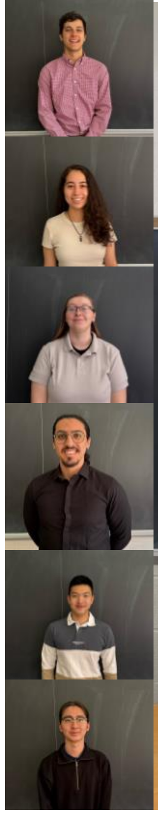
SATELLITE

Team Members

Aidan Schaffer
Anjeli Estrada
Cady Brunecz
George Maximos Zipitis
Steven Kang
Taylor Bayarerdene

Customer

Professor Christopher Muir

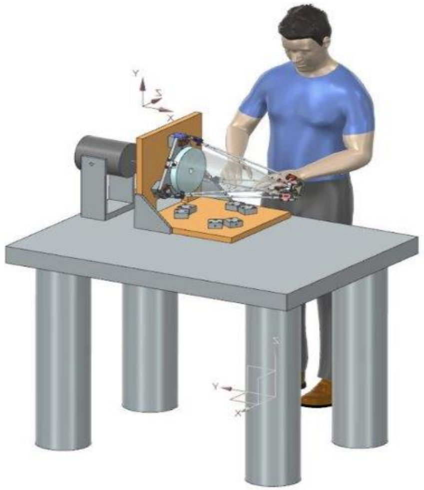


Project Overview

A Cassegrain telescope is a type of telescope that uses two reflective mirrors to form an image and is a key part of space exploration as this technology was used in the Hubble telescope. Our project was to assemble and test a current table-top Cassegrain telescope and based on those findings, design, manufacture, simulate and test our newly designed telescope.

Problem Statement

- By testing, analyzing and redesigning the tabletop Cassegrain telescope, the issues that arise in full-scale models such as the Hubble telescope will be better understood.
- We will be specifically working on the **primary support**, **secondary mirror support** and the **alignment structure**.
- Based on our requirements, this will improve **manufacturability**, the **weight**, and increase the **resonant frequency** to ultimately provide better imaging of objects from large distances.
- The changes in design are to be correlated and tested against simulations
- The broader impact for this project is that the findings found on the design, manufacture and simulation can be used to improve full-scale Cassegrain telescope designs and improve our understanding of space



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:

- Initial Prototype Assembly
- Testing and Simulation
- Design of Updated Prototype
- Manufacturing of Updated Prototype
- Updated Prototype Assembly
- Testing
- Final Design Report

Requirements:

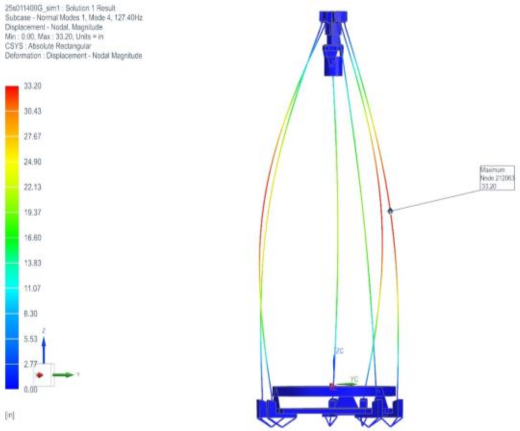
- Manufacturable in house
- Manual alignment
- Accessible for FARO for testing
- Setup for shaker/hammer test

Specifications:

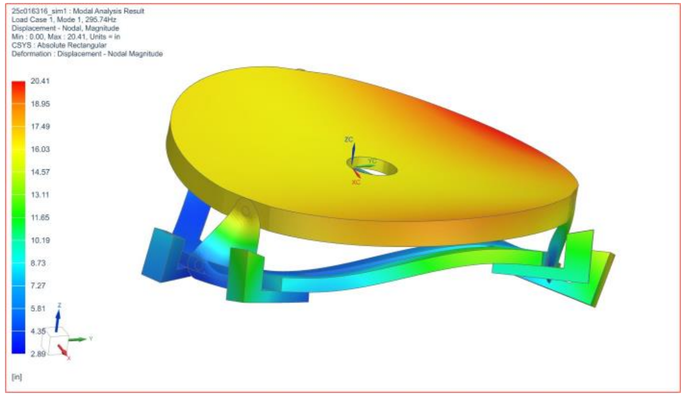
- 10% Reduction in weight
- 10% Reduction in total part count
- First vibrational mode must be >120Hz
- Obstruction of primary mirror must be <14%

Modal Analysis

Satellite Assembly

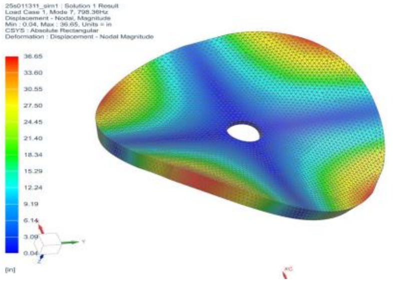


Primary support Assembly

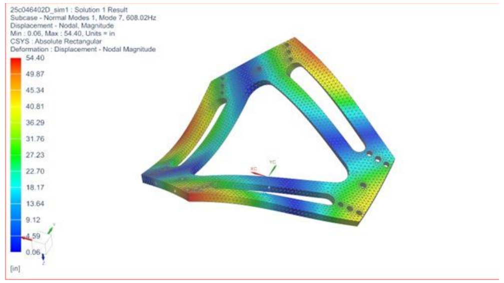


Strut Assembly

Primary mirror



Primary support base



Current Project Status

The satellite has been fully assembled and both optics have been diamond-turned. Additionally, we were able to correlate our vibrational simulations to our hammer testing on the struts, primary mirror and primary base.

We have also evaluated our design against our requirements and determined if they were met or not. We were able to reduce the weight of the design by 64%, reduce our part count by 30%, increase our frequency analysis by 323%, and reduce the area obstruction by 40%.

Requirements	Initial	Final	% Improved	Status
Weight Reduction	7.2 lbs	2.57 lbs	64%	Met
Part Count Reduction	288	203	30%	Met
>120 Hz	30 Hz	127 Hz	323%	Met
120 Degrees Apart				Met
G Loads				Not Met
<14% obstruction	35%	21%	40%	Improved

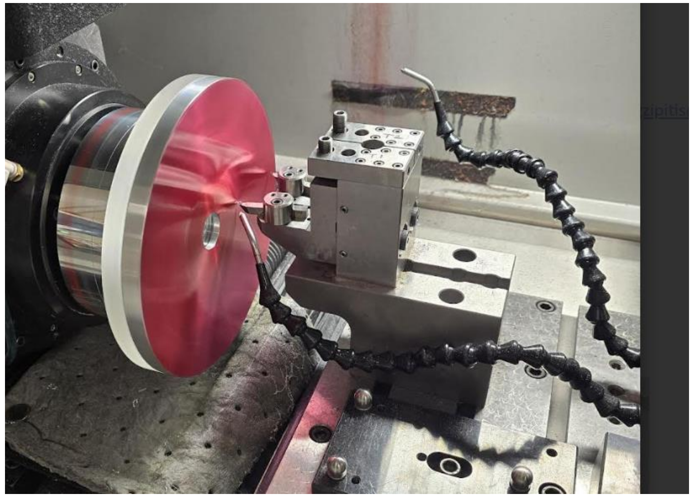
Current Project Status

Testing and Correlation

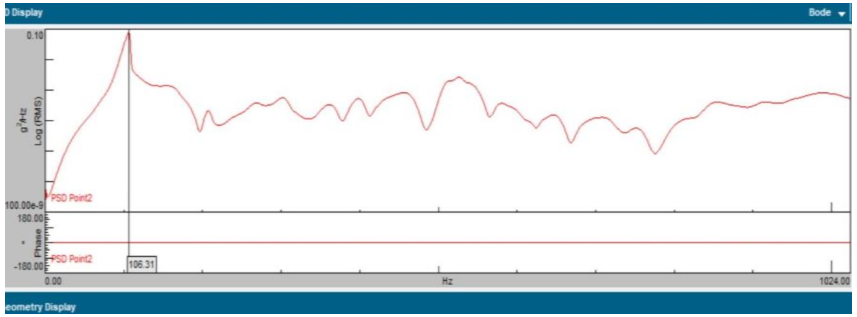
We have also been able to conduct a hammer test for a frequency response and use these findings to correlate back to our simulations. The simulated fundamental frequency of the simplified strut model is 130Hz, while the fabricated strut model shows a frequency of 106Hz. In the simplified strut model screws were not included and the strut bolts were fully threaded. The fabricated model has a pre-set adjustment on both the coarse and the fine adjustment sides; however, the tested model did not incorporate that adjustment. The additional weight, imperfect connection caused by the screws and differences in total strut assembly length, contributed to the lower fundamental frequency observed in the test.

The primary mirror and base have relatively low differences between their simulated and test results. The simulated frequencies were 798Hz and 608Hz, while the tested frequencies were 736Hz and 617Hz, respectively. These differences are likely due to differences in material properties from the simulated 6061-Aluminum and the actual material used. Additionally, there are likely minor differences in thickness and geometry, as the simulations used an idealized model.

Diamond turning primary mirror at MCC



Hammer test for frequency response on Struts Asser

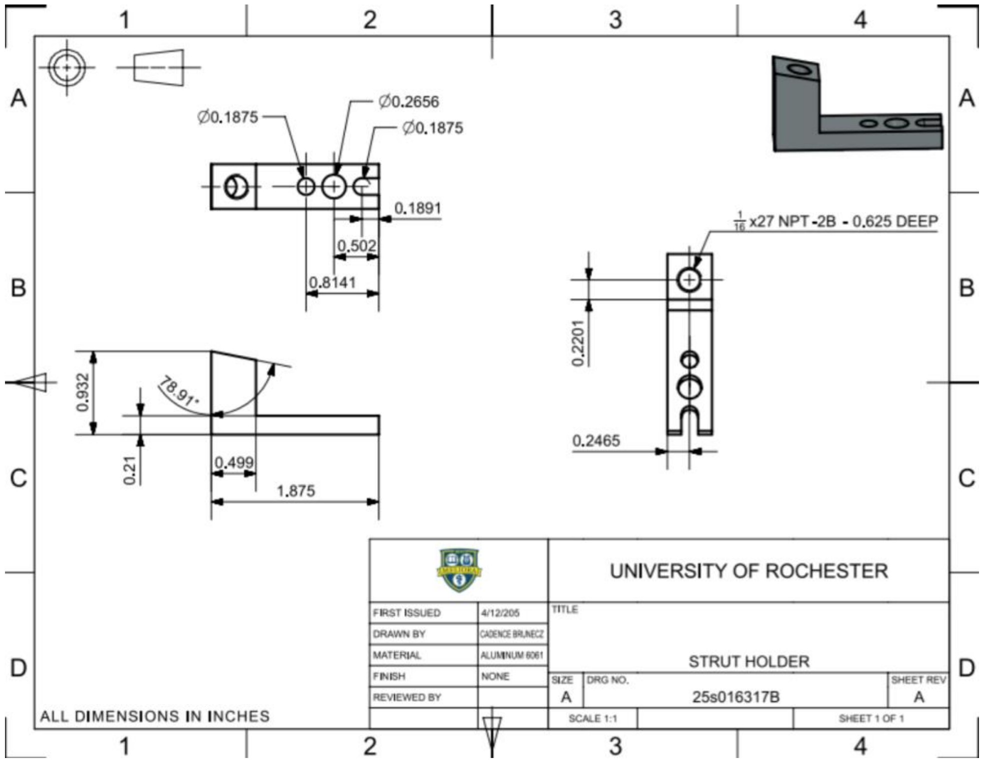


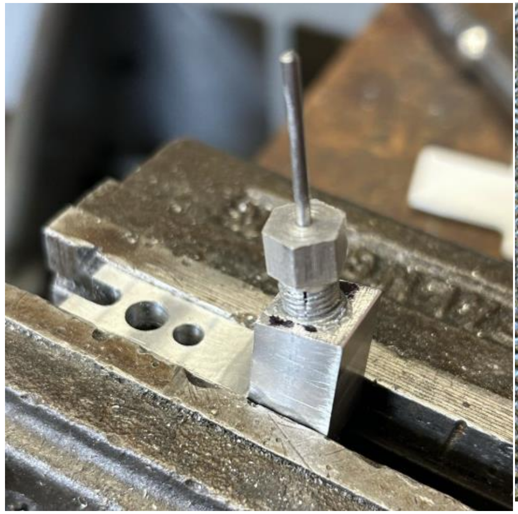
Current Project Status

Shown on the right is a drawing of a primary strut holder. This part was manufactured on a manual mill. To achieve the 11-degree face with the 1/16 NPT, we used an angled vise in the mill. From there we were able to face off 11 degrees to the right height and drill and tap the NPT.

This part includes pins for located as seen by the bottom rightmost picture with the small hole on the lefthand side and the slot. This part is then fastened by a ¼-20 bolt in between the pins as seen by the ¼-20 clearance hole.

The purpose of the 1/16 NPT hole is to clamp the wired parts of the struts down. There is a male 1/16 NPT bolt with slits in it that mates with this part and acts virtually as a collet to clamp onto the wire. This process can be seen by the bottom leftmost picture on the right-hand side.





Conclusions/Future Work

In terms of future work, the most important task would be additional simulation, testing and correlation. This would allow us to test the optic displacement specification under the given thermal loads.

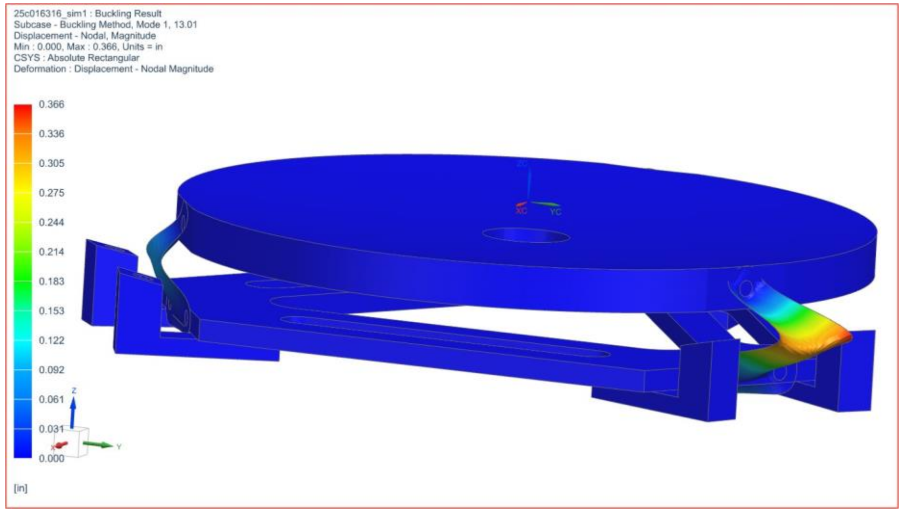
Additionally, the geometry and materials used in the design could very likely be further optimized with more time. With a larger manufacturing budget, a much more complex yet efficient primary mirror support system design could very likely be created.

Finally, we would be very interested in taking real images and optimizing the imaging process for our design. This would involve firstly setting up a controlled lab environment, and then moving on to a harsher, real-life environment. Once the imaging process has been solidified, software could very likely be created that allows us to take multiple images and stitch them together, to make up for the areas blocked by the struts and secondary mirror structure.

Acknowledgements:

We would like to thank our sponsor, Professor Chris Muir, for all of his help throughout this project. Additionally, we would like to thank Chris Pratt, Jim Alkins, Alex Prideaux, Sam Kriegsman, Devin Woodyard, Vic Genberg, Gary Bisson, Bill Mildenberger, Sheli Hernandez, Mike Pomerantz, and Rob Bauer for their contributions to this project.

G-Load Analysis



Properly set the connections for the flexures to the primary mirrors as plane-to-plane connection, to simulate G-load analysis without failures on the flexures.