.1 in mesh
0.05 in lattice
23 lbm CM
Mirrored version of 1/6th model (slide 12)



Lattice Optimization



CQUAD4 0.1 in mesh
No Lattice
23 lbm CM
Mirrored version of 1/6th model (slide 12)



$gmax	5.00E-03
$	
Cycle	Design Ob
	Valu
INITIAL	1.13E-01
1	6.49E-02
2	6.49E-02
DVID	11
Label	SHLTHICK
INITIAL	1.00E-01
1	1.00E-02
2	1.00E-02
End of Data	

Topology Optimization

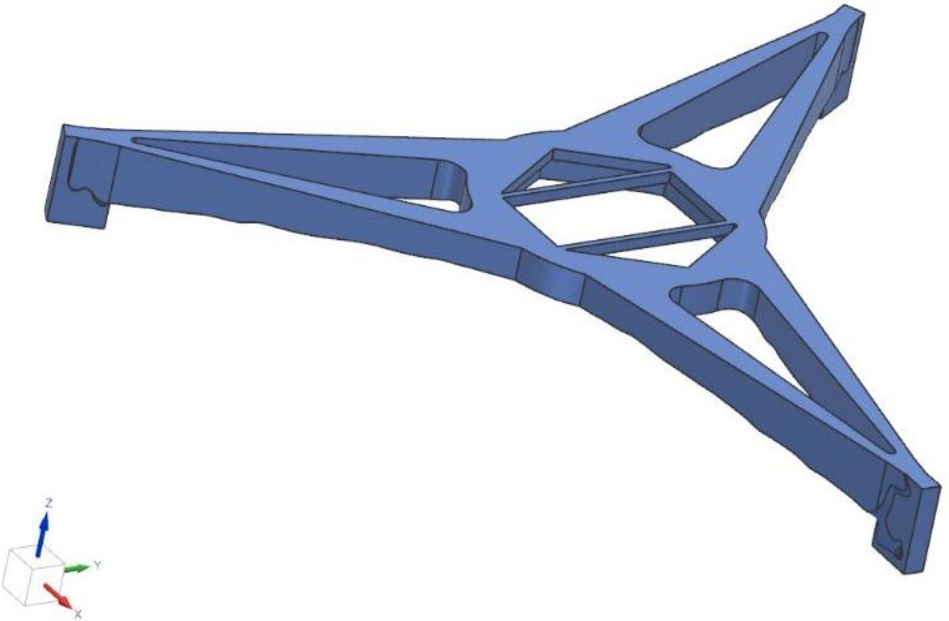
Optimization Studies:

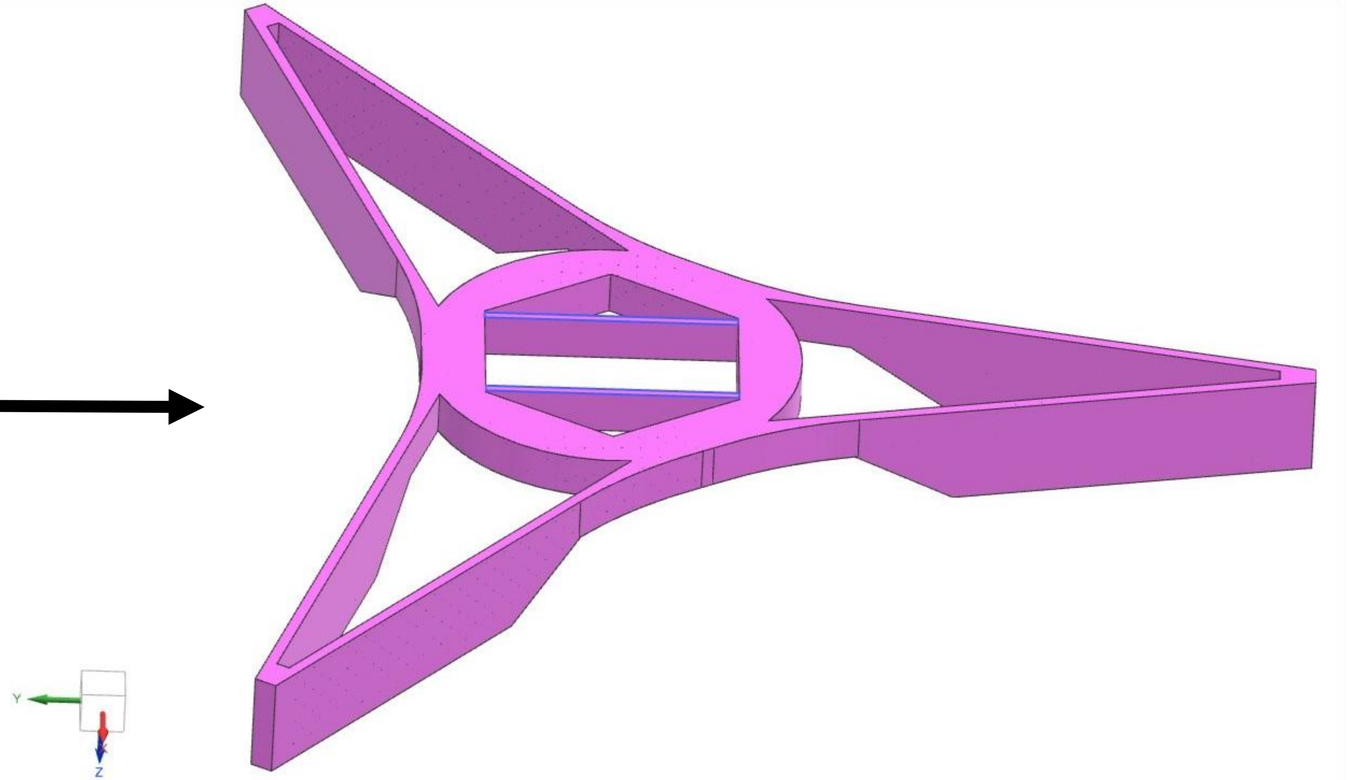
- Max stress
- Max Mass

Load - 18G

Constraints:

- Overhang angle – limited to 45 degrees
- Rod Diameter – 1 inch
- Rotational symmetry
- Contruction bodies – Center and arm ends





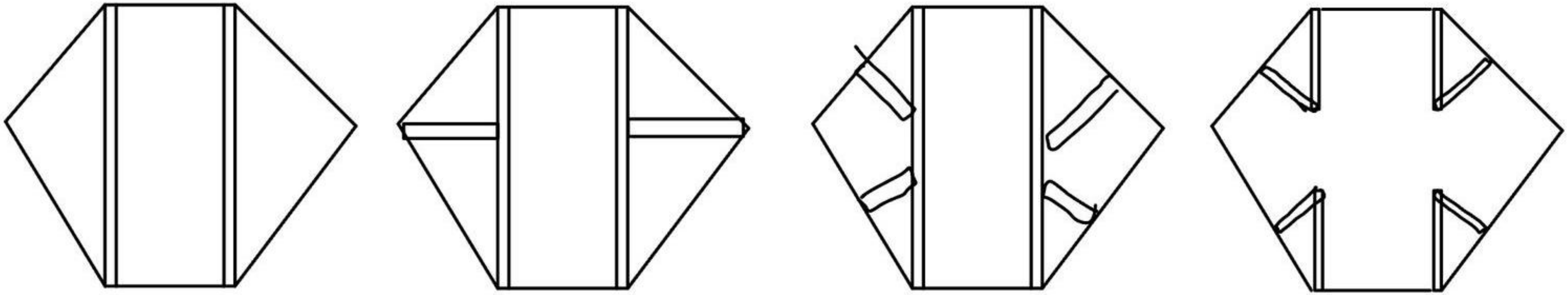
Actuator Mount Optimization

SM displaces too much isothermally, because the actuator mounts expand and cause deformation. The table below shows attempts at modifying actuator mount geometry and their results.

Change	X (in)	Y (in)	Translation (in)	Limit (in)	X (degrees)	Y (degrees)	Rotation (radians)	Limit (radians)
No Change	-1.646e-7	9.304e-6	9.3e-6	6.6e-7	-3.058e-5	-1.887e-6	5.347e-7	3.7e-8
Symmetric Center	-1.355e-7	5.827e-6	5.828e-6	6.6e-7	-1.545e-5	-1.395e-6	2.707e-7	3.7e-8
Perpendicular Beams	-4.37e-8	5.158e-6	5.158e-6	6.6e-7	-9.5e-6	-4.164e-7	1.659e-7	3.7e-8
Angled Beams	7.825e-7	8.093e-6	8.13e-6	6.6e-7	-3.037e-5	5.968e-6	5.4e-7	3.7e-8
Removed Center	8.156e-7	-4.93e-6	4.99e-6	6.6e-7	2.372e-5	6.398e-6	4.288e-7	3.7e-8

Actuator Mount Optimization

Symmetric Center	Perpendicular Beams	Angled Beams	Removed Center



Computers were unable to capture proper geometry images and eventually crashed when running simulations.

Model Analysis

Analytical Results

From NX Ti-Alloy
Ultimate Load w/ FS of 2 = 414750 kPa (low)
And = 400171.5 kPa (high)
Yield Load w/ FS of 2.5 = 304600 kPa (low)
And = 291621 kPa (high)

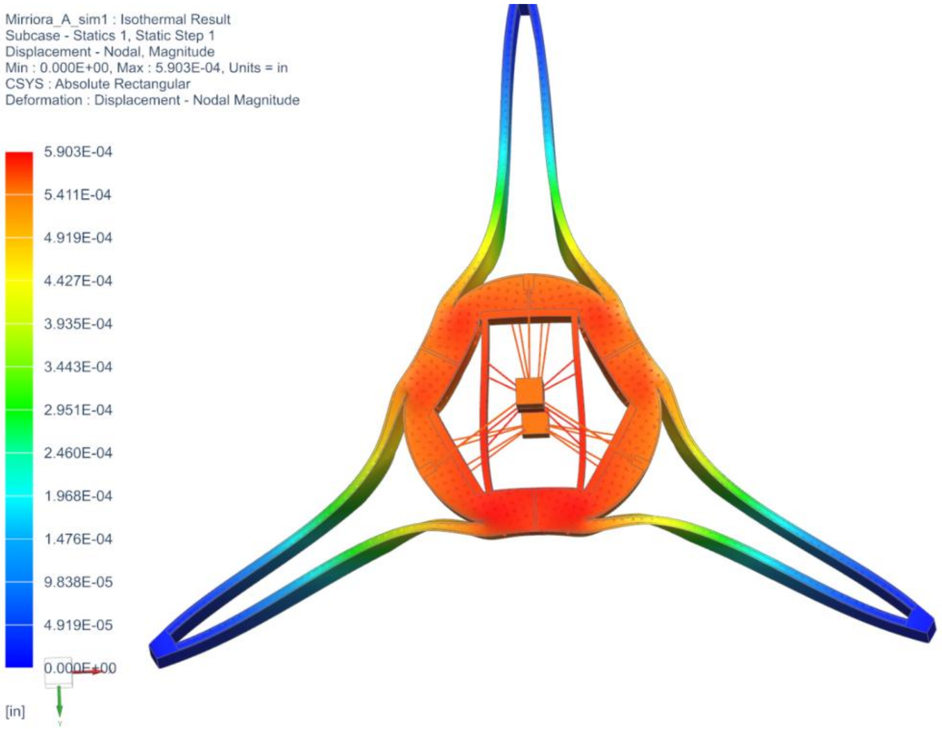
Mass = 16.93145 lbm

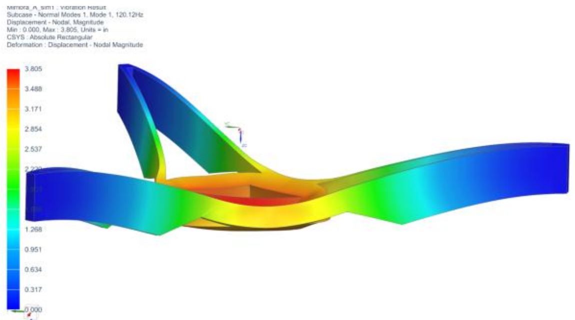
1st Mode = 120.12 Hz

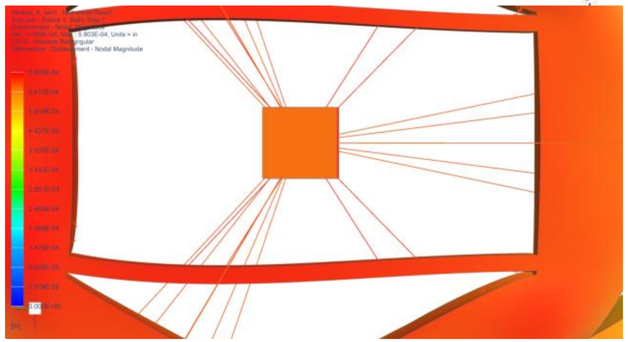
X (in)	Y (in)	Translation (in)	Translation Limit
-1.646e-7	9.304e-6	9.3e-6	6.6e-7
X (degrees)	Y (degrees)	Rotation (radians)	Rotation Limit
-3.058e-5	-1.887e-6	5.347e-7	3.7e-8

No Lattice Buckling:
Pcr= 3.823e4 psi * 81.19= psi
Buckling allowable = 761500/4 kPa
1st Positive Buckling Eigenvalue = 81.19
Buckling MS = -0.939

Lattice Buckling:
Pcr= 7.313e4 psi * 149.49= psi
Buckling allowable = 761500/4 kPa
1st Positive Buckling Eigenvalue = 149.49
Buckling MS = -0.983







Analytical Results

Low-Temp Ult = 1.0183

1	T-Low Ultimate MS	margin_of_safety	0DegLow	1.0876
2	T-Low Ultimate MS	margin_of_safety	105DegLow	1.0183
3	T-Low Ultimate MS	margin_of_safety	120DegLow	1.0347

High-Temp Ult = 1.0682

0	T-High Ultimate MS	margin_of_safety	210DegHigh	1.0712
1	T-High Ultimate MS	margin_of_safety	225DegHigh	1.0682
2	T-High Ultimate MS	margin_of_safety	240DegHigh	1.0743

High-Temp Yield = 0.5072

T-High Yield MS	margin_of_safety	210DegHigh	0.5094
T-High Yield MS	margin_of_safety	225DegHigh	0.5072
T-High Yield MS	margin_of_safety	240DegHigh	0.5116

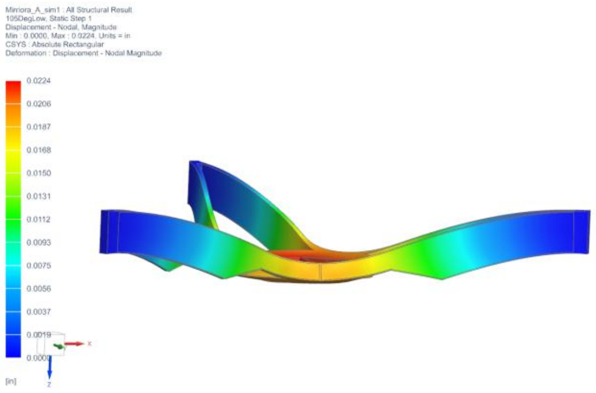
Low-Temp Yield = 0.4823

T-Low Yield MS	margin_of_safety	0DegLow	0.5332
T-Low Yield MS	margin_of_safety	105DegLow	0.4823
T-Low Yield MS	margin_of_safety	120DegLow	0.4943

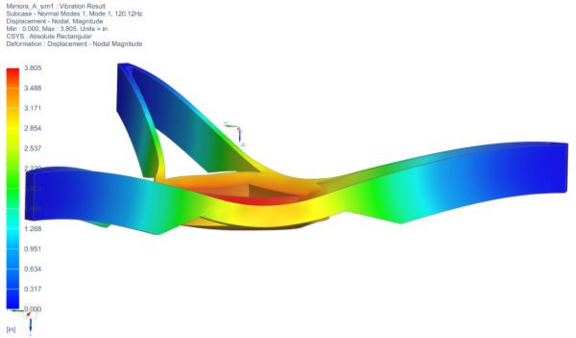
Corresponding Lattice MS = -0.5998

11	T-Low Yield MS	margin_of_safety	225DegLow	-0.5994
12	T-Low Yield MS	margin_of_safety	240DegLow	-0.5998
13	T-Low Yield MS	margin_of_safety	255DegLow	-0.5990

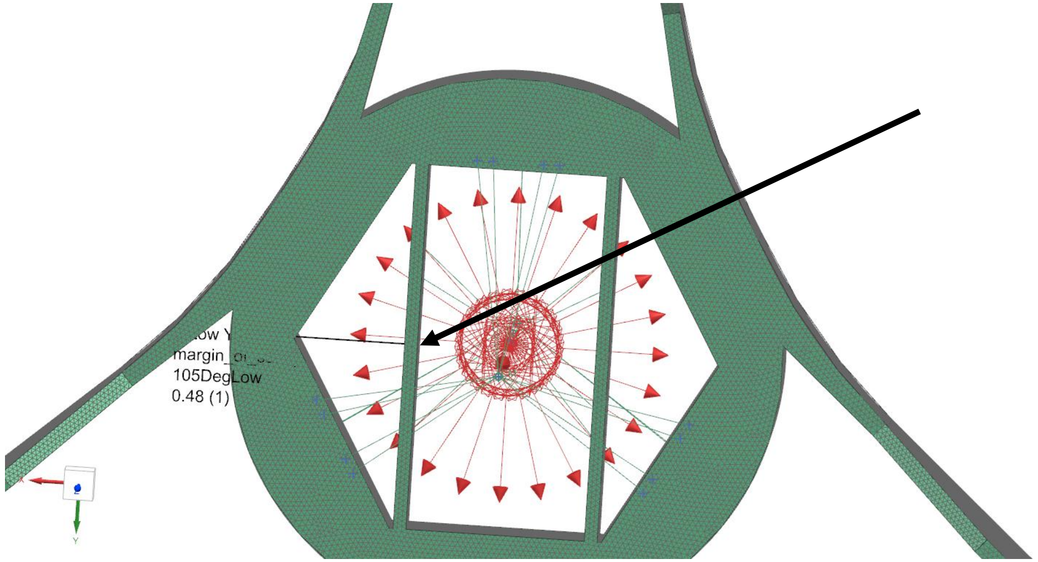
Lowest MS Shape



1st Mode Shape



Location of all Lowest Margins



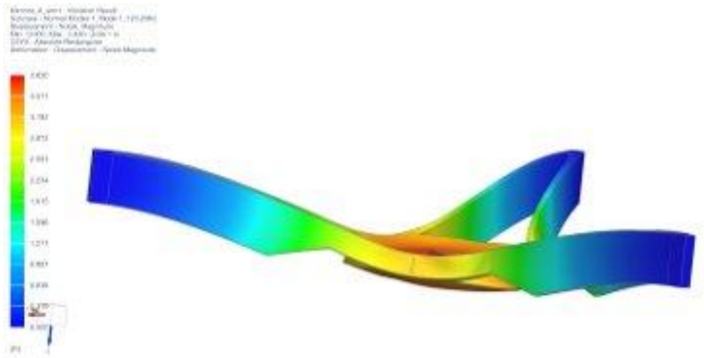
Lattice Efficacy

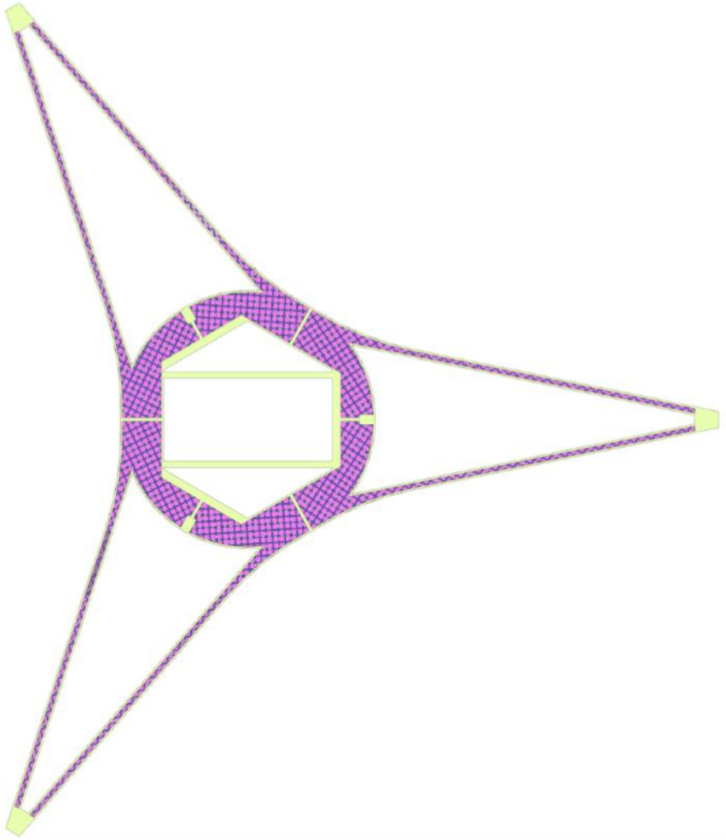
Change in Stiffness - Using 1lbf load and z-axis displacements of mirror		
	Displacement (inches)	Stiffness (lbf/in)
With Lattice	2.284e-5	43782.8
Without Lattice	2.312e-5	43252.6
Loss of stiffness when lattice fails = 530.2 lbf/in		

S/W - Using 1lbf load and z-axis displacements of mirror				
Lattice Thickness (inches)	Displacement (inches)	Stiffness (lbf/in)	Mass (lbm)	S/W
0	2.312e-5	43252.6	16.25	2665.75
0.045	2.284e-5	43782.8	16.93	2585.9
0.1	2.184e-5	45787.5	19.59	2337.12
0.4	1.683e-5	59417.7	69.67	852.77

Takeaway: It is possible that other variables could yield different results, however, for this design, and these lattice parameters, the lattice is little more than dead weight. The one thing it does improve on is printability as the part can be easily printed without the need to add overhang–compatible geometry or removable internal supports.

1st Mode – No Lattice = 120.2 Hz

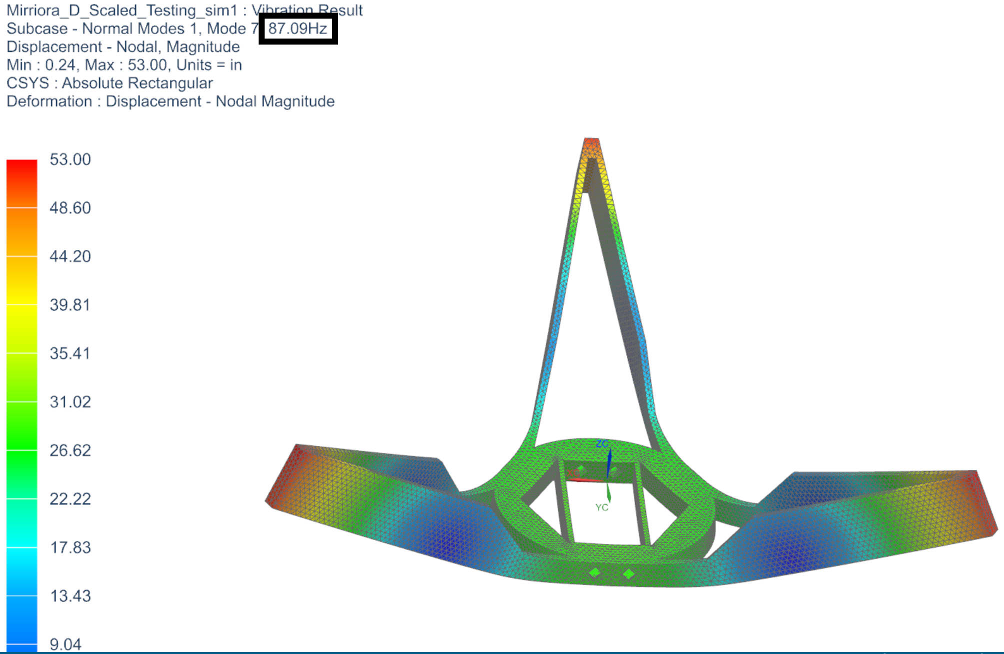


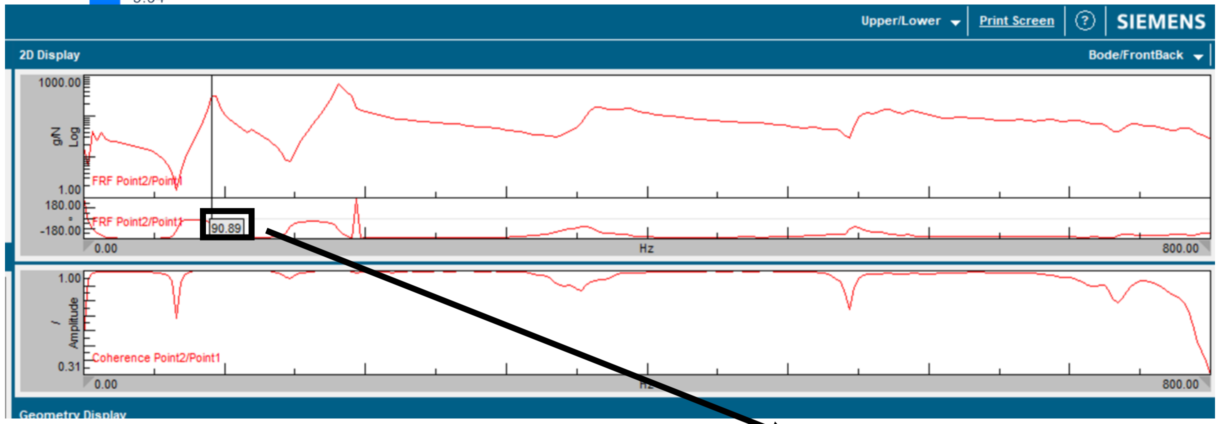


Final Model and Testing

Final Model

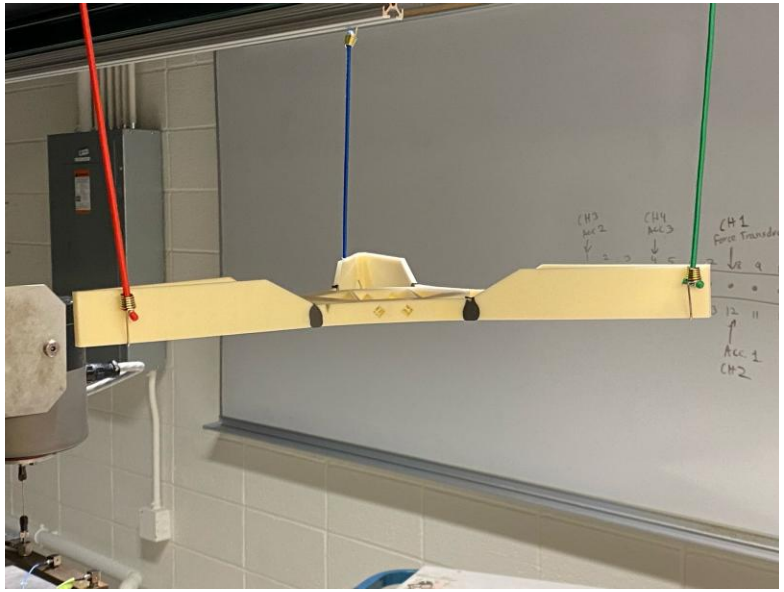
Vibration Testing Results

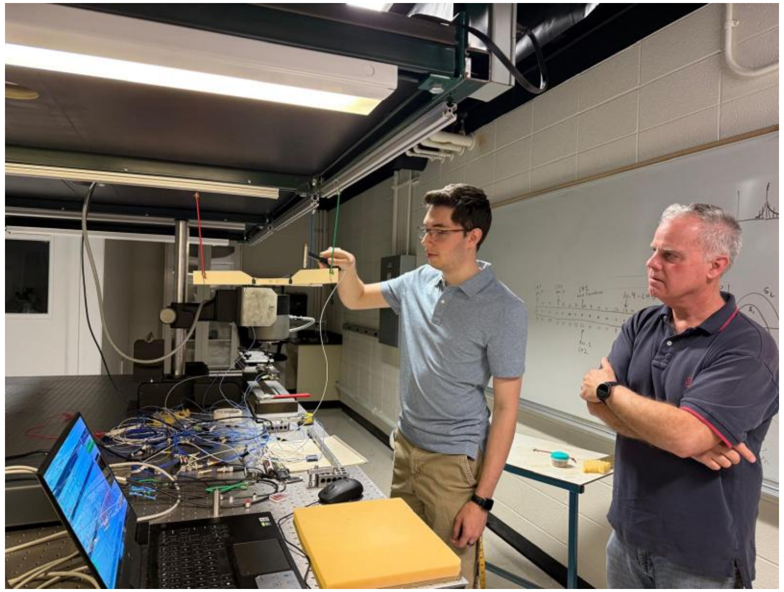




The calculated natural frequency is 90.89 Hz, which shows a 4.36% deviation from the simulation model's result of 87.09 Hz.

Vibration Testing Setup



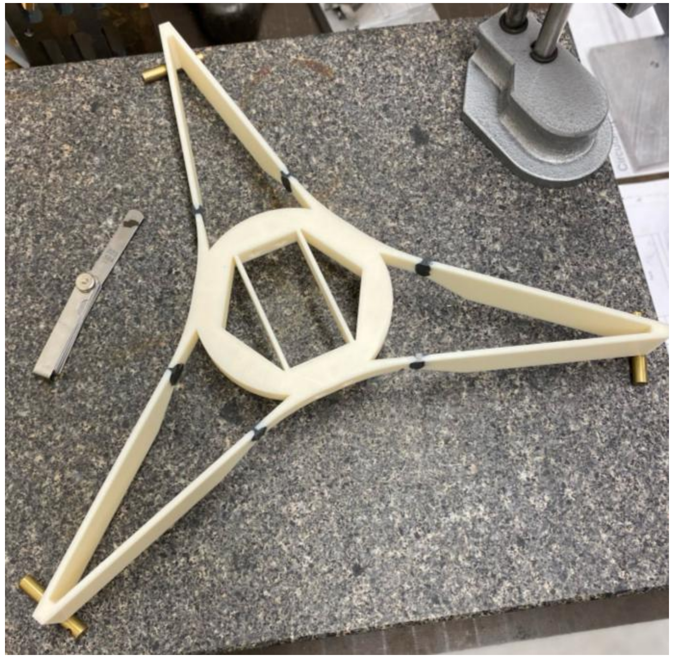


Stiffness Testing Results

Mass of 50 grams applied to the middle portion of the two actuator mount beams. Force is approximately 0.1102 lbf.

	Displacement (in)	Stiffness (lbf/in)
Simulated	2.398e-3	45.995
Tested	2.45e-3	44.98
Percent Error = -2.207%		

Displacement Testing Setup



Project Conclusion, Future Work, and Acknowledgements

Conclusions

ANALYSIS VERIFYING ALL REQUIREMENTS AND SPECIFICATIONS

Requirements and Specifications	Verification
1. The outer diameter of the SMSS (interface to the FMS) shall be 48 inches	All geometry is contained within 48-inch diameter circle. PASSED
2. The first mode of the SMSS shall be 120 Hz or greater when grounded at the FMS interface and supporting all hosted hardware	The 1st mode of vibration is 120.12 Hz PASSED
3. The mass of the SMSS shall be 18 lbm or less	The mass is 16.9 lbm PASSED
4. The SMSS shall have positive margins of safety against yield and ultimate failure when exposed to a quasi-static load of 12 G laterally and 18 G axially simultaneously (lateral swept 15-degree increments) while supporting all hosted hardware	The lowest MS of the shell is 0.48 and the lattice MS is –0.59 PASSED
5. The SMSS shall have positive margin of safety in a 5°C to 35°C temperature range while supporting all hosted hardware	The above MS used the temperature range PASSED

6. The SMSS and the hosted hardware shall not obstruct more than 14% of the Primary Mirror (PM) clear aperture area of 1.1 meters diameter	The SMSS has 12.5% coverage PASSED
7. The average motion of the SM interfaces under a 1 degree C isothermal load should be 0.66 micro-inches translation (RSS of x and y) or less	Average motion is 9.3 micro-inches FAILED
8. The average motion of the SM interfaces under a 1 degree C isothermal load should be 0.037 micro-radians rotation (RSS of Rx and Ry) or less	Average motion is 0.54 micro-radians FAILED

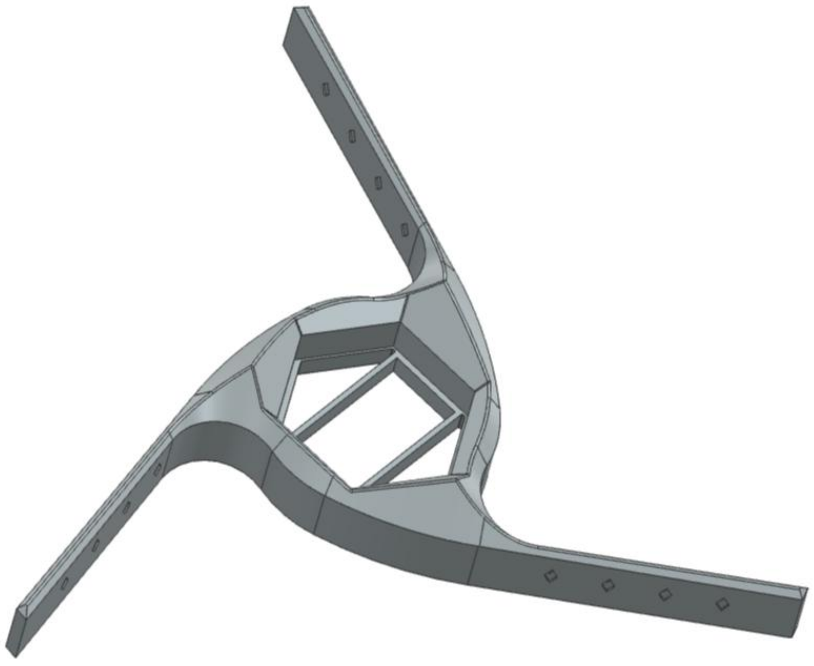
Future Work

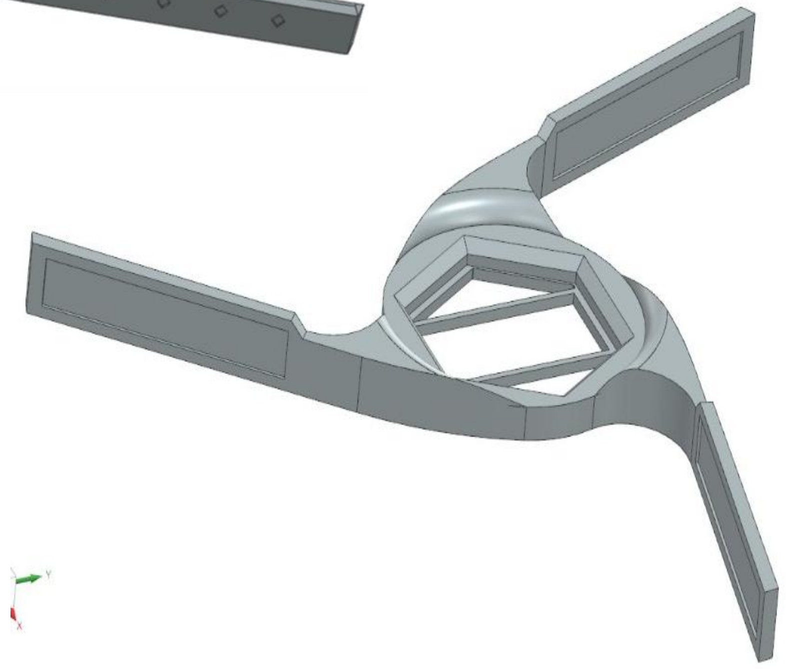
- Teams should carefully evaluate the trade-off for the internal lattice. Increased stiffness and printability vs reduced strength-to-weight ratio

- Earlier communication with vendor – improve understanding of infill density, build orientation, lead times, printer limitations and material additives.

- Further optimization into 2024 L3Harris team's design, learning from their successes, improving the geometry, and printability but utilizing the existing shape.

- Future iterations could focus on the geometry at the actuator mounting beams of the SMSS and may benefit from simulations and tests targeting that area.





Acknowledgements

L3Harris: Patrick Elsworth, Patrick Zinter, Steve Sutton
Professor Christopher Muir
Christine Pratt
Jim Alkins
Alex Prideaux

		as of	5/2/2025		Week of															
					1/20	1/27	2/3	2/10	2/17	2/24	3/3	3/10	3/17	3/24	3/31	4/7	4/14	4/21	4/28	5/5
	input data in cells that are this color	% actual complete	% must be complete	status	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gate																				
	Sponsor Contact	100%	100%		x															
	Problem Definition	100%	100%		x	x														
A	R&S/Schedule/Background	100%	100%		x	x	x	x												
B	Concept Generation (>3)/selection/PDR	100%	100%		x	x	x	x	x	x										
C	Frankenstein Model/Initial Drawing Package/MFG Plan	100%	100%				x	x	x	x	x	x								
	Fabricate	100%	100%							x	x	x	x	x						
	Build/Make it work	100%	100%									x	x	x	x					
D	Testing/Validation/FDR	100%	100%												x	x	x			
S-A	Sponsor Validation Proof of Concept/Deliverables/PDR	100%	100%		x	x	x	x	x	x	x	X								
S-B	Sponsor Validation Satisfied with Build/Test/FDR	75%	97%		x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	

		Approved
Problem Defined	Yes	Yes
Current Deliverables	8	Yes
Requirements	9	Yes
Specifications	8	Yes
Roadblocks	No	
Total Budget	$1,000.00	
Burn	$ 595	
Remaining Budget	$ 405