Two-Step Hub Deployment Mechanism

Team 5:

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Overview of Presentation

- Problem Statement
- Needs Assessment
- Concept Requirements
- Overview of Concepts
- Decision Matrix
- Analysis of Selected Concept
- Final Design Selection
- Cost analysis

Problem Statement

- Design a hub mechanism to deploy a segmented solid reflector in a two-step motion
- Create a CAD model to show the dynamic simulation
- Build a functioning scale prototype

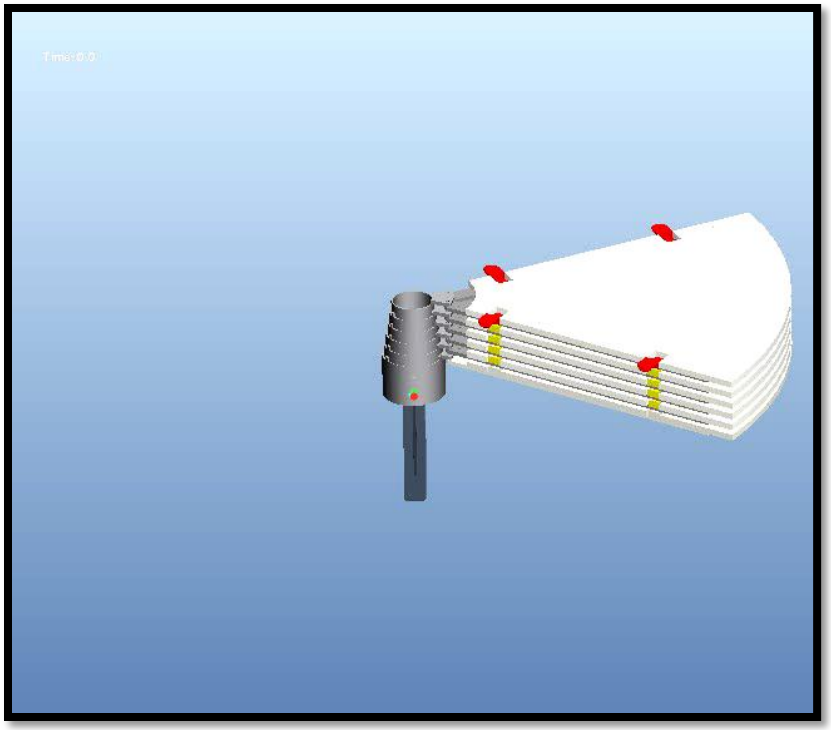
Needs Assessment

- Two types of reflectors commonly used
  - Mesh
  - Solid
- Ease of transportation
  - Size
  - Weight
- Need for portability of mesh reflector with performance of solid reflector

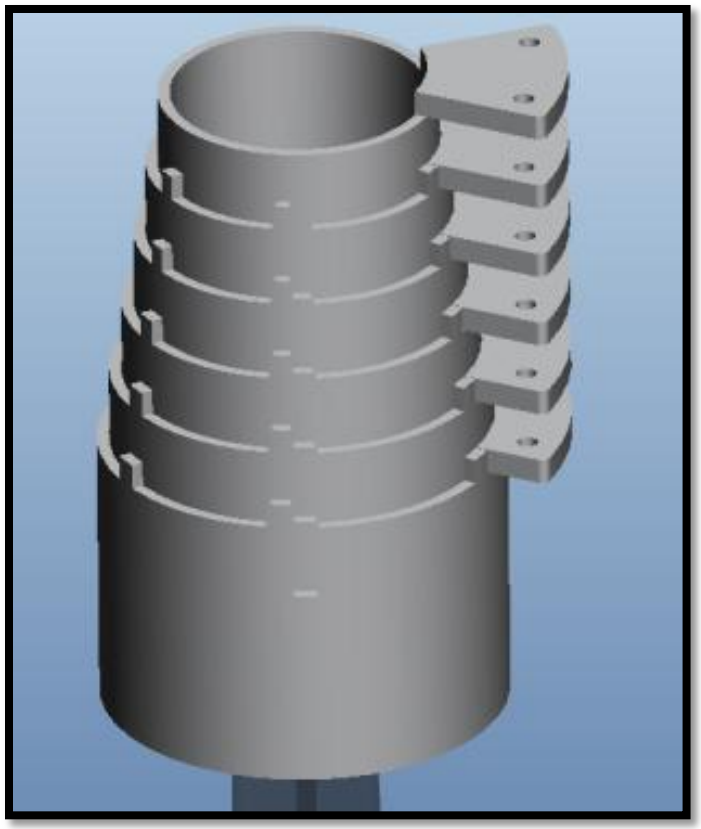
Concept Requirements

- Must rotate panels into position and retract them into the same surface plane while maintaining desired spacing between panels during deployment

- Two ways to retract panels into position
  - Two separate motions
  - Step down motion

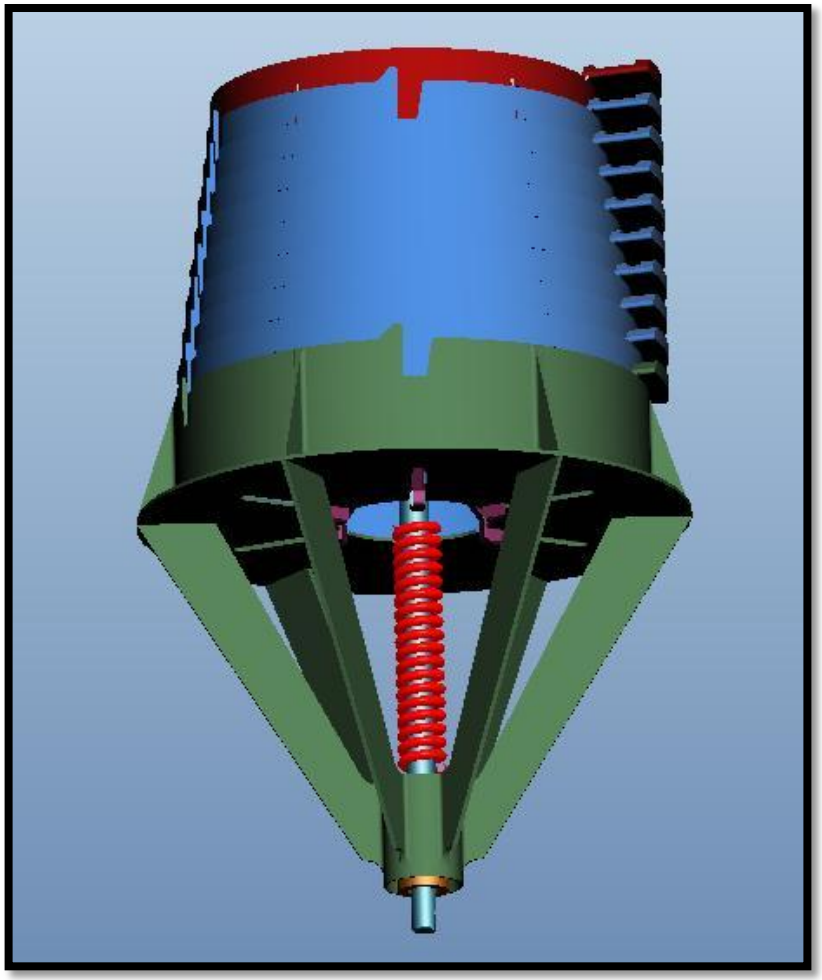


Synchronized Two Step Deployment



- Pros
  - Simplest Construction
  - Ensures precise panel alignment
- Cons
  - Requires a Dual-axis Motor
  - More complex to control driver

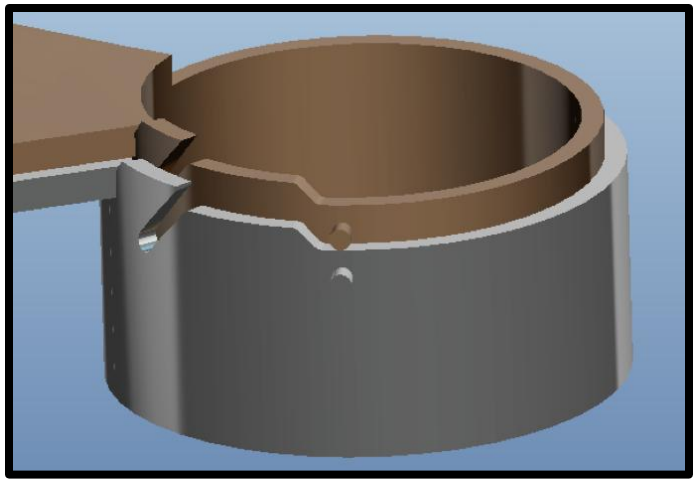
Spring Implementation

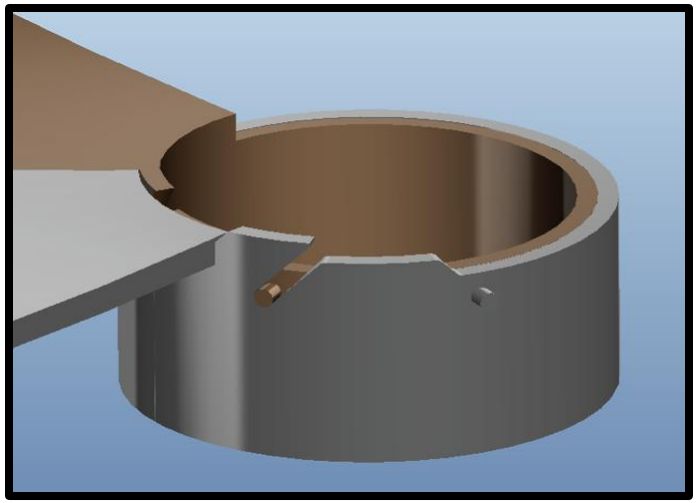


Picture from Harris Corporation
Edited by Noah Nichols

- Pros
  - Single Motor
  - No synchronizer
- Cons
  - Springs could fracture/fail
  - Springs lose tension near end of motion
  - Complex construction

Guide Ramp Slot





- Pros
  - Single Motor
  - Reliable design
- Cons
  - Difficulty of construction
  - High friction
  - Panels retract at an angle

Selection Criteria

- Reliability
  - Most important criteria
- Durability
  - Only needs to deploy once
- Weight
  - Expensive to transport into space
- Efficiency
  - Reduces strain on motor and friction on rings
- Ease of Construction
  - Must be built within the imposed timeline and resources
- Cost
  - Must stay within budget

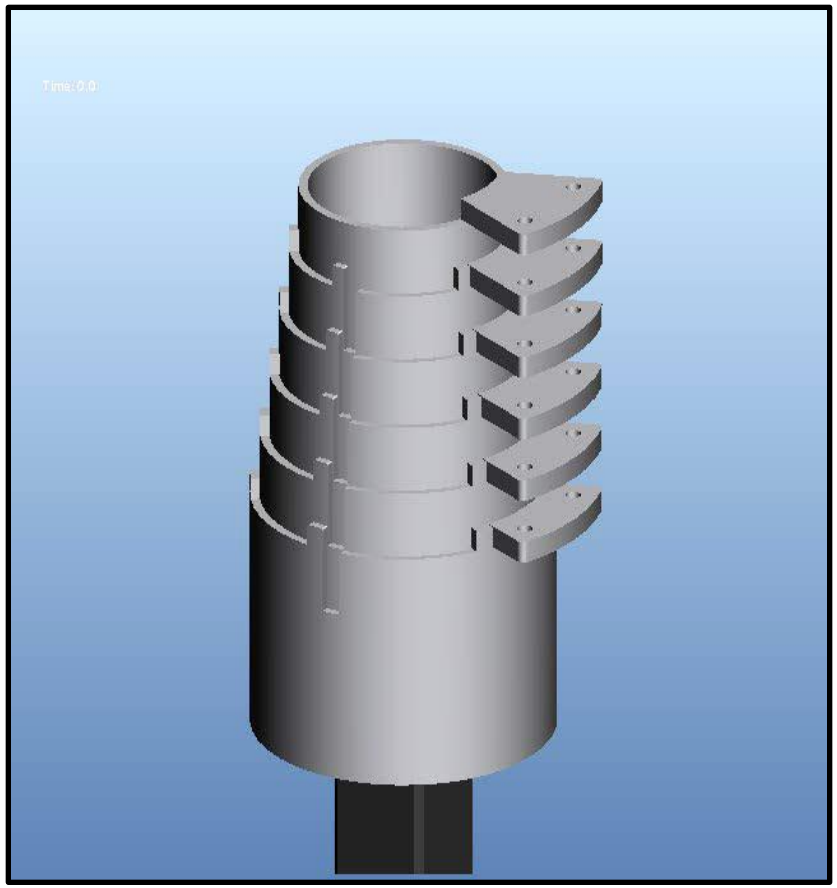
Decision Matrix

Decision Matrix		Concepts					
		Synchronized Two Step Deployment		Spring Implementation		Guide Slots	
Specification	**Weight**	*Rating*	*Weighted Score*	*Rating*	*Weighted Score*	*Rating*	*Weighted Score*
Reliability	0.4	4	1.6	3	1.2	4	1.6
Durability	0.05	4	0.2	2	0.1	4	0.2
Weight	0.1	3	0.3	3.5	0.35	4	0.4
Efficiency	0.2	5	1	4	0.8	3	0.6
Ease of Construction	0.15	2	0.3	3	0.45	2.5	0.375
Cost	0.1	3	0.3	3.5	0.35	4	0.4
Total	1	3.7		3.25		3.575	

Ratings: 1 (worst) to 5 (best)

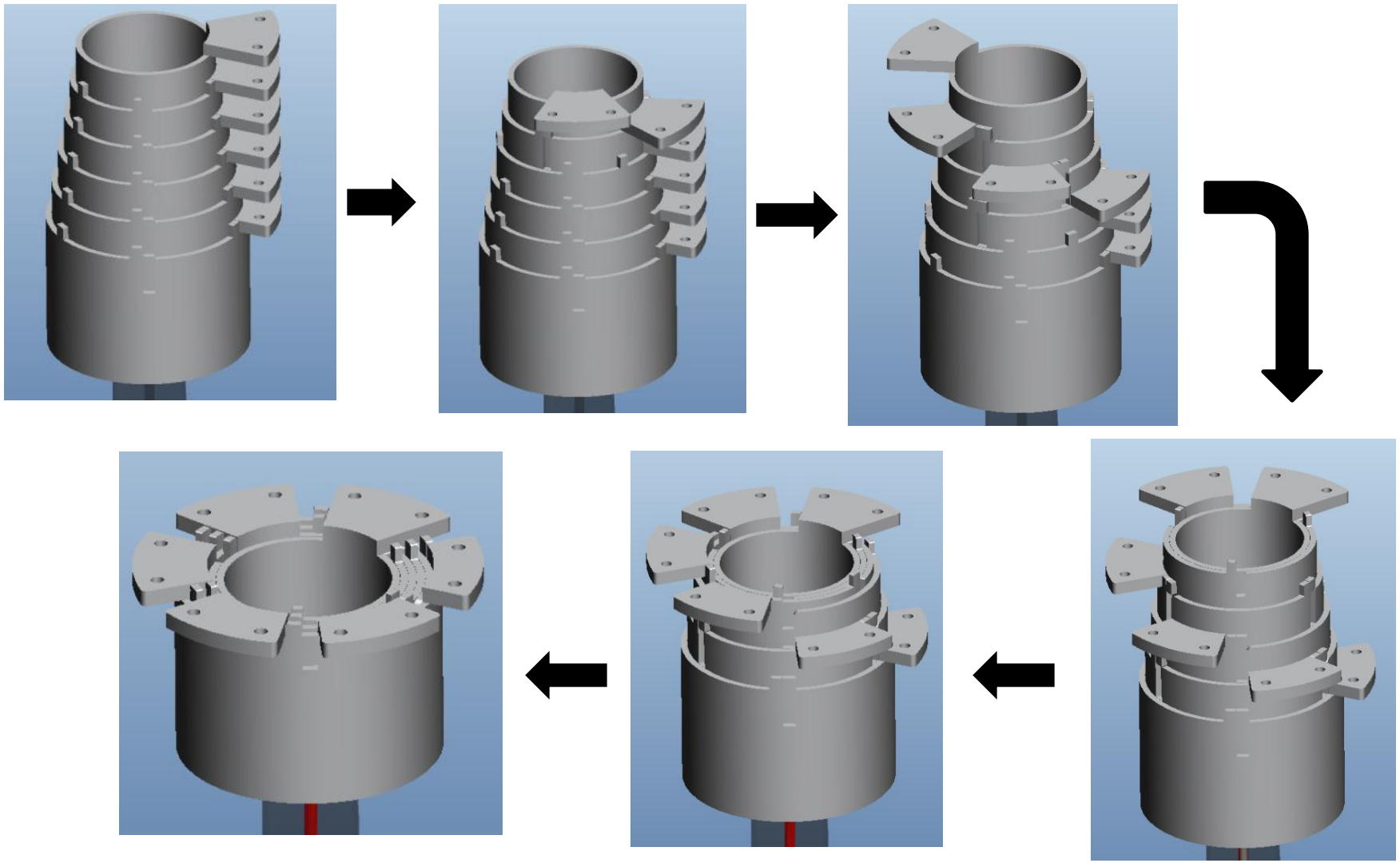
Final Design Selection : Synchronized Two Step Deployment

Synchronized Two Step Deployment



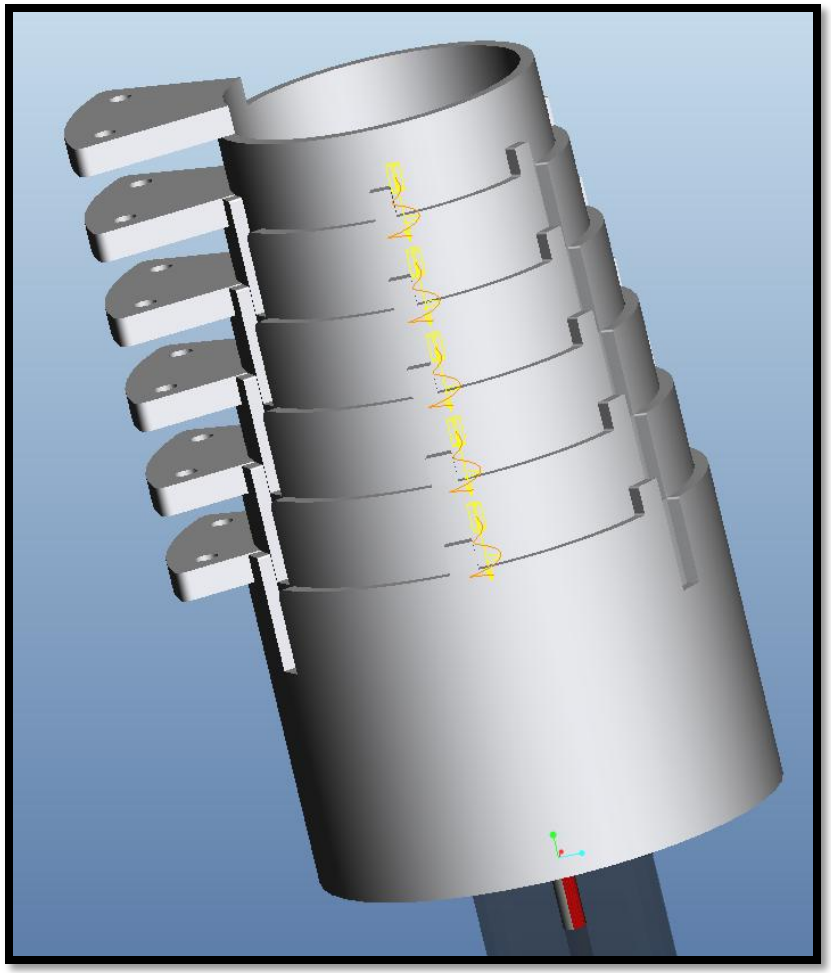
- Kinematic Analysis to determine forces
  - Panel weight
  - Actuator
- Material Selection
- Finite element analysis to determine stresses
  - Mechanica in ProE

Selected Design : Flow of Motion



Kinematic Analysis

- Simulation of desired motion
  - Validates functionality
  - Ensures precise panel alignment
- Ring sizing
- Panel weight
  - Maximum panel weight assumed to be 5 lbs

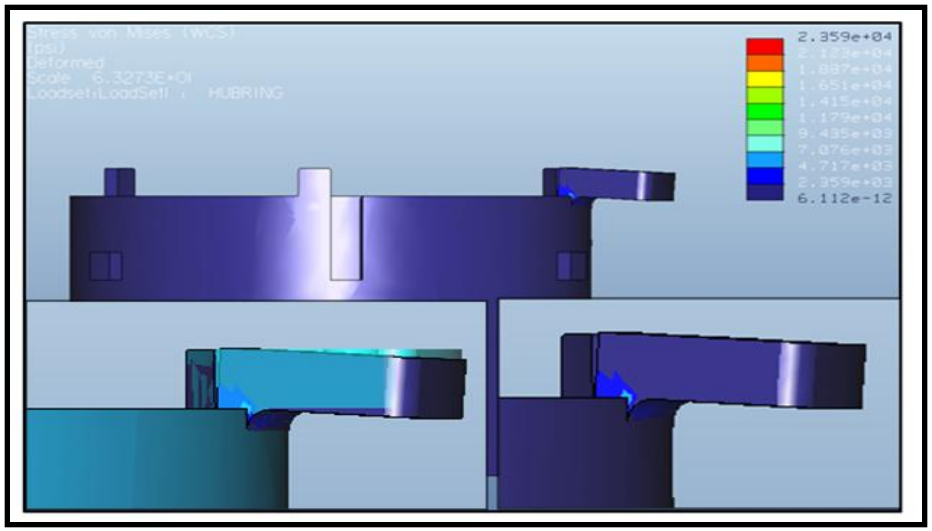


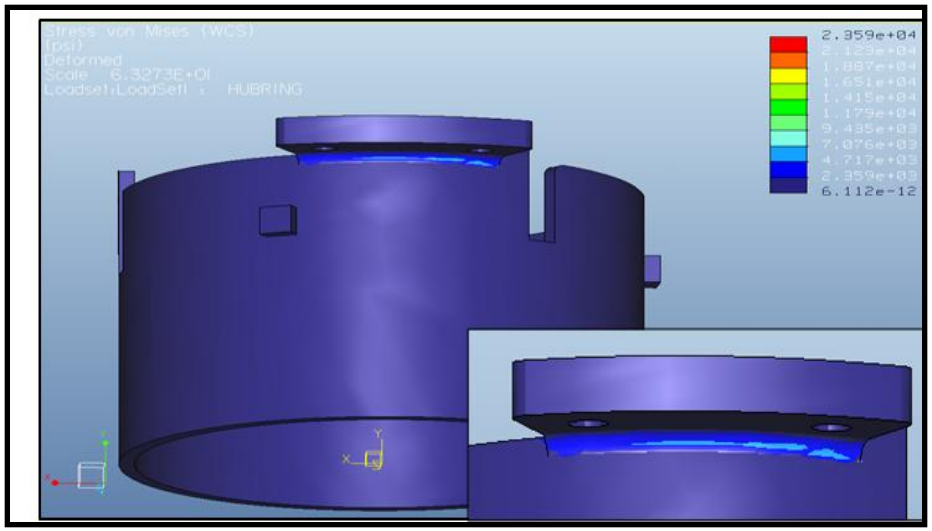
Finite Element Analysis

Mechanica in ProEngineer

- Stress/Strain analysis
  - Determine if panel weight introduces unwanted stresses in ring
  - All resultant stresses remain in the elastic region and are below yield strength of Al2024
- Assumptions
  - Material is Al 2024
  - Uniform Distributed Load Applied to connection tab
  - Distributed load was calculated assuming the panels are 5 lbs each
  - Simulates a binding or maximum loading situation

FEA using Mechanica





Bottom left most image shows the deformation of the connection tab. Bottom right most image shows the stress concentration point.

Bottom left most shows the stress concentration point beneath the connection tab.

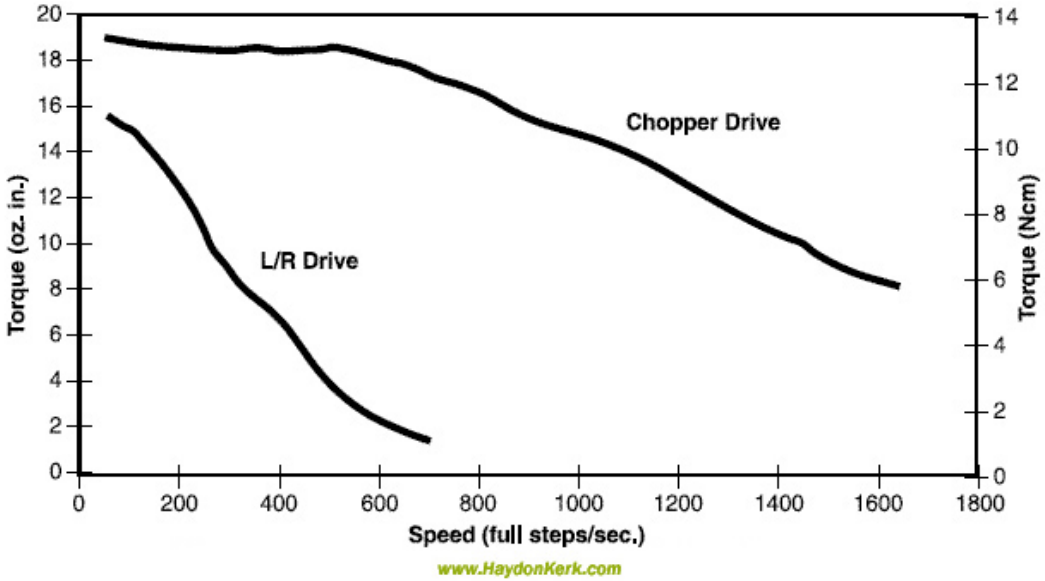
Deformation is within the elastic region and Stress below yield stress of Al 2024.

Material Selection

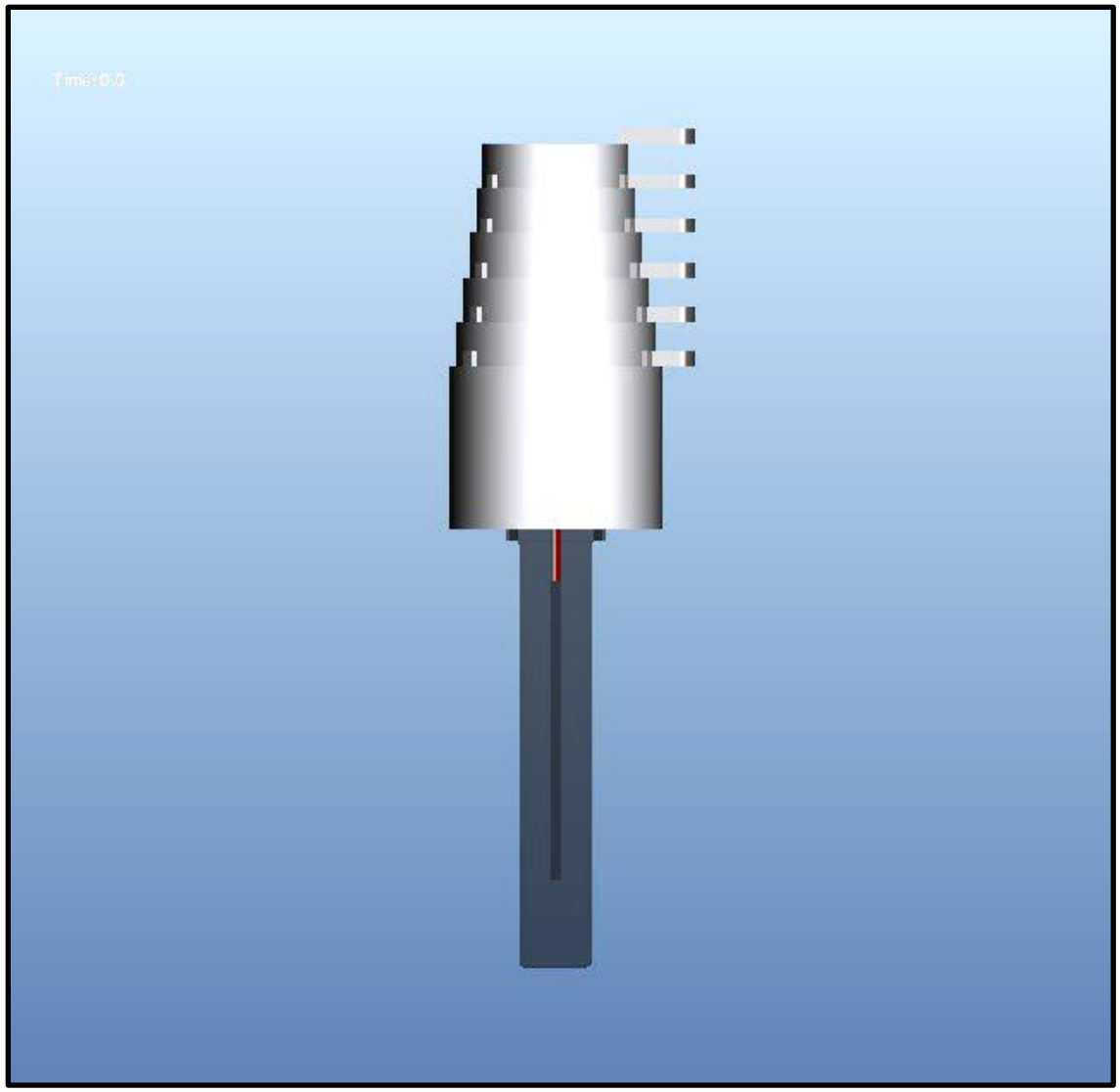
- Aluminum 2024 was selected
  - Pros
    - Lightweight
    - Machinability
    - Readily available
    - Cost efficient
  - Cons
    - Surface hardness is not optimal
      - Anodize to increase surface hardness similar to that of Steel
      - Stainless steel 304 : 170 Brinell Scale
      - Aluminum 2024 T3: 120 Brinell Scale
      - Anodized Aluminum 2024 T3 : up to 360 Brinell Scale
    - Low Lubricity
      - Teflon added to reduce friction and prevent corrosion
        - » Parts will be anodized per MIL-A-63576A

Actuator

- Haydon Kerk 43000 Series Dual Motion Actuator
- Independent Linear and Rotary Motions
- 4” Stroke Capability
- 50 pounds max thrust



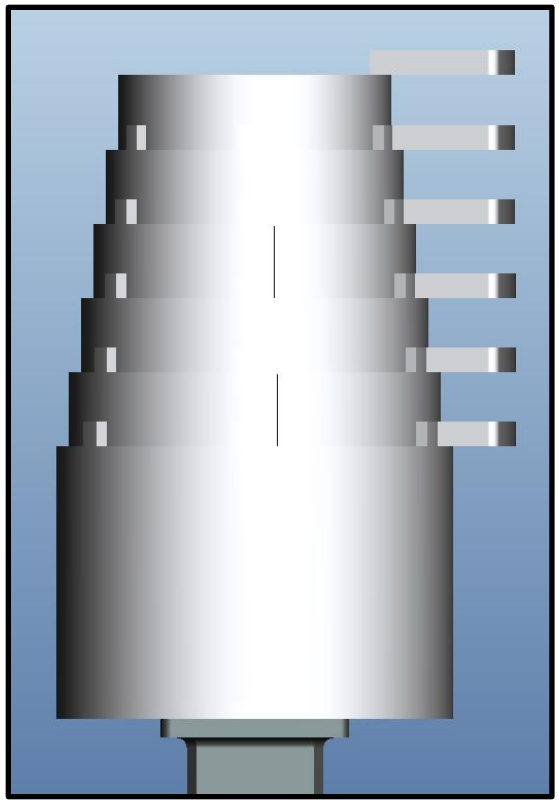
Dual Motion Rotary/Linear Actuator



Actuator Control

- 2035XS by Applied Motion Products
- Dual Axis control stepper motor drive
- Controls step and direction
- Oscillator
- Idle current reduction
- Supplies up to 35VDC
- 7 to 1 supply to motor voltage
- eXposition Software

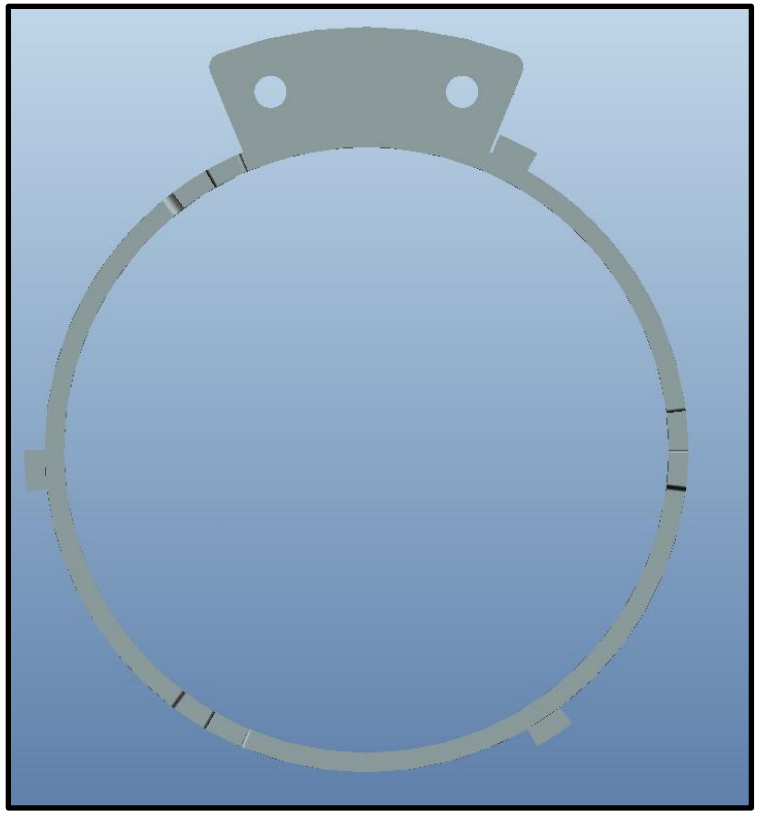
Ring to Panel Interface



Connection Tabs are seen in the above pictures. As the rings get smaller, the tabs become longer

- Group 6 is designing the panels and interlocks
- We worked with them to determined an acceptable minimum clearance in the stowed position

Ring to Panel Interface



Two threaded holes will be drilled into the tabs in order to secure the panels into place.

- Agreed on a standard bolt pattern
- Ensures compatibility between the Hub and Panel prototypes

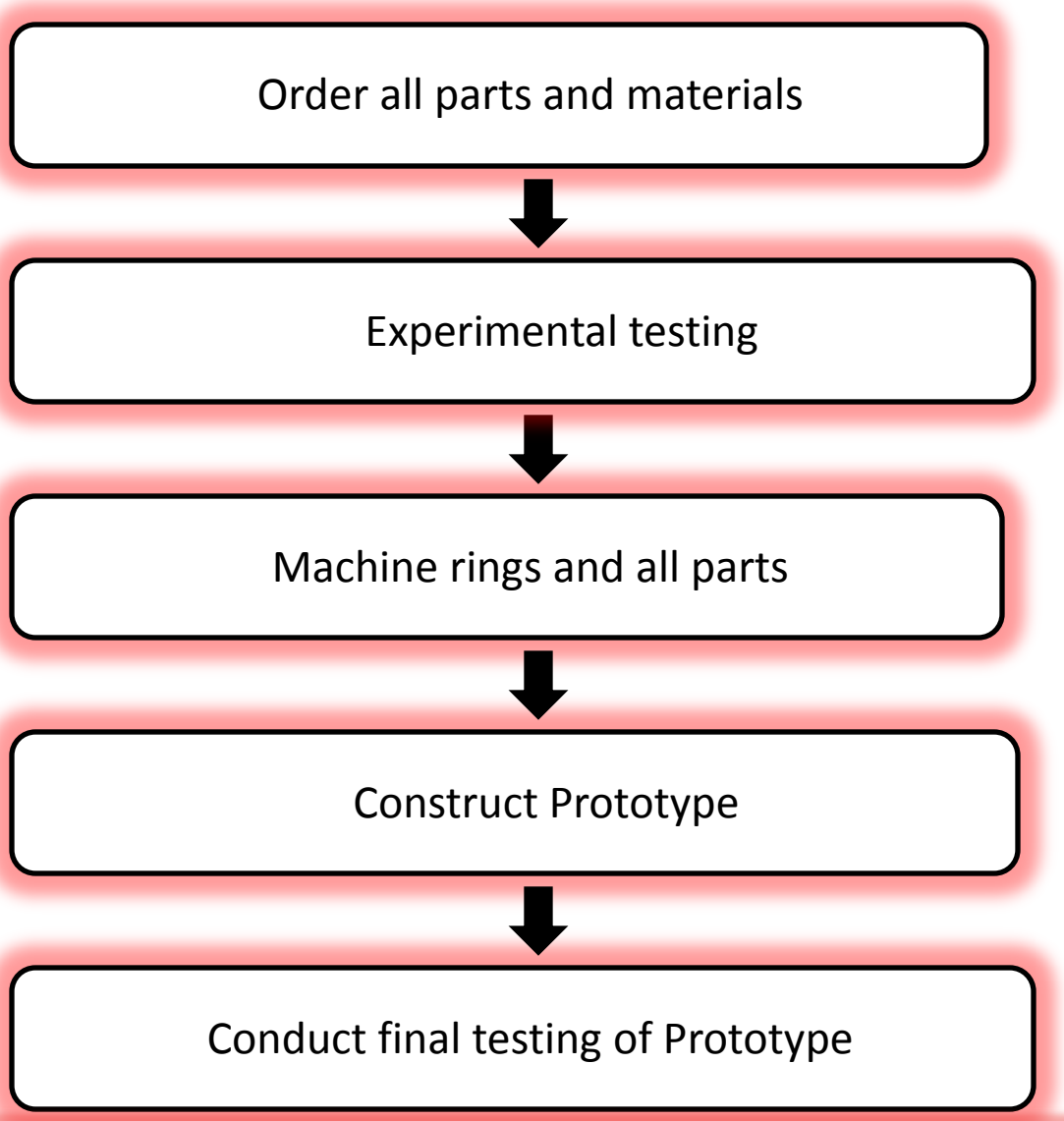
Final Selection

- Ring Sizing
  - 4 inches in diameter (largest ring)
  - 2.75 inches in diameter (smallest ring)
- Connection Tab
  - Pie shaped with 2 threaded holes
- Actuator : 4 inch stroke
- Material Selection
  - Hard Anodized Aluminum infused with Teflon

Cost Analysis

Actuator				
	Quantity	**Cost/Unit**	**Total Cost**	**Place of Purchase**
High Strength Aluminum 2024	1 - [1 ft rod (4.5" diameter)]	229.65	229.65	Mcmaster
High Strength Aluminum 2024	1 - [3/16" thick, 1/2" wide rectangular bars (3 feet)]	14.19	14.19	Mcmaster
High Strength Aluminum 2024	1 - [1/4" thick, 1 1/4" wide recatangular bars (1 ft)]	14.18	14.18	Mcmaster
Hard anodizing with teflon coating	All aluminum parts	200.00*	200.00*	various
Actuator	43000 Series (Size 17) Dual Motion : 4 inch stroke	297	297	haydon kerk
Acutator Control	1- [2035XD Dual Axis Drive]	269	269	Applied Motion Products
machining costs	3 hours/ring with 6 rings	18 hours	18 hours	FSU machine shop
Total ($)			**$1024**	

Next Steps


Order all parts and materials
Experimental testing
Machine rings and all parts
Construct Prototype
Conduct final testing of Prototype

We would like to thank…

- Project Sponsor
  - Gustavo Toledo from Harris Corporation

- Advisor
  - Dr. Shih

Questions?