UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Single-Winged Heliostat

Section 30314, Group 623T

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POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

Our Team at Weenie Hut Junior Inc.

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Raul Lopez

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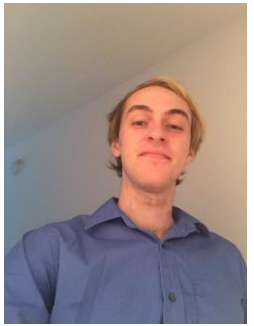
Samantha Scholl



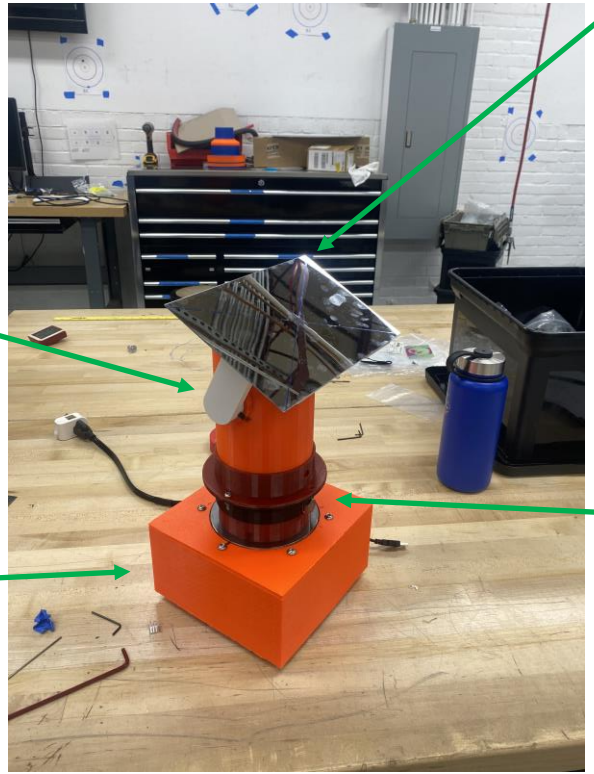
Stephen Supinski

Hedgehog Concept

- The intent of our project was to design a low cost, simple heliostat module, that maintains high efficiency and functionality. This was achieved through using parts that are easily 3D printed and readily sourced for a quick and easy assembly, to make solar thermal power more accessible and scalable.

Single-Winged Heliostat

Reflector Backing
345 cm^2 of reflection area



Top Actuation Assembly
Rotates the crossbar and reflectors to desired elevation with ±0.11° accuracy

Base & Controls
Base which houses the controls for the heliostat unit including 12V Power Supply, ESP32, and two A4988 Motor Drivers

Bottom Actuation Assembly
Rotates the reflectors azimuthally with ±0.45° accuracy

Key product specifications

The design:

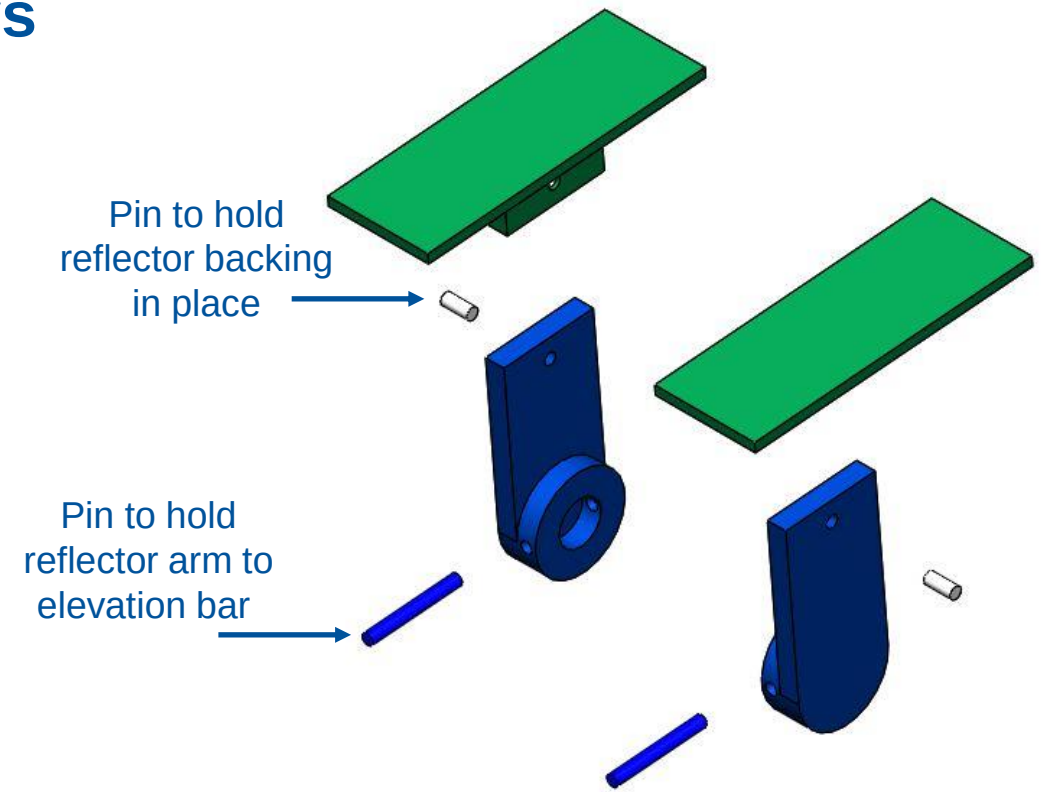
- rotates a reflective mirror both upon the azimuth (z) and elevation (y) axes
- Reflects laser pointer to hit a target within $\pm 0.5^{\circ}$
- Connects to a standardized mount
- Withstands winds up to 82 m/s
- Compact with mainly 3-D printed components,
- Covers electrical components from environment
- Software for electronics coded in Arduino

Exploded CAD Views

Reflector Assembly

Key Features and Designs:

- Printed in parts for faster manufacturing
- Reflective surface can be replaced and cleaned with ease
- Can be scaled to fit any reflector size
- Only needs 2 pins to attach to crossbar

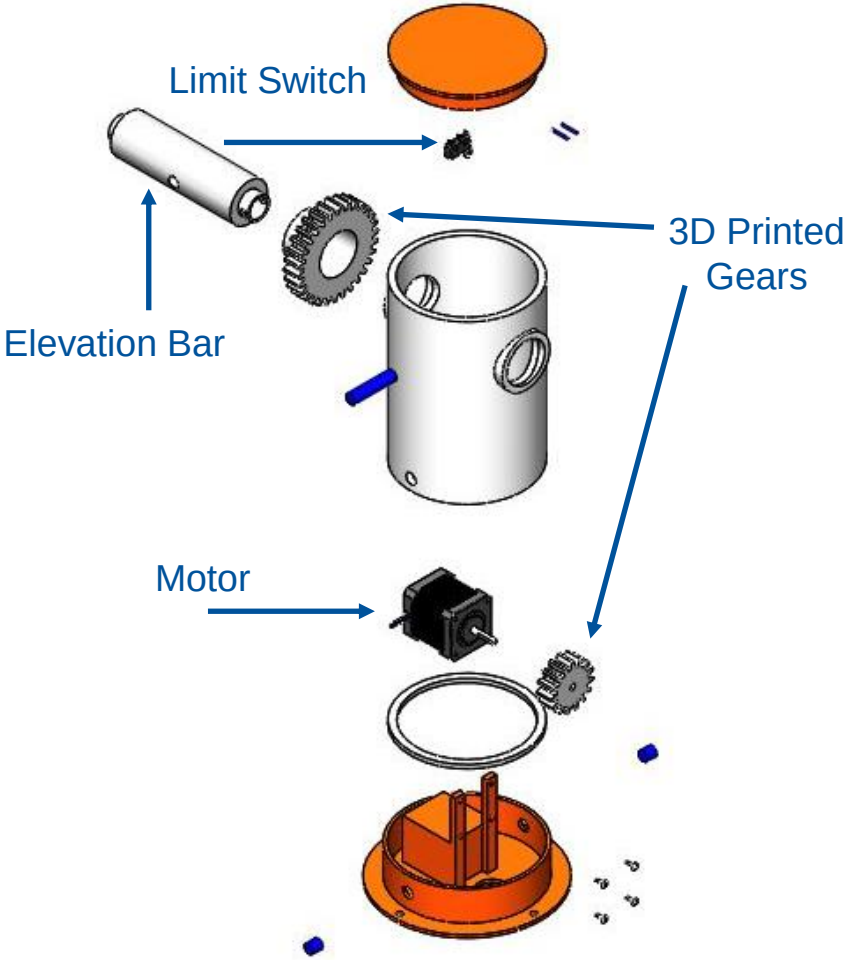


Exploded CAD Views

Top Assembly

Key Features and Designs:

- Elevation Bar changes elevation of reflector mounts
- Elevation Bar hollowed to reduce weight and required motor torque
- Driven by a stepper motor and 3D printed gears
  - 1:2 gear ratio
- Limit switch to prevent tangled wires
- Safety feature to prevent environmental damages

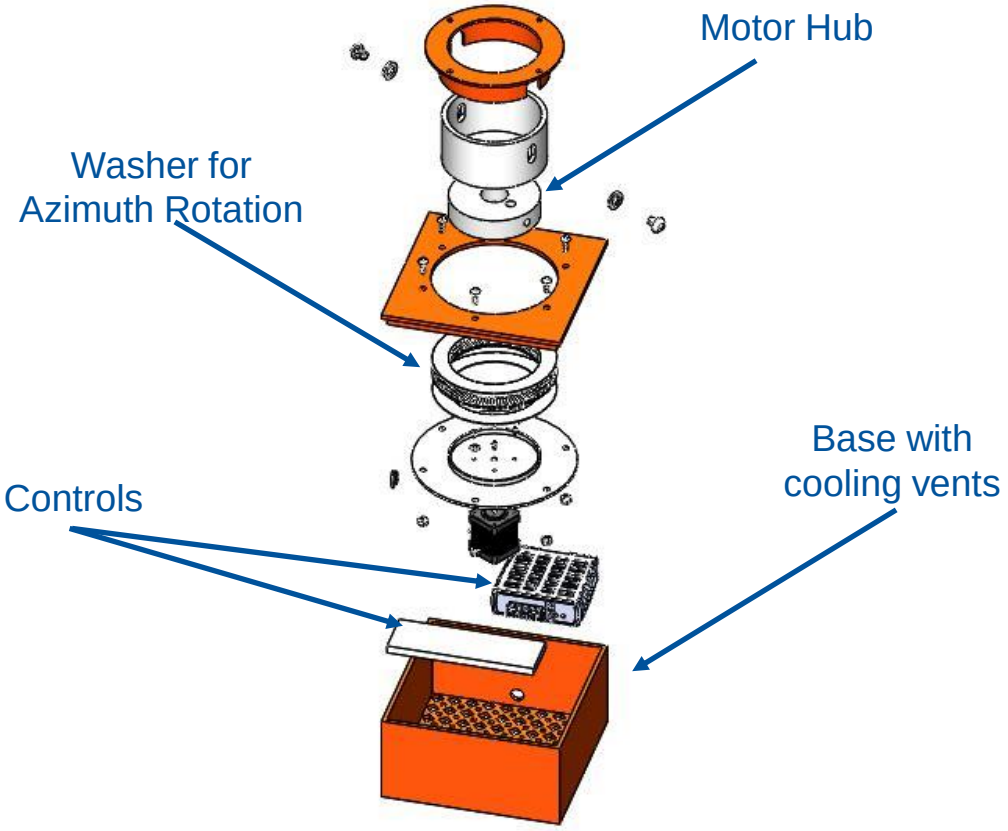


Exploded CAD Views

Bottom Assembly

Key Features and Designs:

- Azimuth rotation driven by stepper motor and 3D printed wheel hub
- Limit switch to prevent over-rotation and tangled wires
- Base houses control system
- Base contains cooling vents to prevent controls overheating



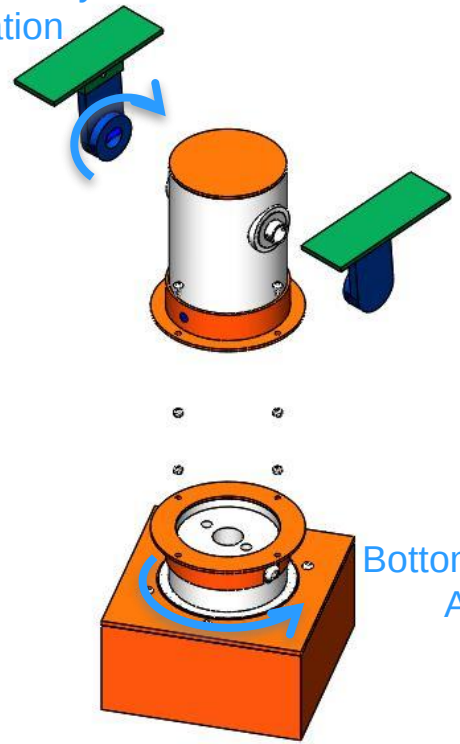
Exploded CAD Views

Full Assembly

Key Features and Designs:

- All parts easily 3D printed or readily sourced to reduce cost
- Parts easily replaced
- Scalable
- Cost effective
- Actuation split by axis of rotation

Top Assembly:
Elevation

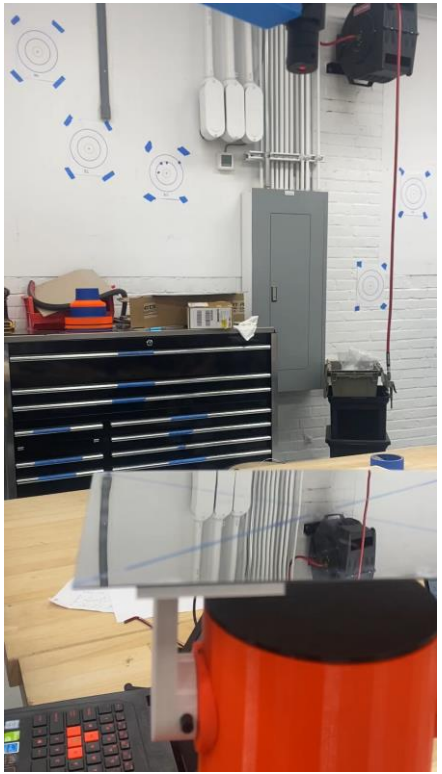


Bottom Assembly:
Azimuth

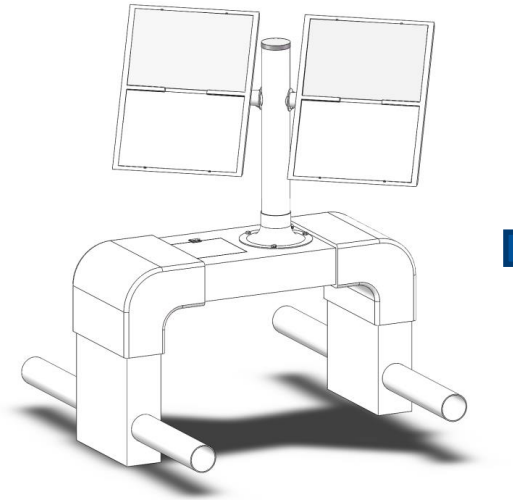
Wind Survivability Test

Laser Reflection Targeting Test

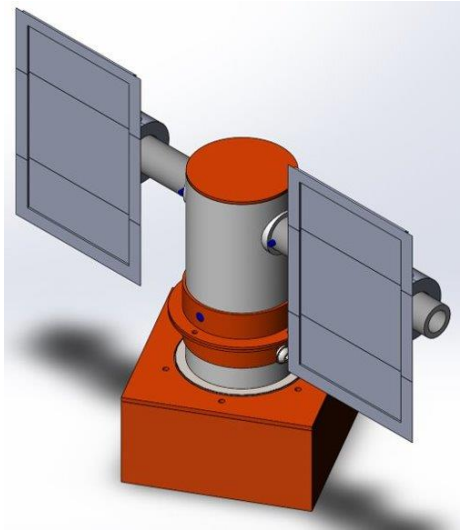
Target	Accuracy
B1	± 1.0°
B2	± 0.5°
B3	± 0.5°
B4	± 1.5°
B5	± 0.5°



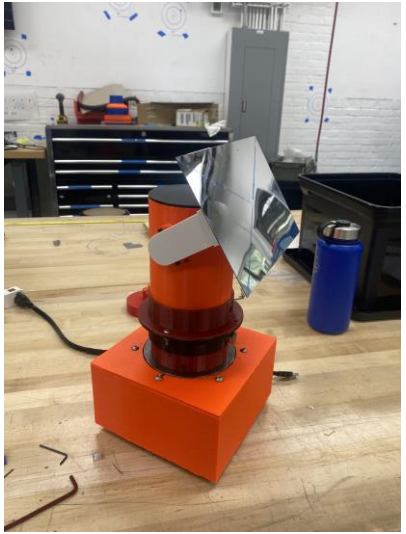
Design Evolution



Design Inspiration:
Fall 2021 Group 8 Design



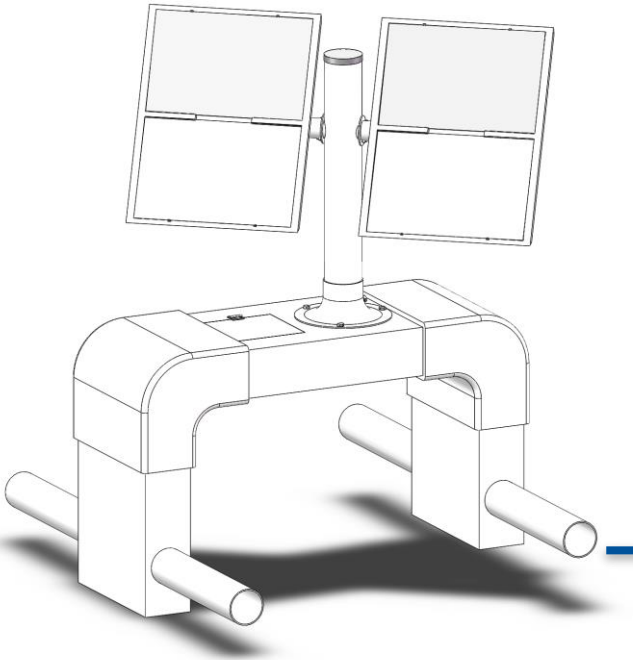
Initial Design



Final Product

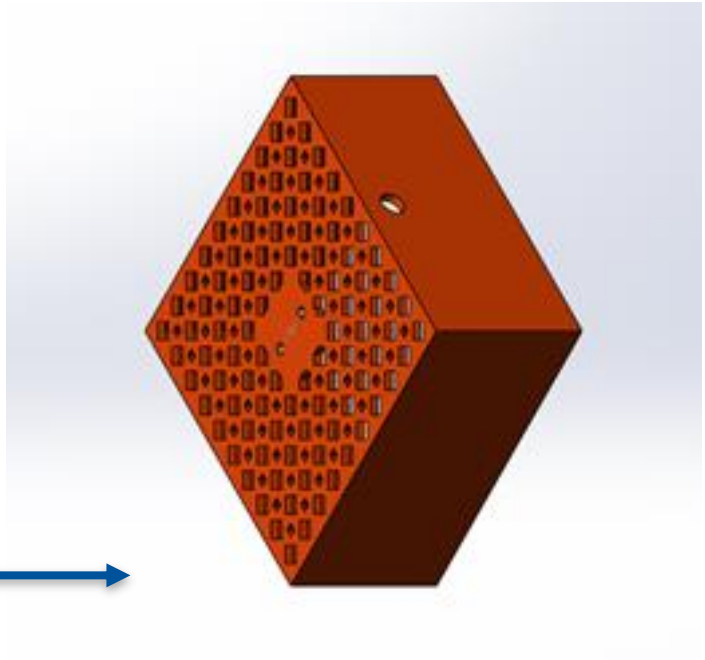
Design Evolution

Key Changes - Base



Base

- Re-Designed to attach testing mount
- Went from PVC root system to 3D printed box
- Reduced overall cost and design simplicity
- Cooling vents added

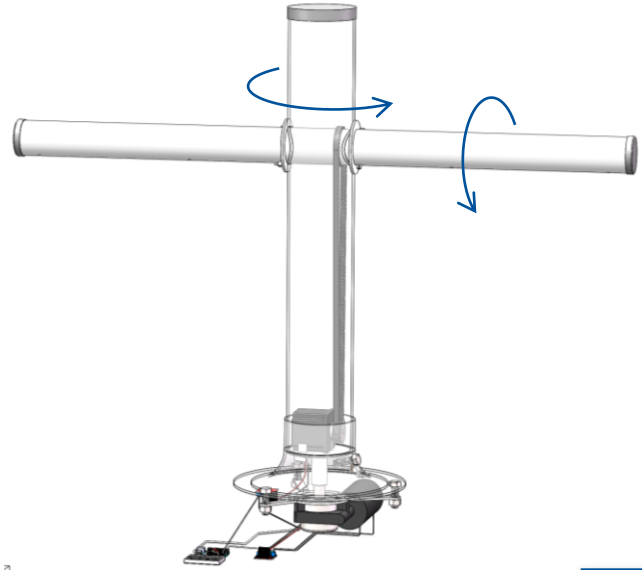


Fall 2021 Group 8 Design

Current Design

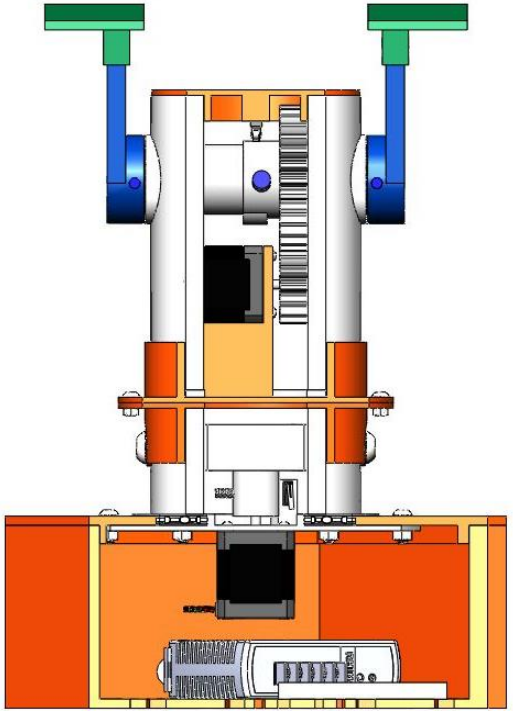
Design Evolution

Key Changes - Actuation



Actuation

- Material changed from PVC to 3D printed parts
- Went from rubber belt with teeth to 3D printed gears
- Re-designed center column by axis of rotation
- Went from a stepper and worm gear motor to 2 stepper motors

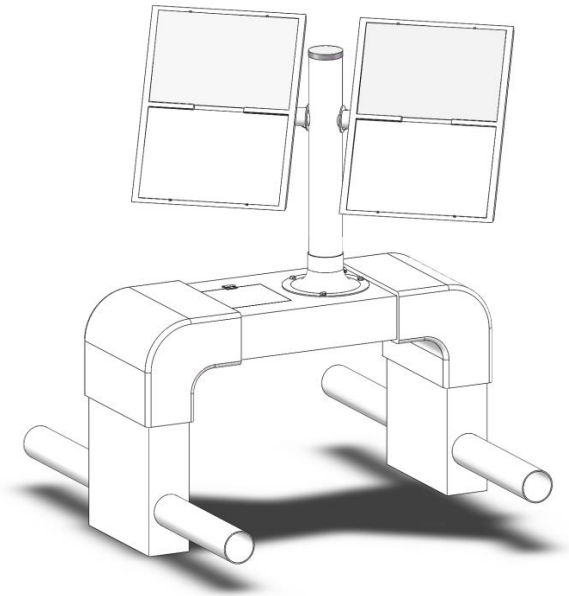


Fall 2021 Group 8 Design

Current Design

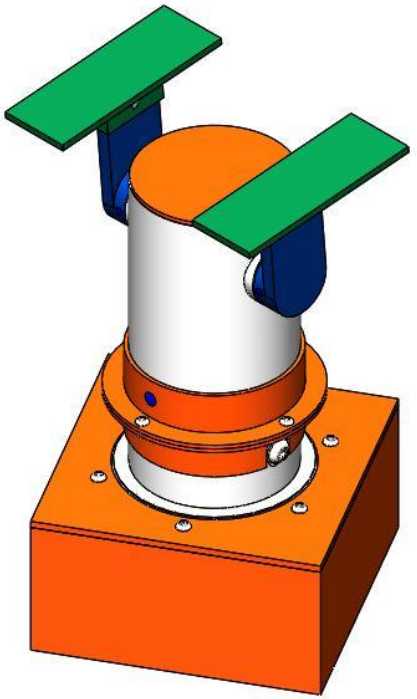
Design Evolution

Key Changes – Reflector Mount



Reflector Mount

- Went from 2 mounts down to 1
- Redesigned how reflectors are mounted
- Reduced parts
- Reduced cost
- Less wind resistance

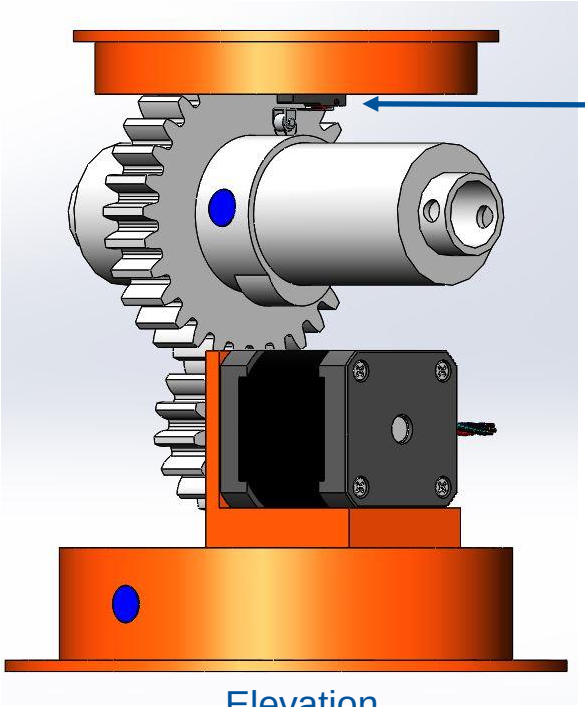


Fall 2021 Group 8 Design

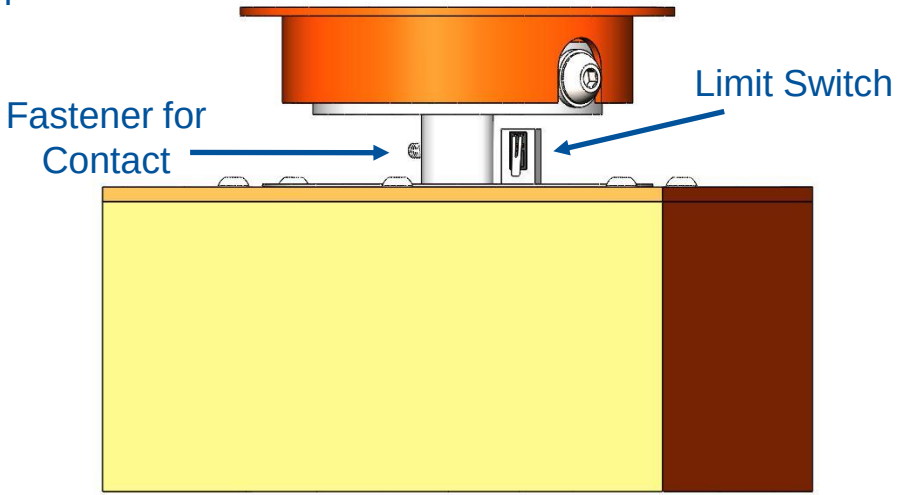
Current Design

Design Evolution

Limit Switch – Elevation and Azimuth



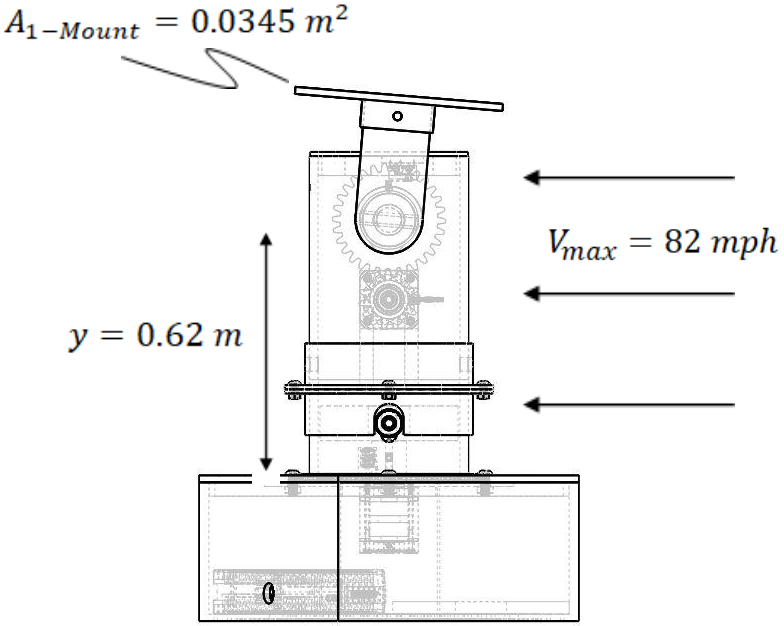
Elevation



Azimuth

Engineering Analysis

Structural Concerns – Reflector Mounts During High Winds



$$F_{wind} = \frac{1}{2}\rho_{air}(A)V^2$$

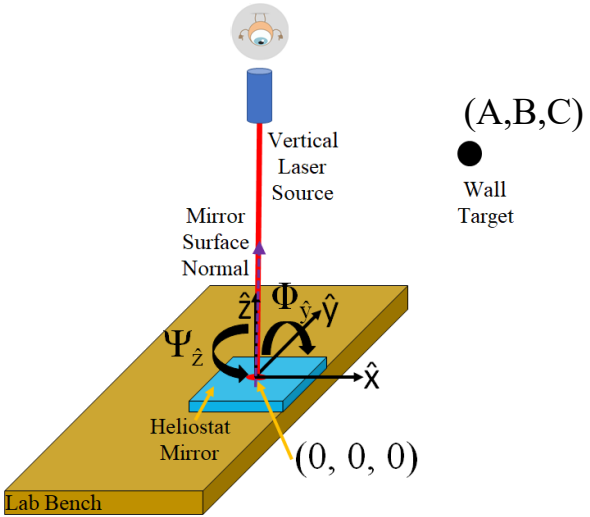
$$F_{wind} = 109.7\ N$$

$$\sigma = \frac{F_{wind} yc}{0.25\pi({r_o}^4 + {r_i}^4)}$$

$$\sigma = 4.6\ kPa < \sigma_{y_{PETG}} = 51\ MPa$$

Heliostat Angle Calculations

Experimental Setup



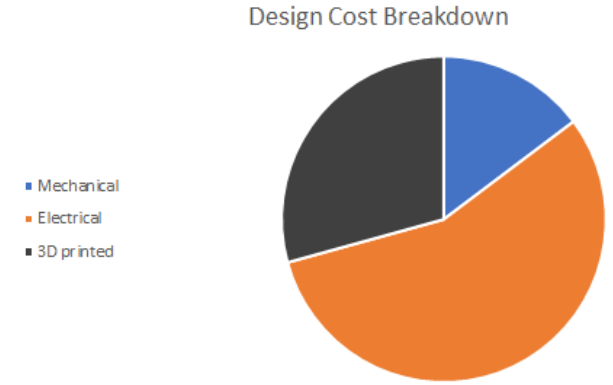
Azimuth and Elevation angles

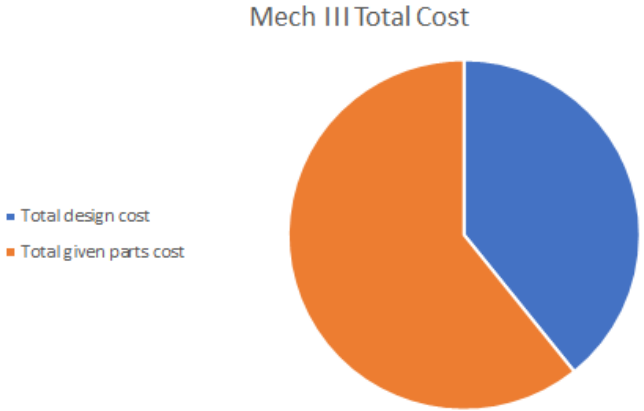
Elevation: $$-2\Theta_E = \Phi_{\hat{y}} = \tan^{-1}\left(\frac{\sqrt{(A_x - d_x)^2 + (B_y - d_y)^2}}{C_z - d_z}\right)$$

Azimuth: $$2\Theta_A = \Psi_{\hat{z}} = \tan^{-1}\left(\frac{B_y - d_y}{A_x - d_x}\right)$$

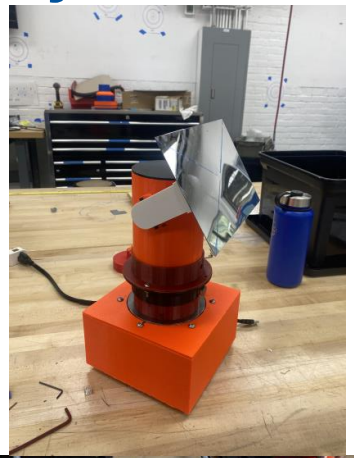
Total Cost

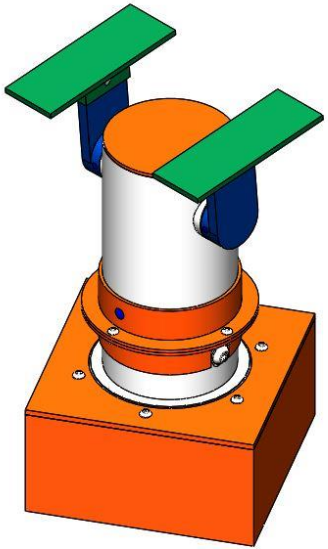
- The total cost of one unit with given parts and added parts is $175.01
  - **Design cost: $68.67**
  - Given parts cost: $106.34
- For a Thermal farm of 3,000 heliostats, the total cost would be approximately $446k.
  - Assuming 15% discount





Why our Design Should be Selected





- Low cost
- Simple design
- Easy to manufacture
- Scalable
- High stability
- Factor of Safety >> 2

Questions?