Two-Step Hub Deployment Mechanism

Team 5:

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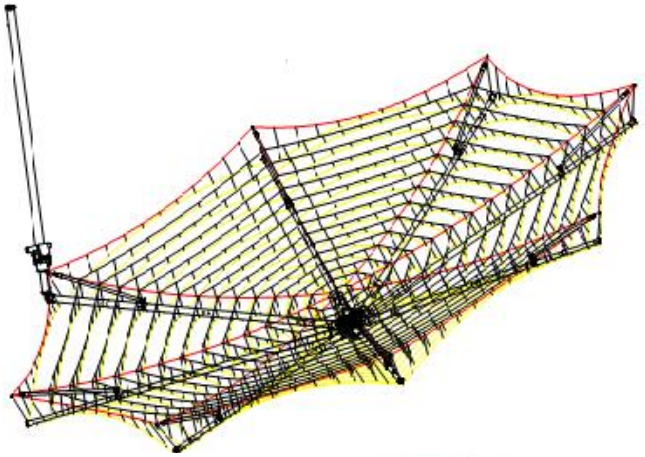
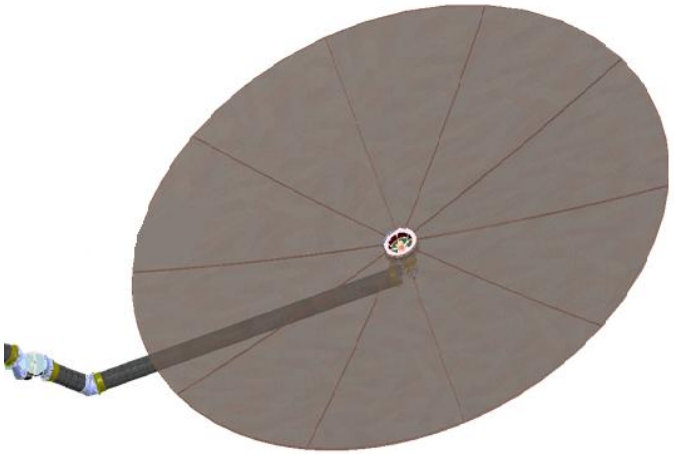
Overview

- Introduction
  - Needs Statement
  - Project Goals
- Concepts Overview
  - Concept Selection
- Final Design Breakdown
- Functional Diagram
- Engineering Economics
- Results and Discussion
- Conclusion

Introduction

- Two types of reflectors commonly used
  - –Mesh
  - –Solid
- Ease of transportation
  - –Size
  - –Weight





Pictures From Harris Corporation

Needs Statement

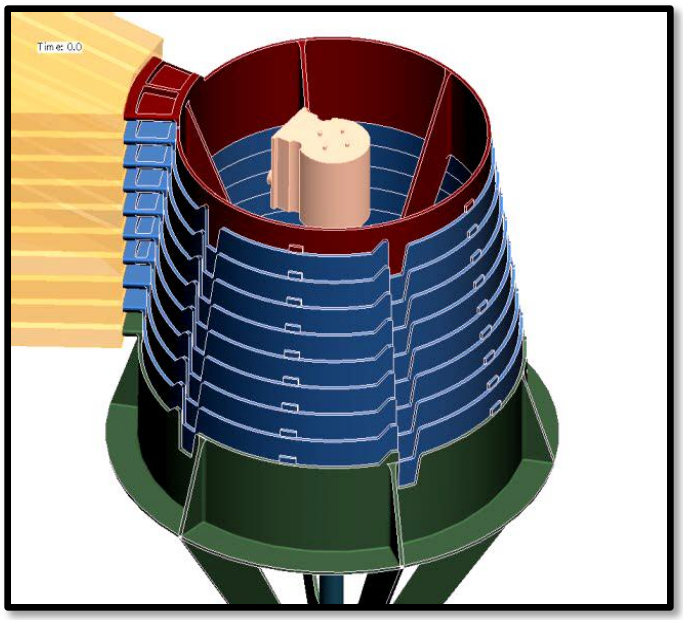
As technology becomes more complex, there is an increasing demand for solid reflectors that maintain high efficiency levels yet have the ability to be compacted and stowed in a small area.

Project Goals

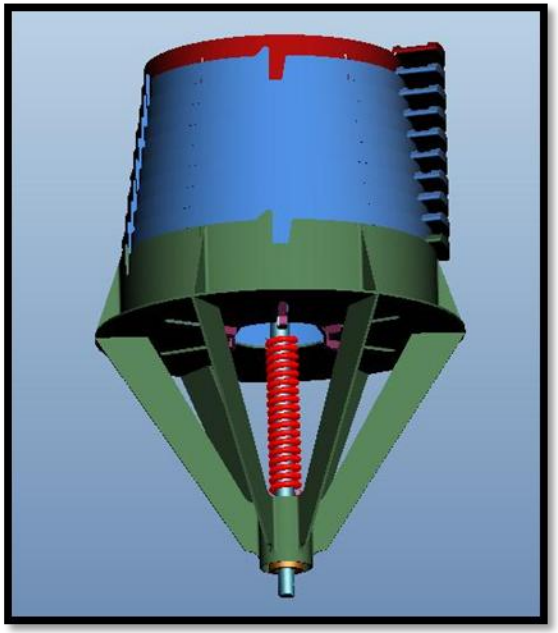
- ✓ Design a hub mechanism to deploy six segmented solid reflector panels in a two-step motion
- ✓ Create a 3D CAD model to show dynamic simulation
- ✓ Work together with the Harris Panel Interlocking Team to create panel-to-hub interface
- ✓ Build a functioning scaled prototype

Concepts

Multiple Motors

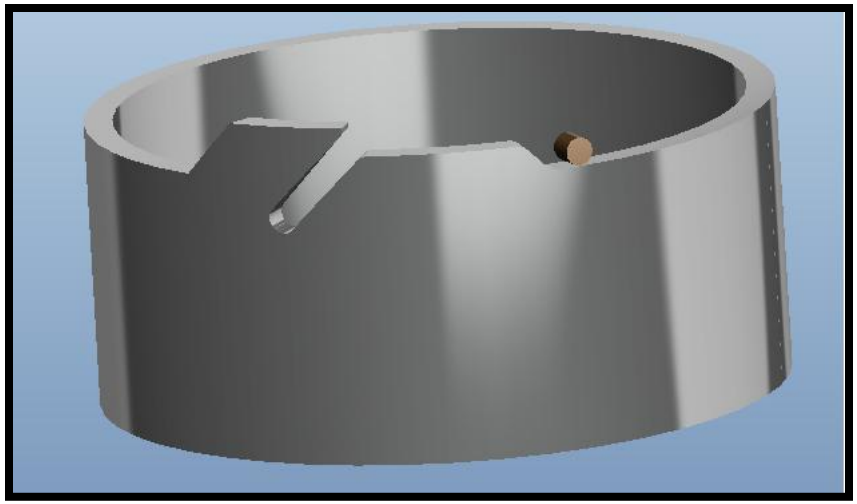


Spring Implementation

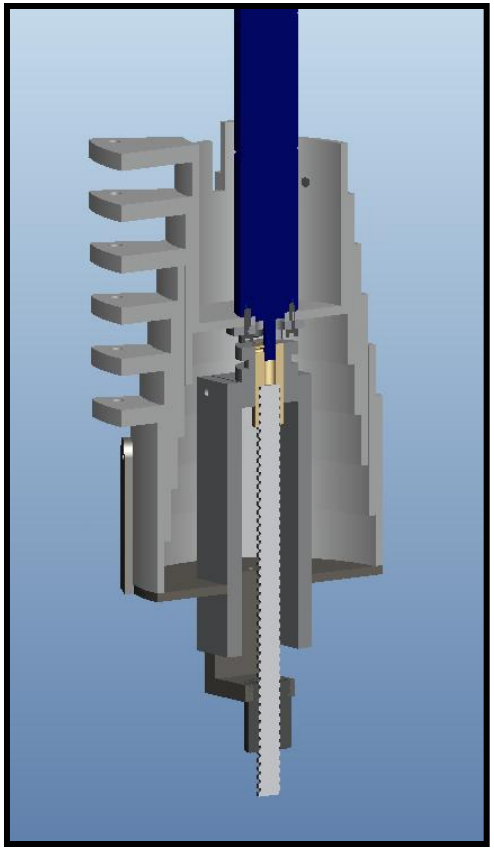


Concepts

Guide Slots



Synchronizer and Ball Screw

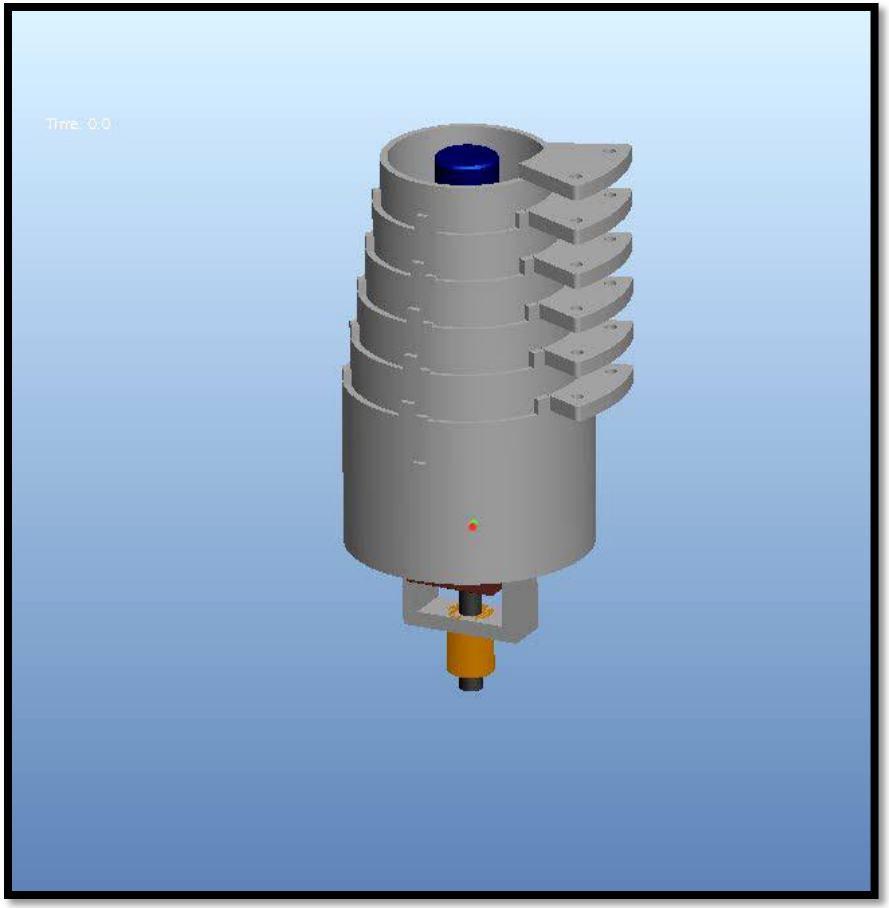


Concept Selection Matrix

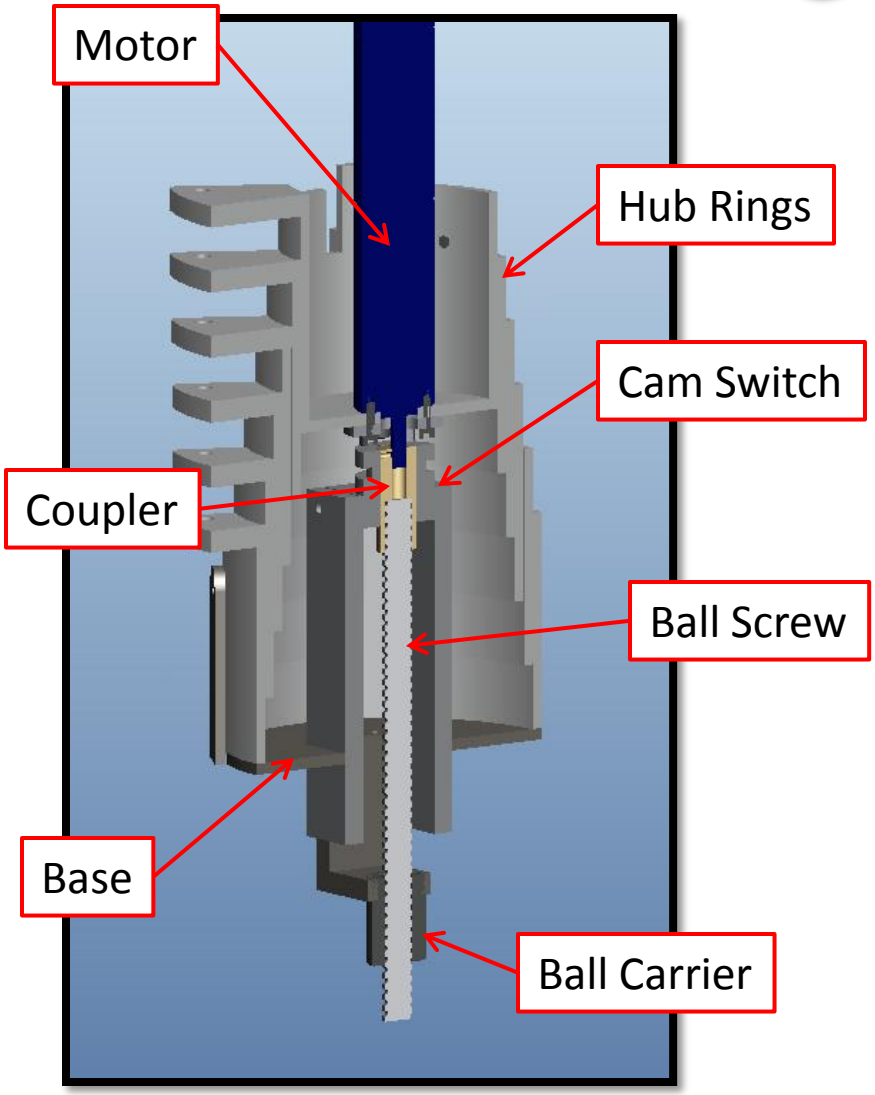
Decision Matrix		Concepts							
		Synchronized Two Step Deployment		Spring Implementation		Guide Slots		Multiple Motors	
Specification	**Weight**	*Rating*	*Weighted Score*	*Rating*	*Weighted Score*	*Rating*	*Weighted Score*	*Rating*	*Weighted Score*
Reliability	0.40	4.00	1.60	3.00	1.20	4.00	1.60	3.75	1.50
Durability	0.05	4.00	0.20	2.00	0.10	4.00	0.20	4.50	0.23
Weight	0.10	3.00	0.30	3.50	0.35	4.00	0.40	2.00	0.20
Efficiency	0.20	5.00	1.00	4.00	0.80	3.00	0.60	2.00	0.40
Ease of Construction	0.15	2.00	0.30	3.00	0.45	2.50	0.38	3.50	0.53
Cost	0.10	3.00	0.30	3.50	0.35	4.00	0.40	2.50	0.25
Total	1.00	**3.70**		**3.25**		**3.58**		**3.10**	

Final Design

Two-Step Hub Mechanism



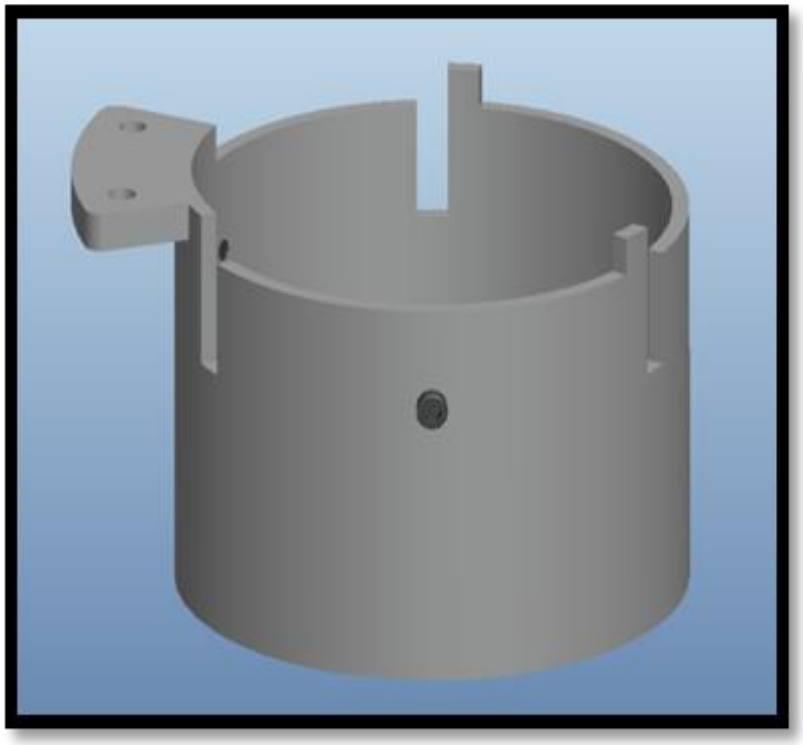
Final Design Description



- Single motor accomplishes rotary and linear motion with ball screw
- Two major subsystems
  - Hub Rings
  - Drive Mechanism

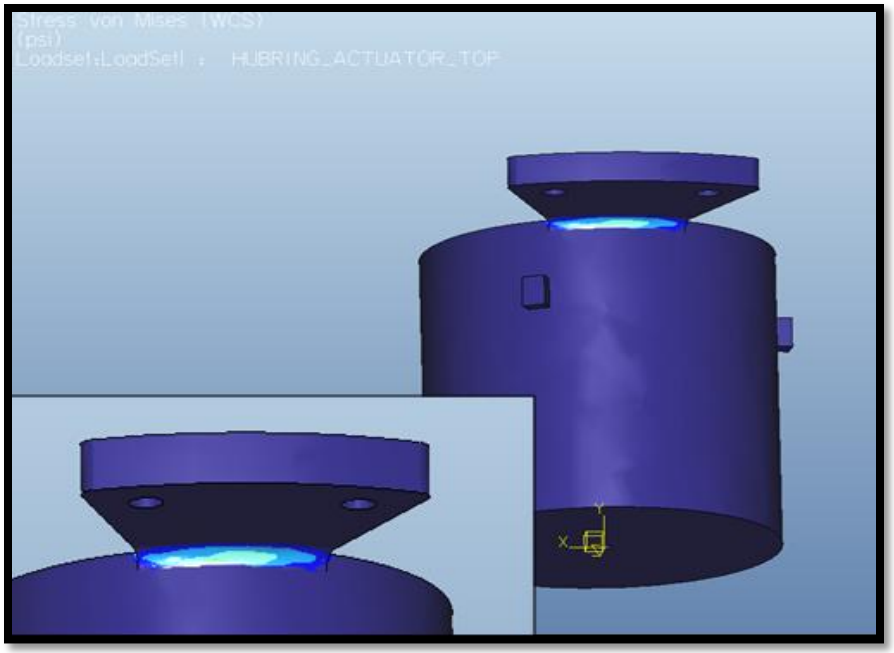
Hub Rings

- 6 concentric rings
- Each supports a single panel
- Pins and slots guide motion



Hub Ring Design

- Finite Element Analysis was used to determine appropriate material
- Von Mises stress: 20,000psi
- AL 6061 was chosen for its strength and low weight and machinability

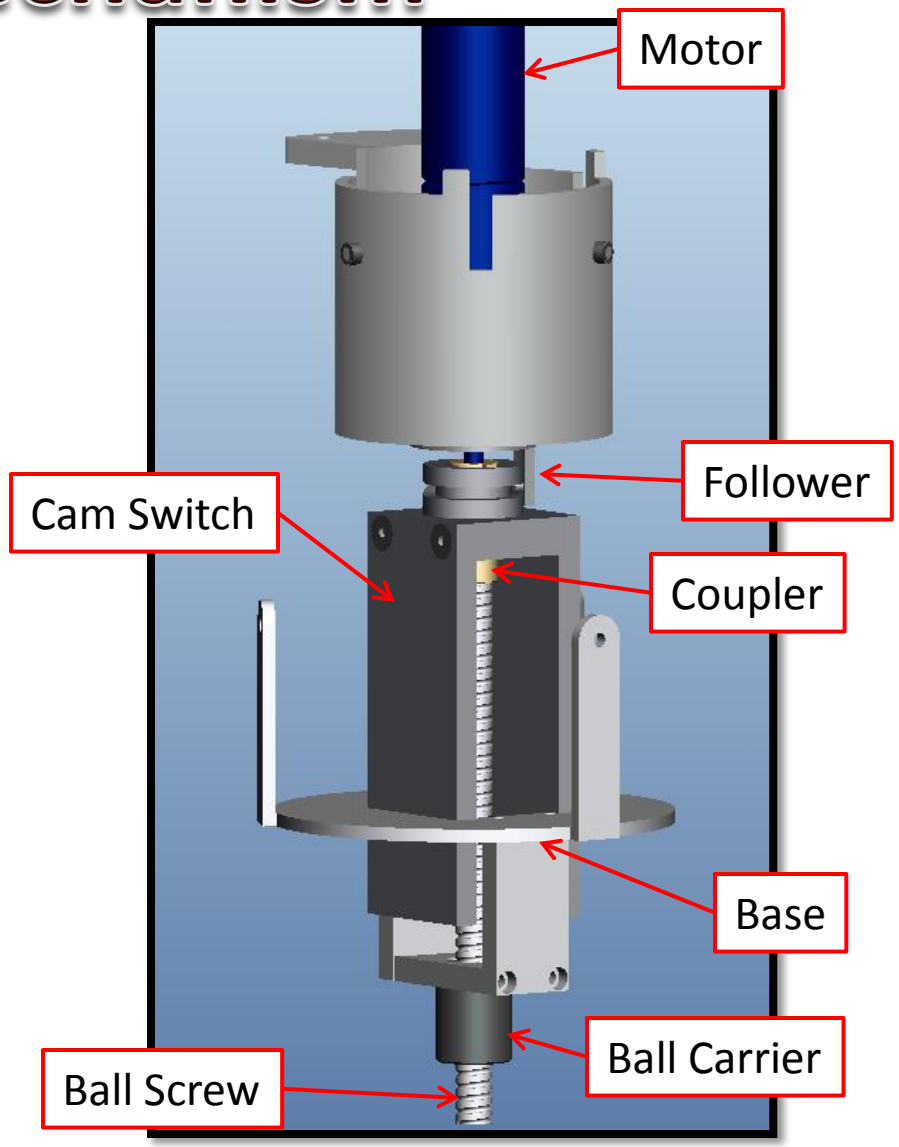


Hub Ring Design cont.

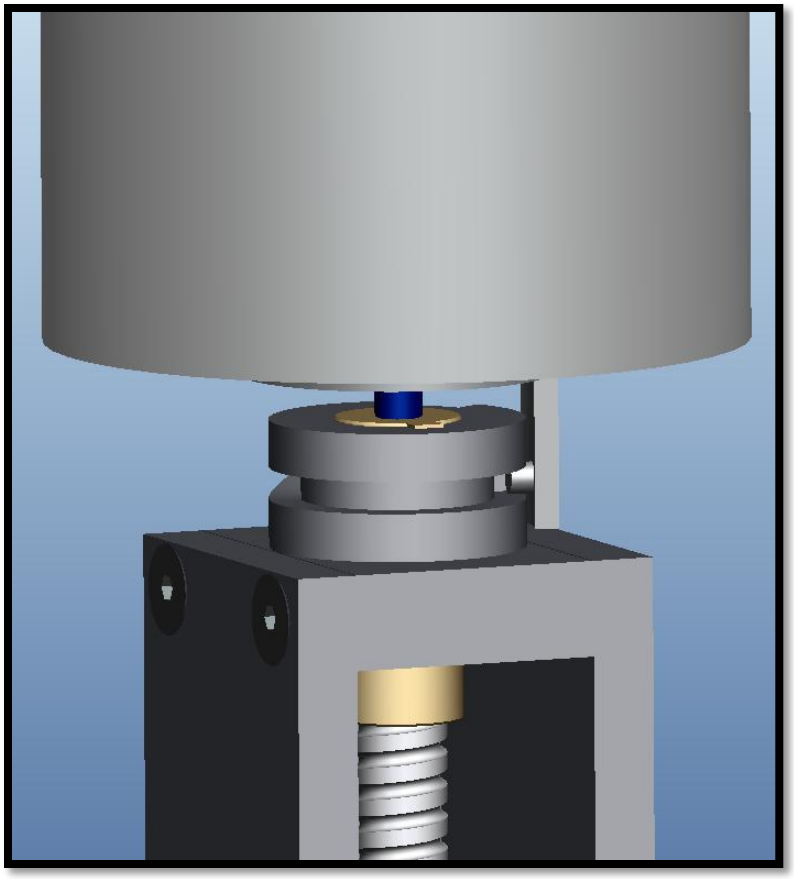
- AL6061 meets strength requirement
- Friction and galling is a concern
- Solution was Hardcoat Anodizing with Teflon impregnation
- Exceptional surface hardness, wear resistance and lubricity

Drive Mechanism

- Actuates the Hub
- Consists of the interior components
  - Motor
  - Coupler
  - Cam Switch
  - Switch Follower
  - Ball Screw
  - Ball Carrier

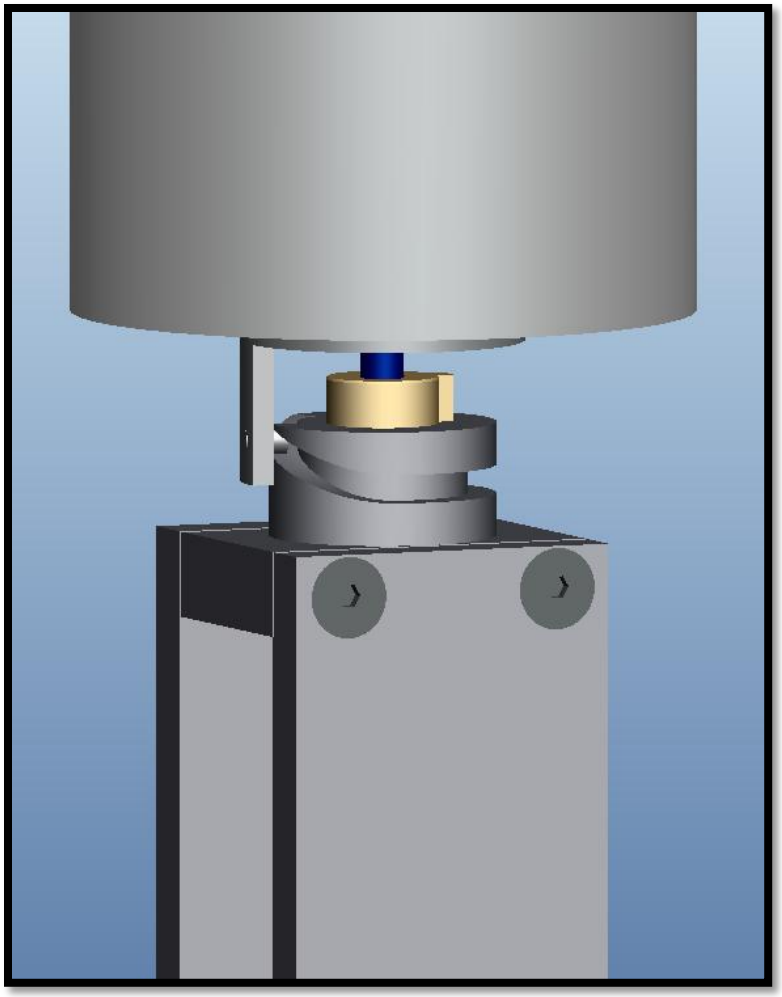


Mechanism Walkthrough



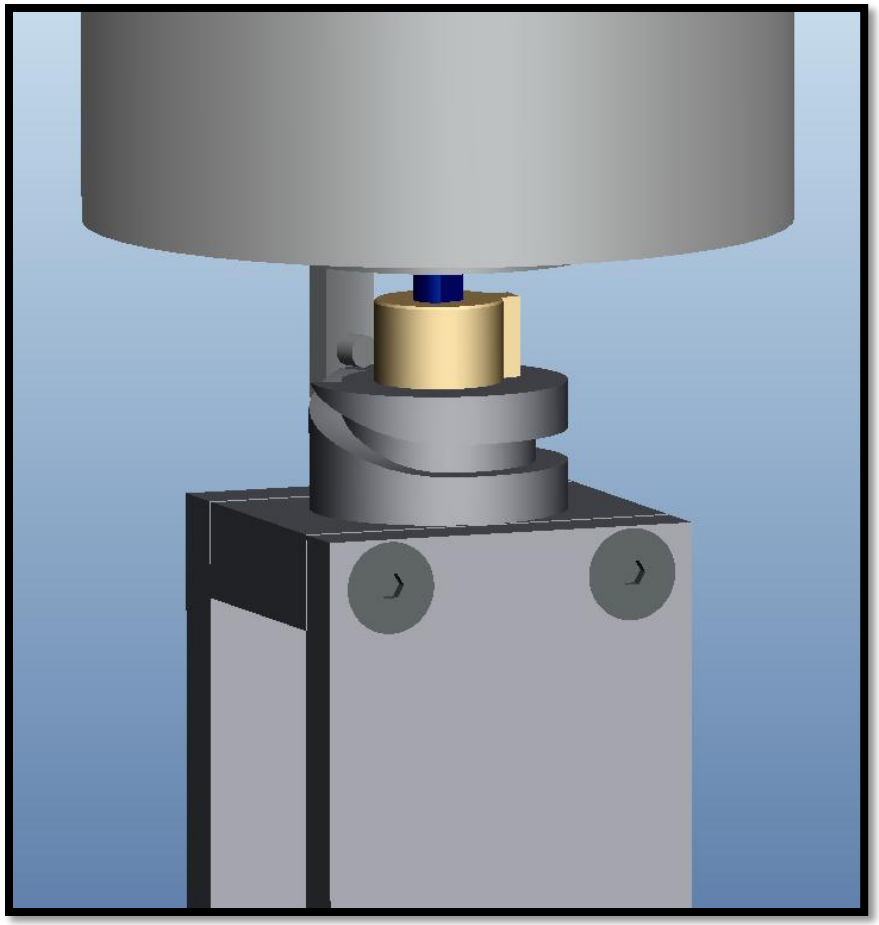
- Coupler key engaged with Cam Switch
- Switch Follower in initial position
- Cam Switch locks motor shaft, coupler & ball screw
- Motor only rotates Hub Rings

Mechanism Walkthrough cont.



- Coupler key still engaged with Cam Switch
- Switch Follower begins to push Cam Switch down
- Motor shaft, coupler & ball screw still locked
- Hub Ring rotation nearing completion

Mechanism Walkthrough cont.

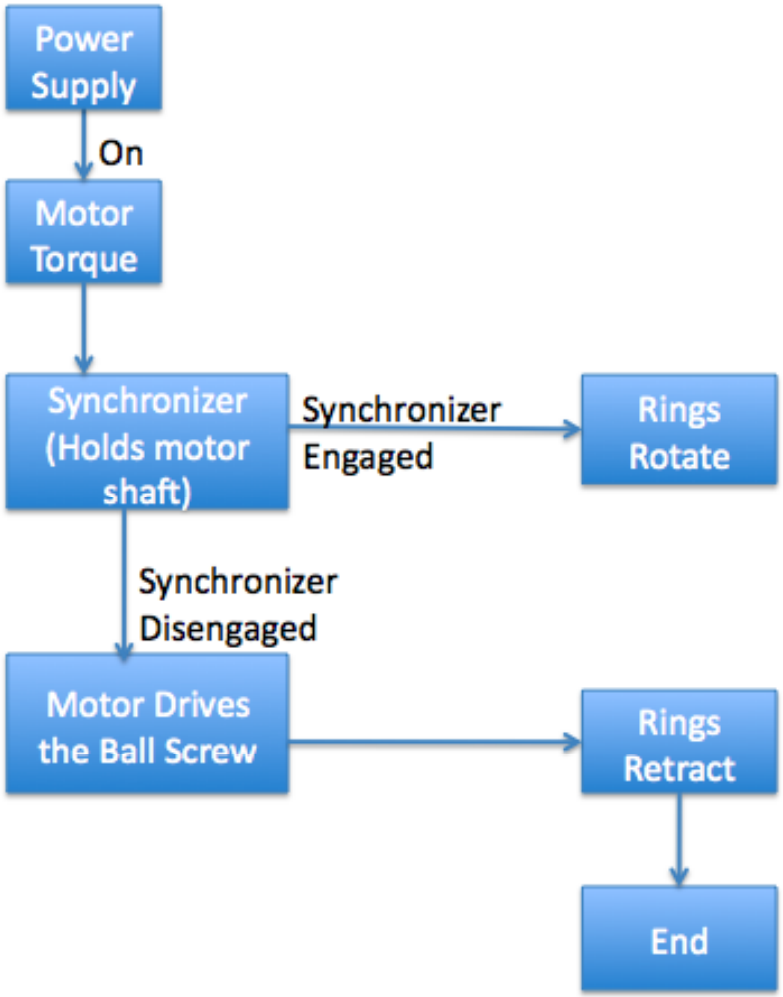


- Coupler key disengages Cam Switch
- Switch Follower pushes Cam Switch completely down
- Motor shaft, coupler & ball screw free to rotate
- Hub Ring rotation complete
- Motor turns Ball Screw

Final Design

Prototype Test Run

Functional Diagram



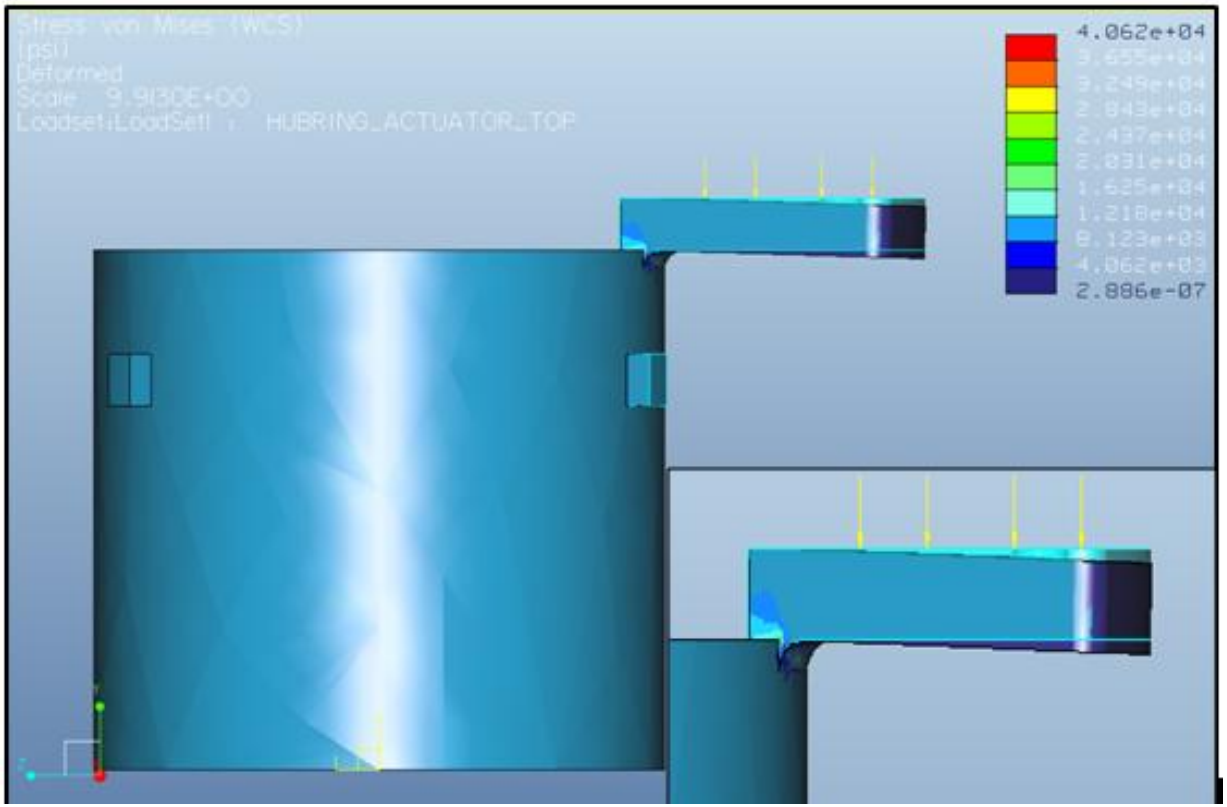
Engineering Economics

	Quantity	Cost/Unit	Total Cost	Place of Purchase
Aluminum 6061 (Hub Rings)	1 - [1 ft tube (4.5" diameter)] 1 - [1 ft tube (4.0" diameter)] 1 - [1 ft tube (3.5" diameter)] 1 - [1 ft tube (3.0" diameter)]	81.38 71.86 48.95 36.09	238.28	McMaster
Aluminum 6061 (Connecting Tabs)	1 - [1/4" thick, 2" wide recatangular bar (3 ft)]	17.23	17.23	McMaster
Hard anodizing with teflon coating	All aluminum	374.50	374.50	A.M. Metal Finishing
Motor	1 - MicroMo 2657 DC motor	742.90	742.90	MicroMo
Feedback Controller	1 - Feedback Controller	491.00	491.00	MicroMo
Screws	1 - [6-40 Black Oxide Alloy Steel 3/16", 100 pack]	11.22	11.22	McMaster
Ball Screw	1 - [3/8" diameter, 1/8" travel dist./turn, 1 ft. long]	30.68	30.68	McMaster
Ball Screw nut	1 - [3/8" diameter, 1/8" travel dist./turn, 136 lb load cap.]	93.89	93.89	McMaster
Aluminum 6061 (Synchronizer)	1 - [2" thick, 1 ft. long rectangular bar]	32.95	32.95	McMaster
Aluminum 6061 (Baseplate)	1 - [1/8" thick, 6"wide, 3 ft. long]	26.78	26.78	McMaster
Steel Hand Taps	3 - [General purpose high-speed hand taps, 6-40 thread]	4.74	14.22	McMaster
Machining Cost (man hours)	3 hours/ring with 6 rings 4 hours - synchronizer 12 hours - assembly	34 hours	34 hours	FSU machine shop
Total ($)			**2073.65**	

Results and Discussion

Finite Element Analysis

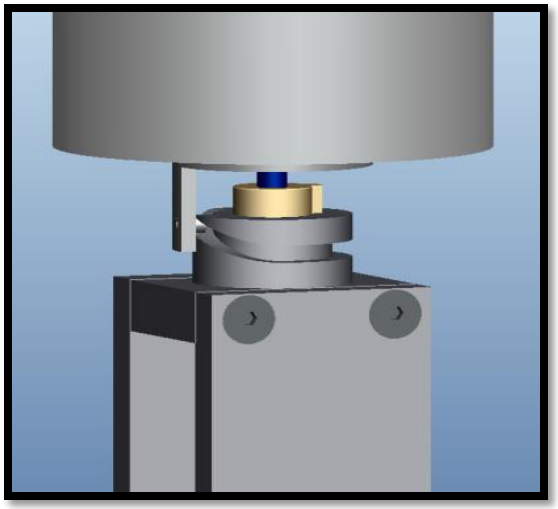
- Shows that for our loading there would be some deflection.
- Similar when panels were actually attached

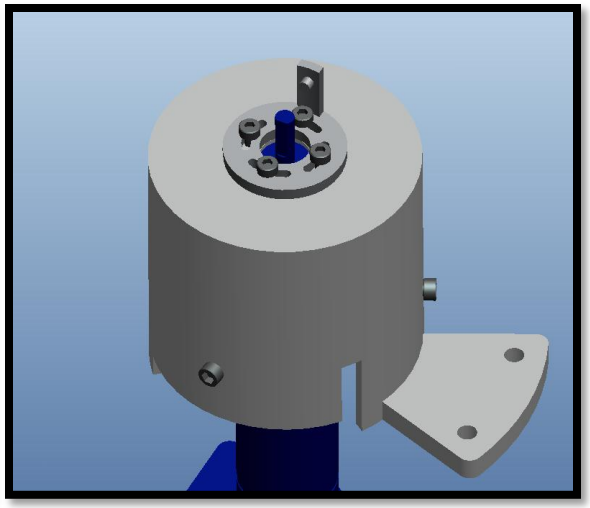


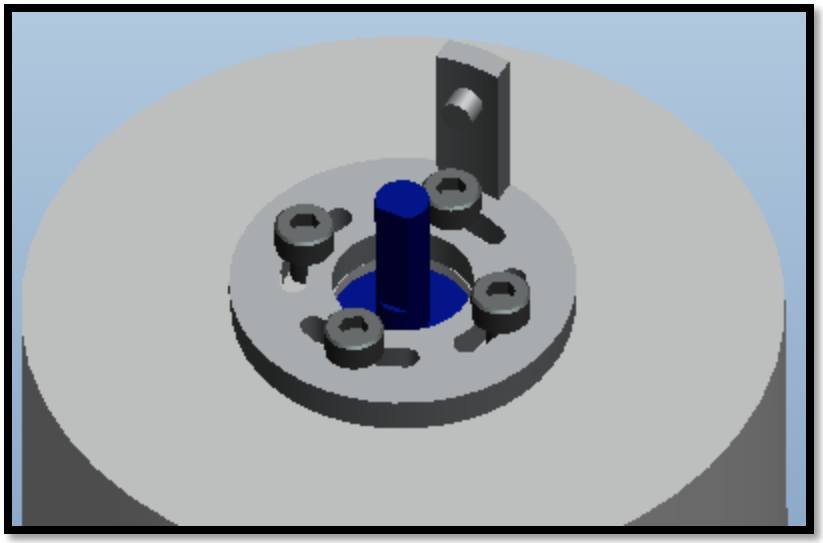
Results and Discussion

Testing the Synchronizer

- Testing for the point of release of the synchronizer
- Alignment of pin and keyway
- Trial and error







Results and Discussion

Customer Needs

- Ease of transport
- Autonomous Deployment
- Rotate and retract panels into position while keeping alignment

Our Design

- Panels are stowed
- Low speed, High torque Motor with 21 in. lbs of torque
- Synchronizer switch and ball screw

Conclusion

- Key Points/Main Achievements
  - Created 3D model to show dynamic and kinematic simulation
  - Produced hub mechanism prototype
  - Worked together with Interlocking Panel Team to create Panel-to-Hub interface
- Improvements to make the prototype better
  - Slots for the guide pins of the hub rings
  - Make hub rings out of a solid piece
- We have proven the viability of one day sending segmented solid reflectors into space.

Special Thanks To:

- Mr. Gustavo Toledo
  - Harris Corporation
- Dr. Chiang Shih
  - Faculty Advisor

Questions?