Automated Mirror Cover Naval Precision Optical Interferometer

Team 8
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Aerial view of the NPOI facility

Overview

- Problem Statement
- Concept Generation
- Design Considerations
- Preliminary Designs
- Final Design
- Material Selection
- Updated Gantt Chart

The NPOI

- The Naval Precision Optical Interferometer is a United States Navel Facility
- The facility uses several small siderostats to collect light from stars
- The light is then reflected down a vacuum tube where it is collected and translated into meaningful data
- This data is then used to recreate an image of a star

The Mirrors

- The mirror is made of glass coated with aluminum
- The aluminum is only a few molecules thick
- Condensation will damage the mirror's surface

Needs Identification

- The current mirror cover system is awkward and hazardous
- Possibility for damage to sensitive equipment exists
- Physical labor is required to make the current system work
- Time requirements are an issue as the facility increases in size

Problem Statement

- Automatic mirror cover is needed at NPOI and must operate without interfering with current equipment while maintaining a nitrogen purge.

Current System

Operational telescope and Siderstat

Telescope and Siderostat currently under construction

Manual Covers

Siderostat with Current Cover Attached

Constraints

- Must not block star light from siderostat
- Full range of motion of siderostat must be maintained
  - Tilt: -10 to 60 degrees
  - Pan: -60 to 60 degrees
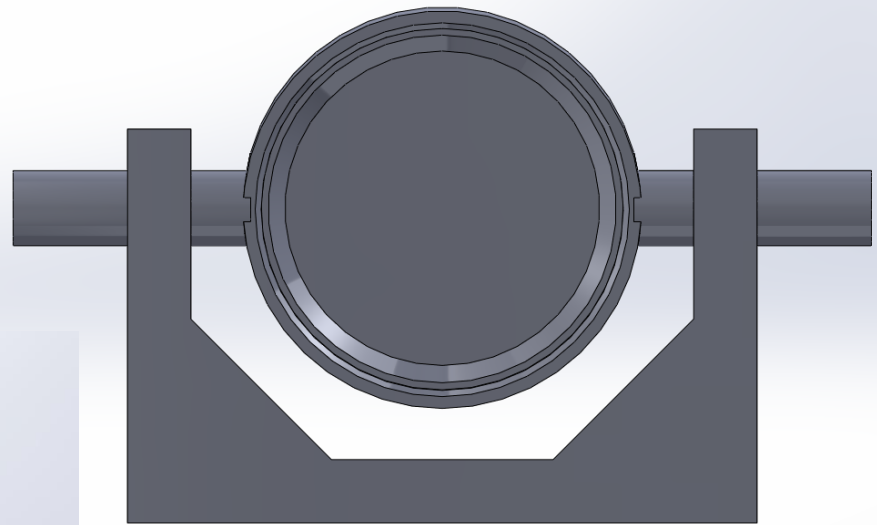- The cover must be able to close in the event of a power outage

Additional Design Considerations

- Material issues
- Environmental issues
  - Wind
- Clearance issues,
  - The cover must operate when the dome is open or closed
  - 4 inches below mirror
    - ½ inch when tilted
  - 10 inches above mirror

Siderostat Model

Front View of Siderostat
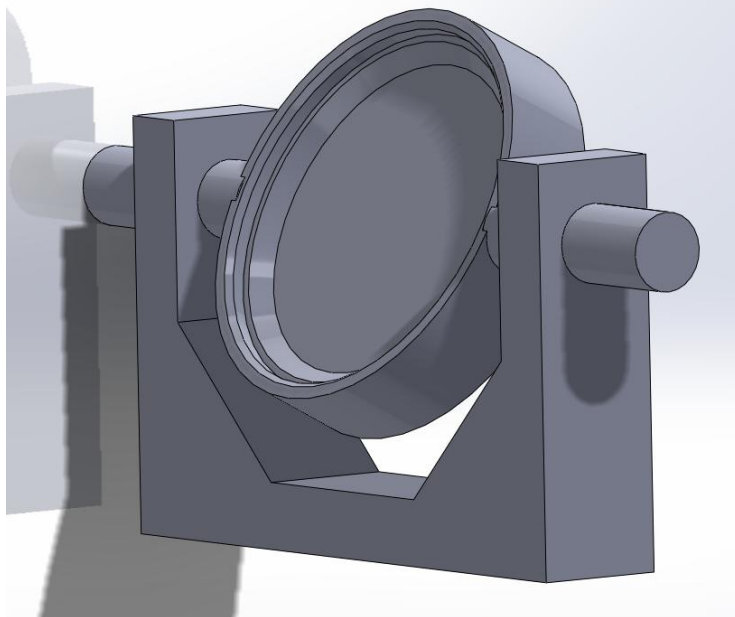
Isometric View of Siderostat

Test Environment

- Equipment:
  - Scale model of the siderostat with identical functionality.
  - Tank of compressed Nitrogen
- Temperature range (-20F to 100F)
  - A foam cooler and dry ice
  - A foam cooler and a heat source
- Interruptible power source
  - Power outlet

Concept Generation

- ## Current System
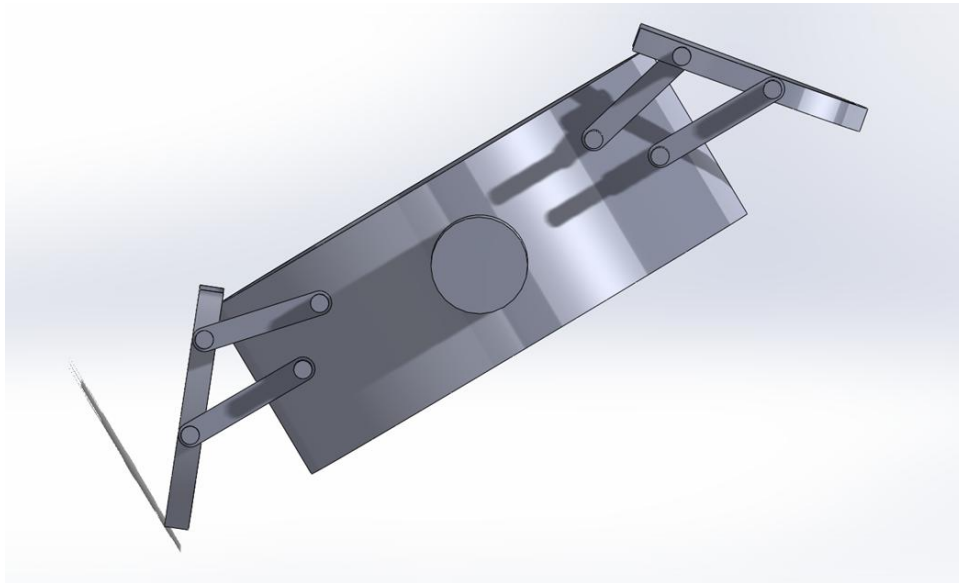 - ### Solid Piece of Lexan
  - ### Rubber Stopper

Rubber Stopper Used to Hold Mirror Cover
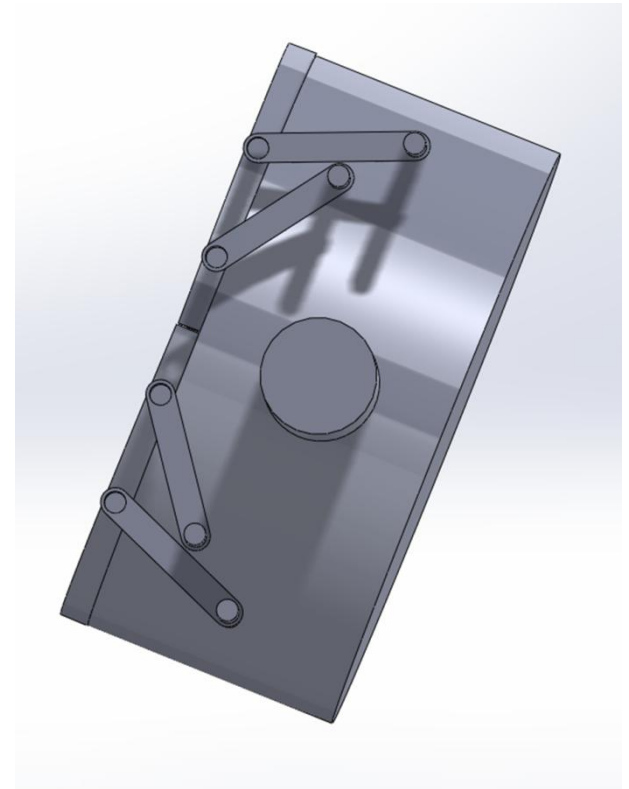

Jim Clark Holding the Current Mirror Cover

Four Link Design

Cover Open

Cover Closed

Four Link Clearance

2" clearance overage

15
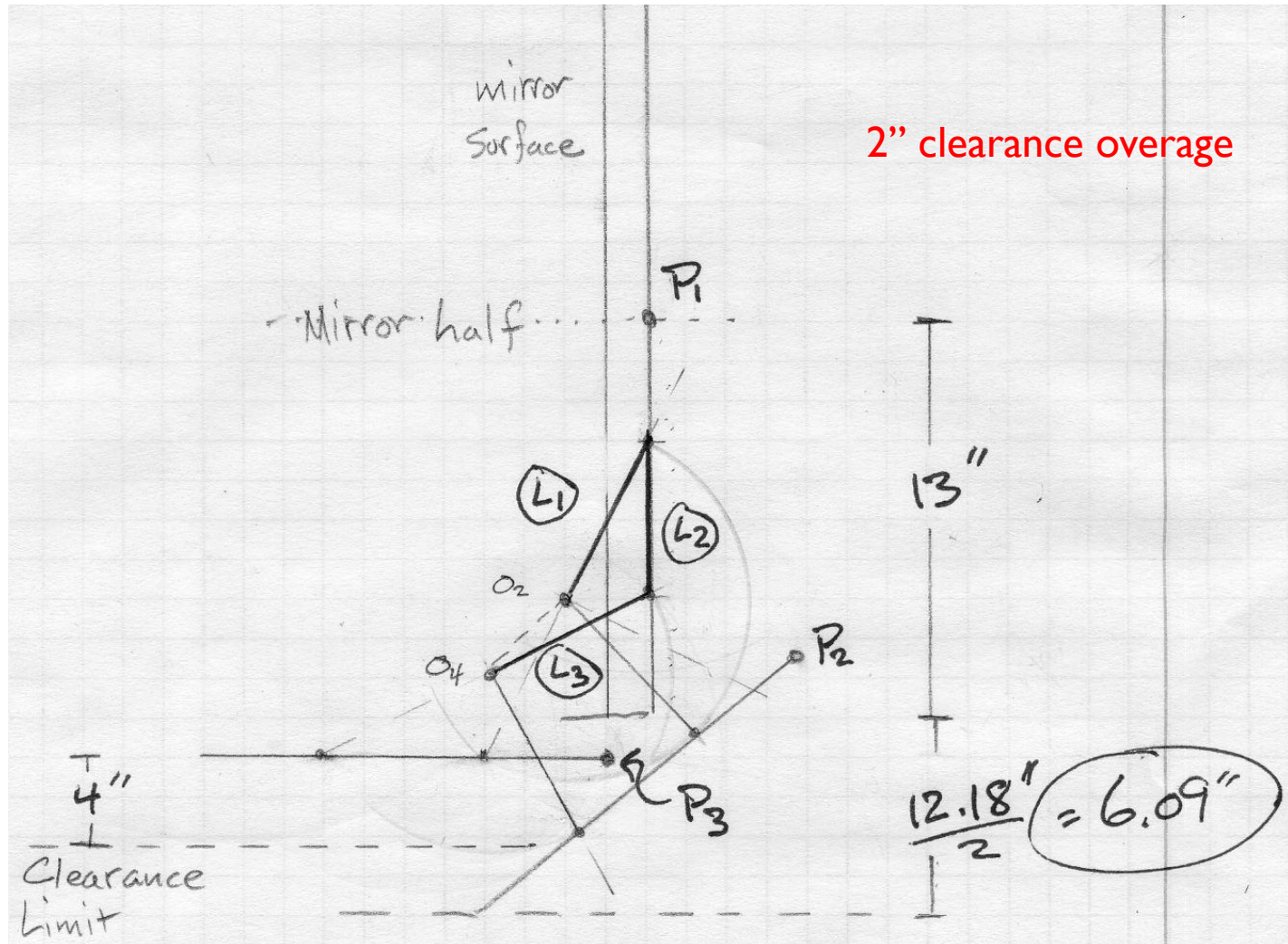
Client Suggestions

- Blinds
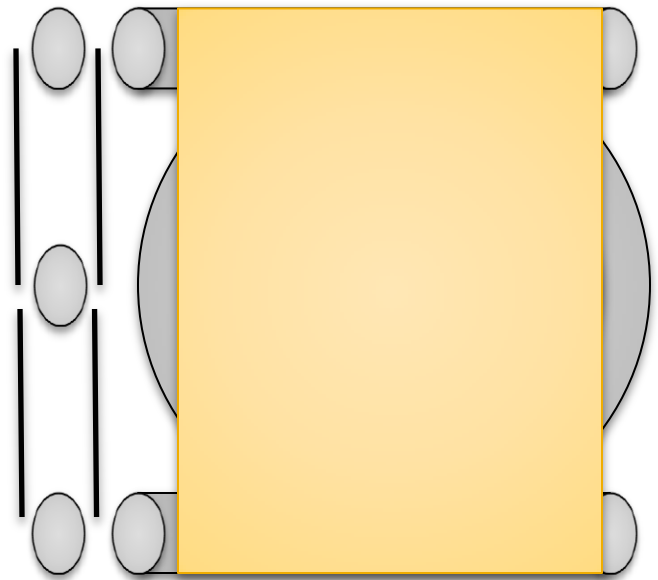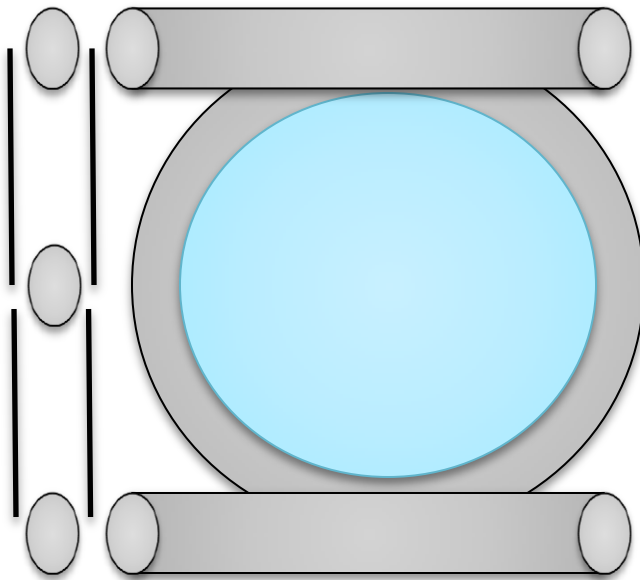
Figure 1 – Blinds open

Figure 2 – Blinds closed

Design Discussion

- Advantages
  - Simple
  - Inexpensive
- Drawbacks
  - Wind
  - Nitrogen Purge and Seal
  - Lifespan
  - Mounting Locations
  - Clearance

Iris Design

Iris Fully Open
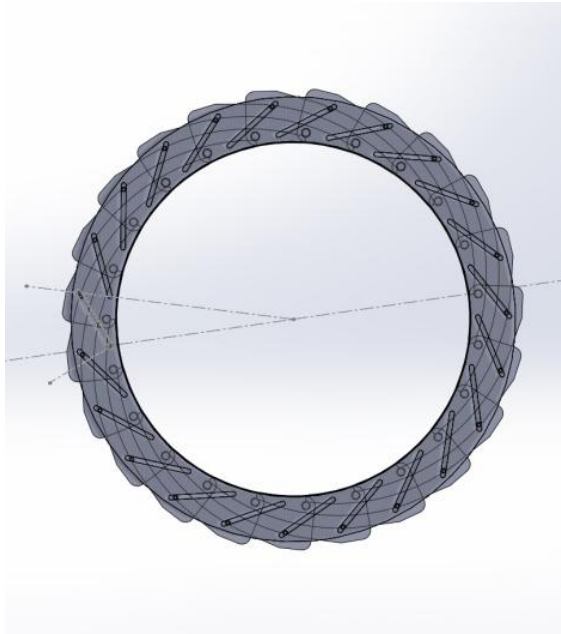
Iris Partially Open
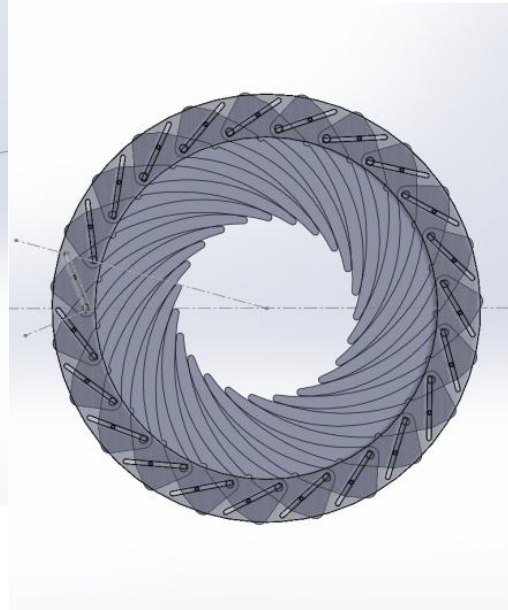
Iris Fully Closed
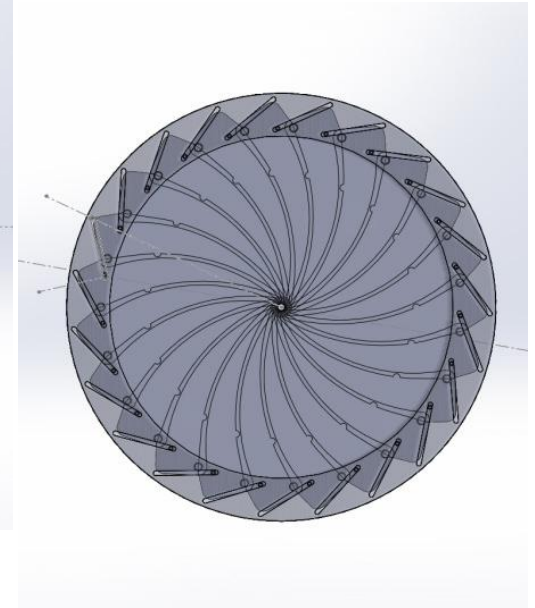
Iris Discussion

- Advantages
  - Elegant design
  - Minimal cross section exposed to wind
  - Well balanced
  - Rigid components
- Drawbacks
  - Complex
  - Redesigned to address clearance issues

Materials Selection

- Top and bottom rings must have similar thermal expansion to the cast aluminum mirror cell

- Plate Aluminum will be machined to the required geometry for the rings

Materials Selection

- Iris blades
    - Low coefficient of friction
    - Low thermal expansion
    - High tensile strength
    - Low density
    - Inexpensive
- Polyoxymethylene "Delrin"

Gannt chart

Task Name	Duration	Start	Finish	Pr
Project Assesment and Identification	8 days?	Thu 9/27/12	Tue 10/9/12	
Design and Testing	24 days	Sat 10/13/12	Thu 11/15/12	
Prototype Analysis	24 days	Tue 10/30/12	Fri 11/30/12	
Solid Works model	3 days	Fri 11/2/12	Tue 11/6/12	14
Materials Selection	3 days	Tue 10/30/12	Thu 11/1/12	
Presentation: Engineering Analysis	0 days	Tue 11/6/12	Tue 11/6/12	
Report: Engineering Analysis	0 days	Fri 11/9/12	Fri 11/9/12	
Redesign of Analyzed components	5 days	Fri 11/2/12	Thu 11/8/12	
Concept Finalization	16 days	Fri 11/9/12	Fri 11/30/12	21
Presentation: Final Design	0 days	Tue 11/27/12	Tue 11/27/12	
Report: Final Design	0 days	Fri 11/30/12	Fri 11/30/12	

Questions?

Quality Function Diagram

		Engineering Requirements							
		Yield Strength	Young's Modulus	Moment of Inertia	Weight	Cost	Thermal Expansion	Dimensions	Power
Client Requirements	Durability	x	x			x			
	Inexpensive	x	x		x	x			
	Protect mirror from the elements	x						x	
	Maintain nitrogen purge							x	x
	Mitigate need for human interaction								x
	Low weight	x	x	x	x	x			
	Does not interfere with star light							x	
	Maintain range of swivel of siderostat			x				x	
	Withstand Temperatures (-20F TO 100F)						x		
	Units	psi	psi	in^4	lb	$	in/in *F	in	Volt

Weighting Factors

Criteria Tree With Weighted Factors

Decision Matrix

Criteria	Design Options			
	Pneumatic Roller	Two Piece Four Link	Inflatable	Worm Gear
Doesn't Block Light	6	9	9	8
Balance	8	8	7	6
Clearance	5	4	9	2
Impact	6	8	9	8
Simplicity	4	8	4	8
Reliability	5	5	6	7
Purge	3	7	3	7
Auto Shut Off	7	7	9	7
Lubrication	3	3	7	2
Installation	2	5	7	8
Life	8	6	2	7
Cold Weather	5	5	3	5
Power Loss	6	6	9	4
Cost	5	8	5	8
Total	73	89	89	87
Weighted Total	4.885	6.739	5.491	6.386

Top Four Concepts Shown in Weighted Matrix