Team 6 - Final Design
Panel Interlocking Mechanism for Solid Reflector

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Overview

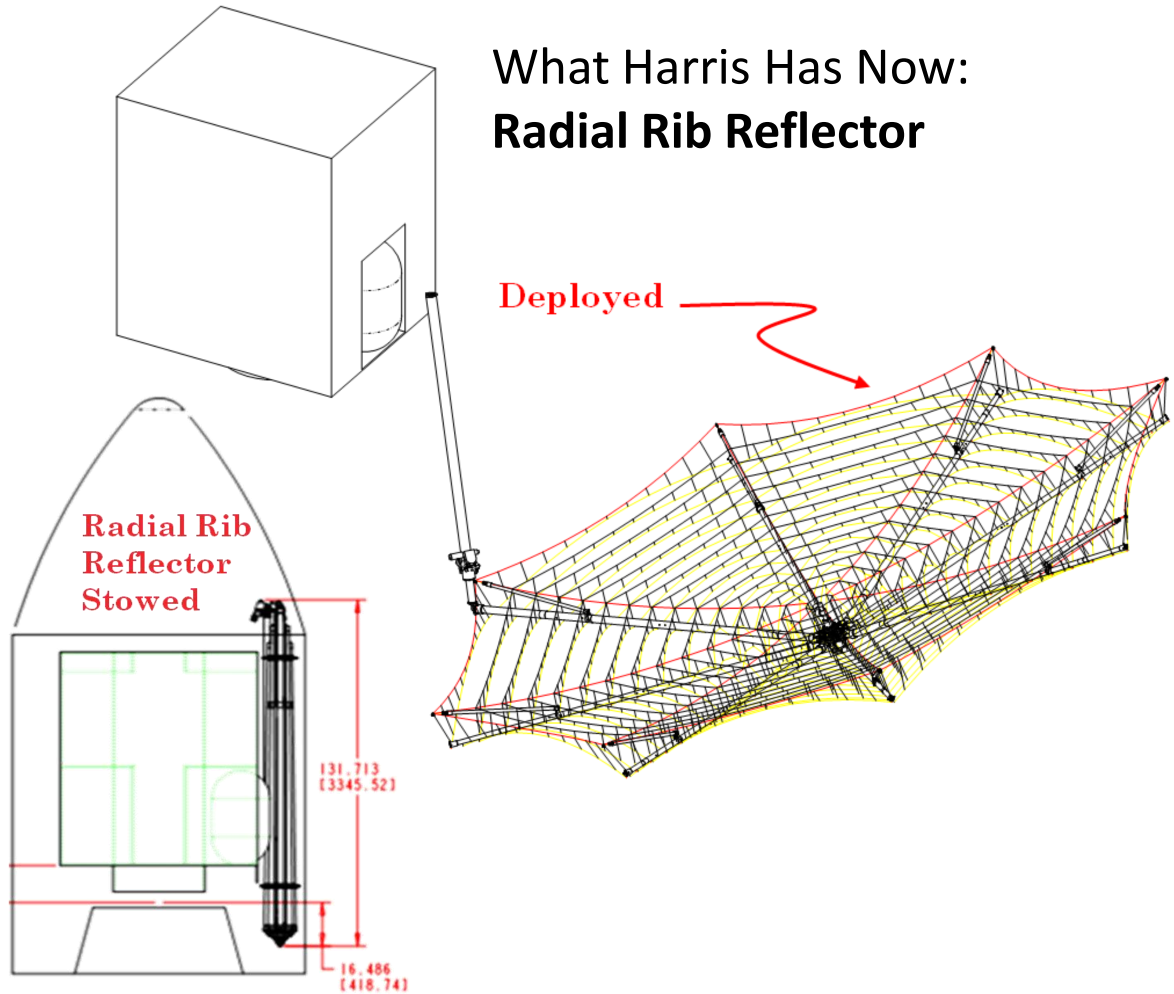
- Introduction
- Design
- Analysis
- Bill of Materials
- Future Plans
- Conclusions
- Questions

Introduction – What Harris Needs

- Alternative Interstellar Reflector Dish
- General Requirements:
  - Higher Surface Accuracy
  - Equivalent Packing Volume
  - Equivalent Reliability

What Harris Has Now:

Radial Rib Reflector



Introduction – Where We Fit In

- Our Goal:

  Help Harris make an **informed decision** regarding a **particular concept**
- Key Questions
  - Can it work? Is it feasible?
  - What are the potential gains?
  - What are the concept's limitations?

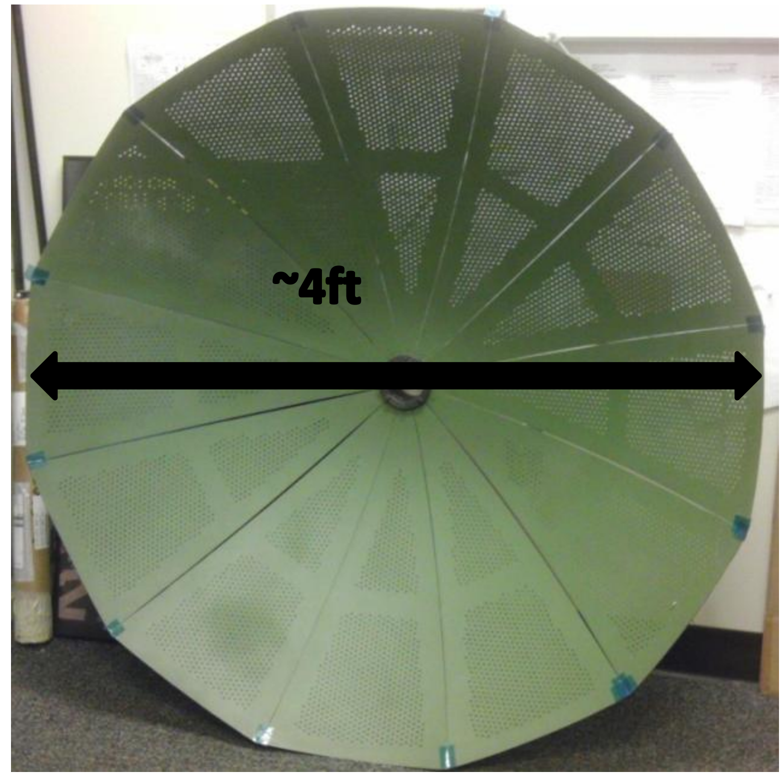


Image provided by Harris Sponsor

Introduction – The Concept

- Tangentially Deployed
  Achieved by hub mechanism design
- High Surface Accuracy
  Achieved by rigid material
- Interlocking Panels
  Achieved by panel design

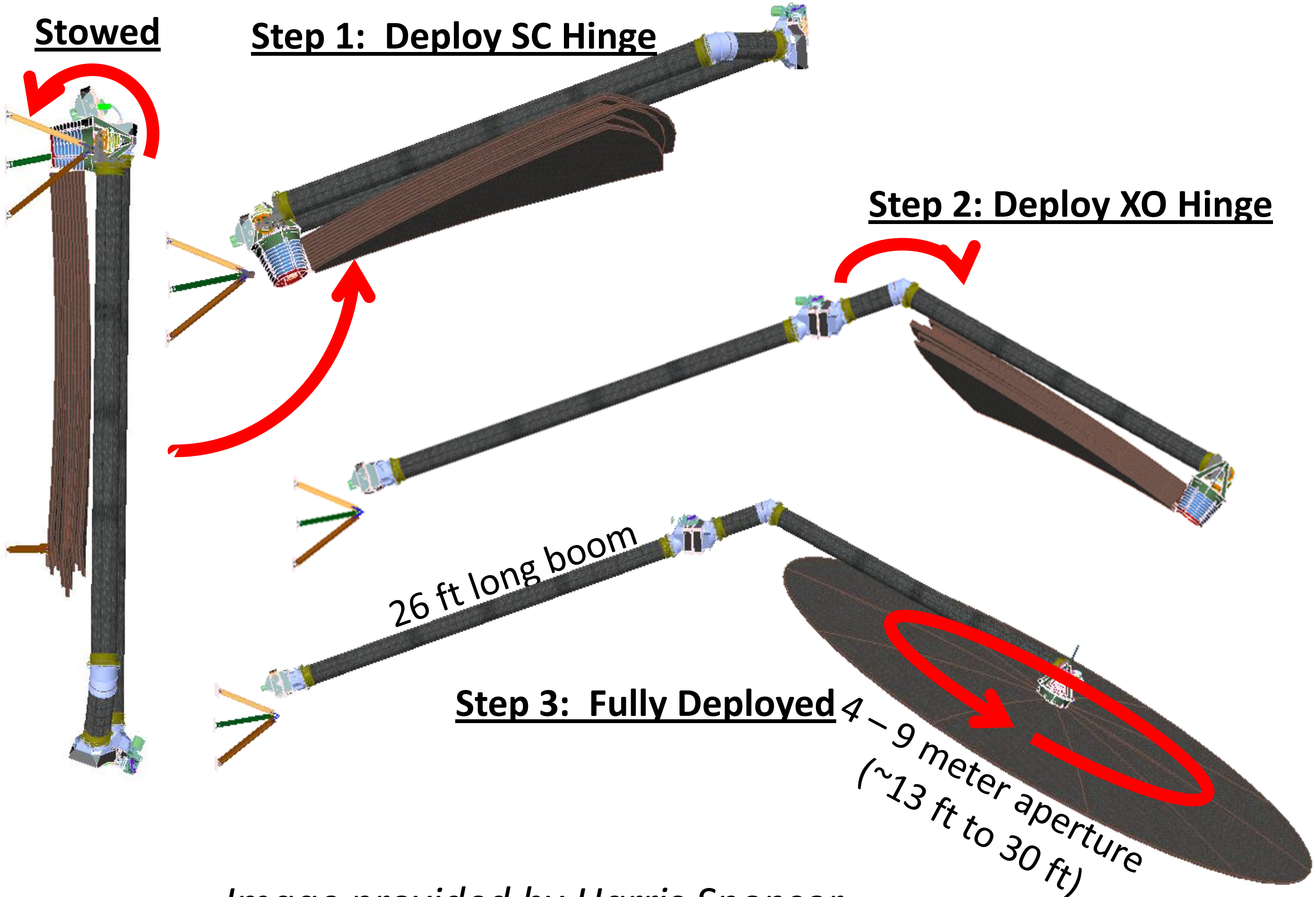
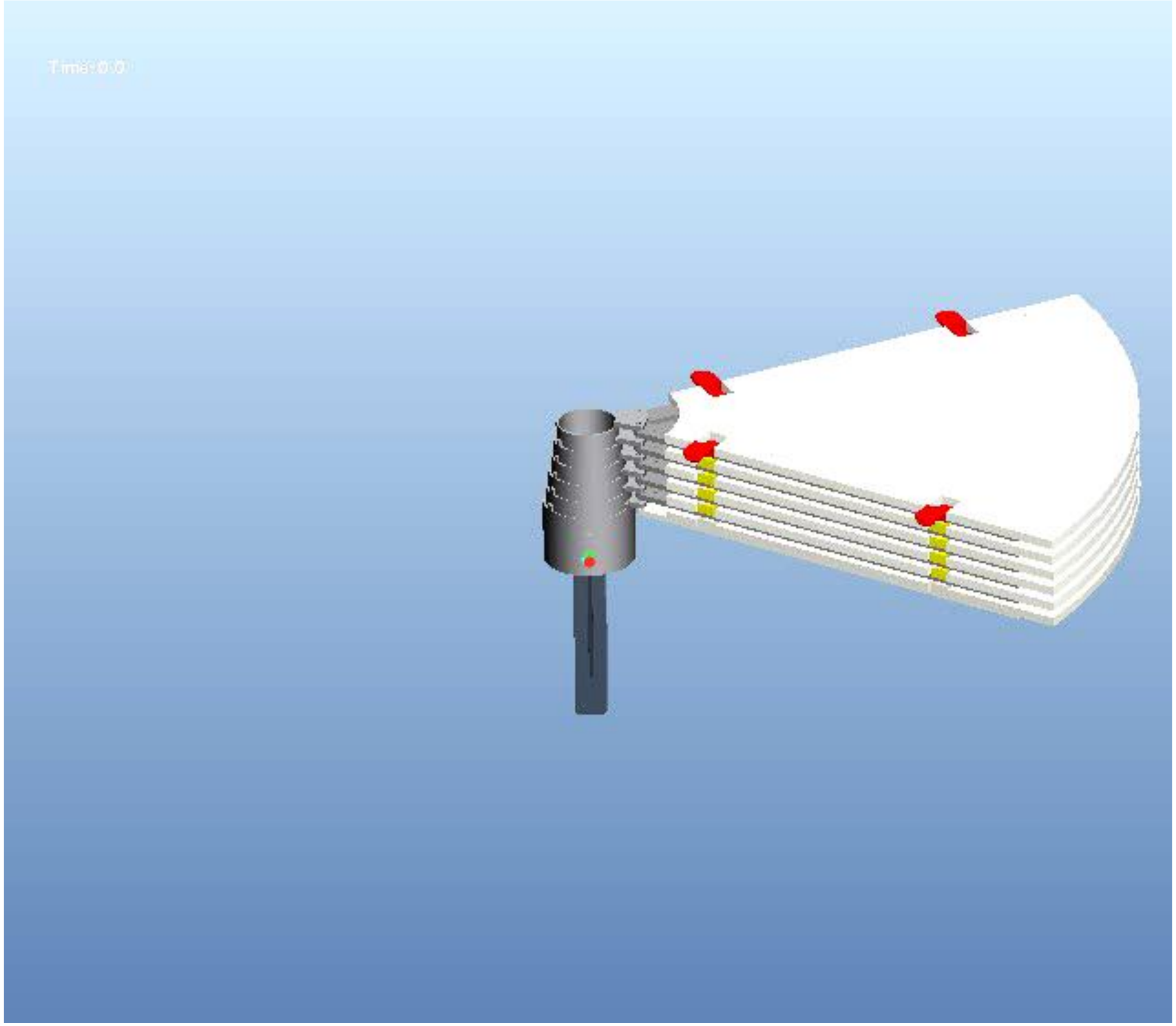
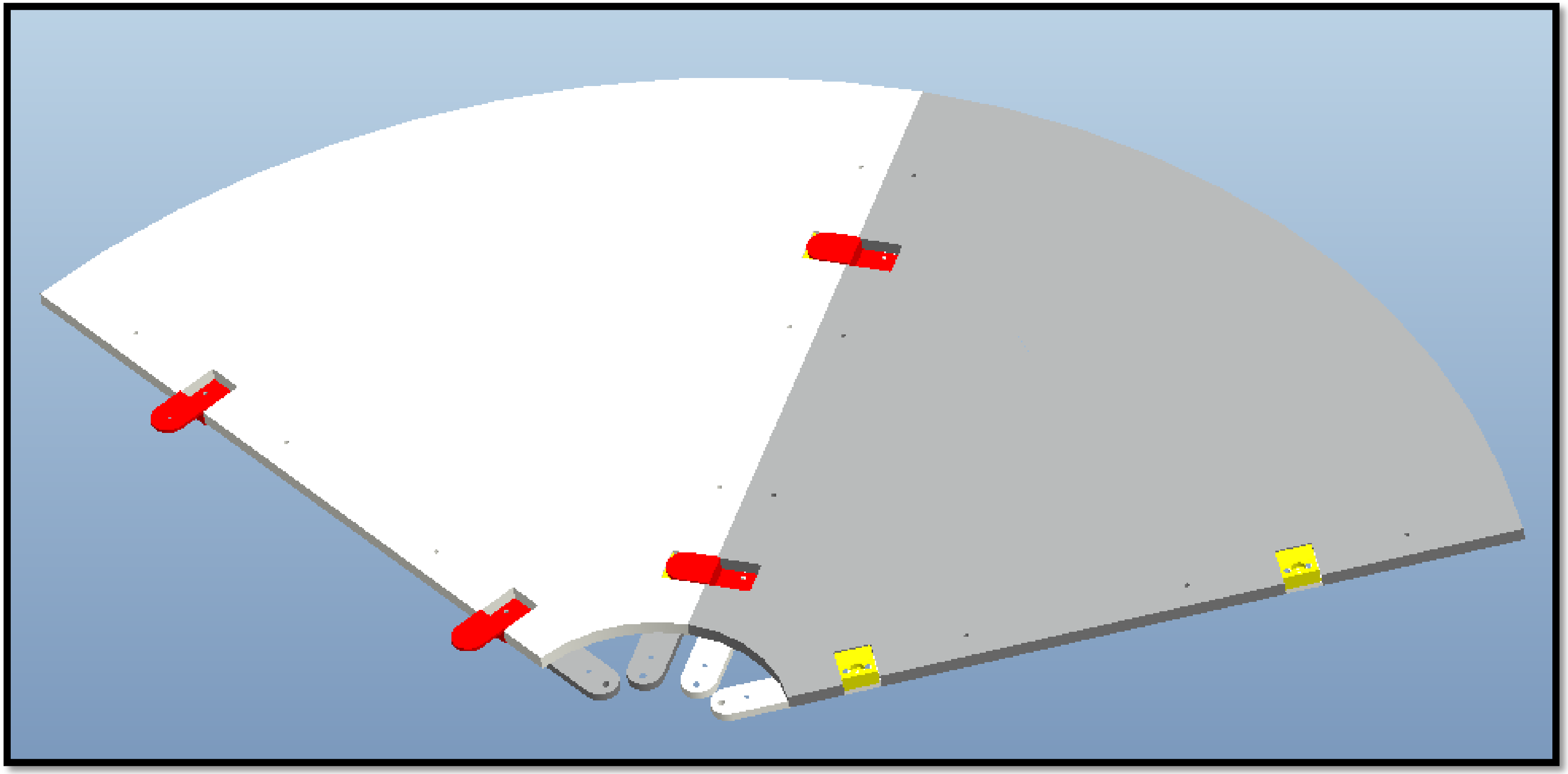


Image provided by Harris Sponsor

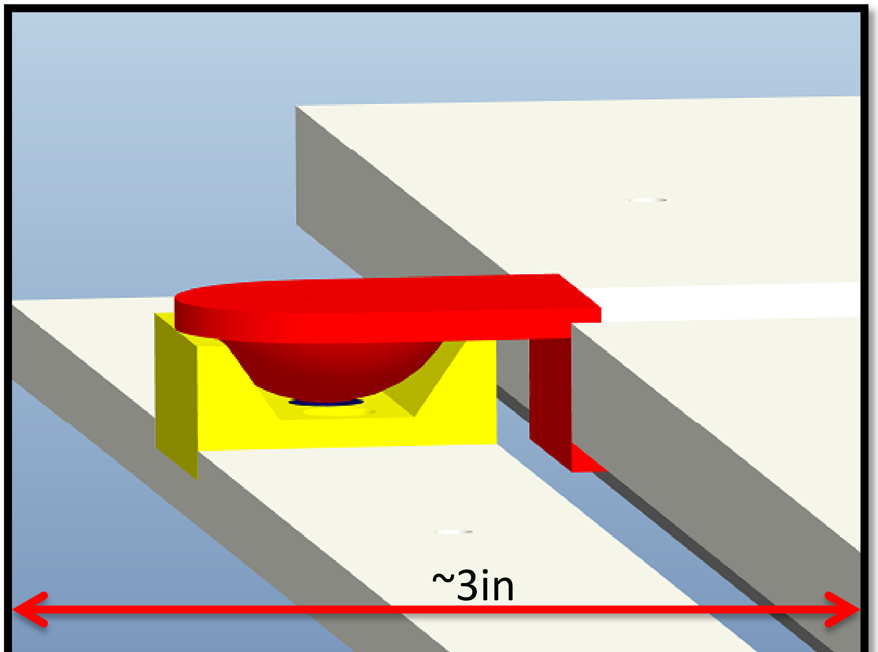
Our Design - Video

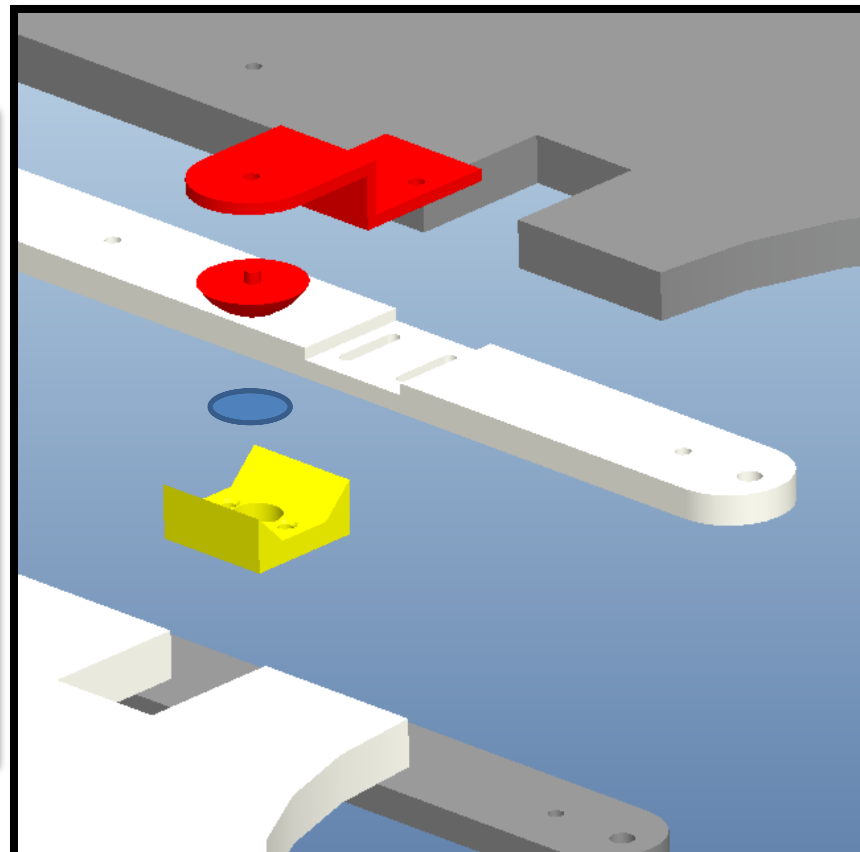


Magnet Assisted Kinematic Interpanel Coupling Mechanism

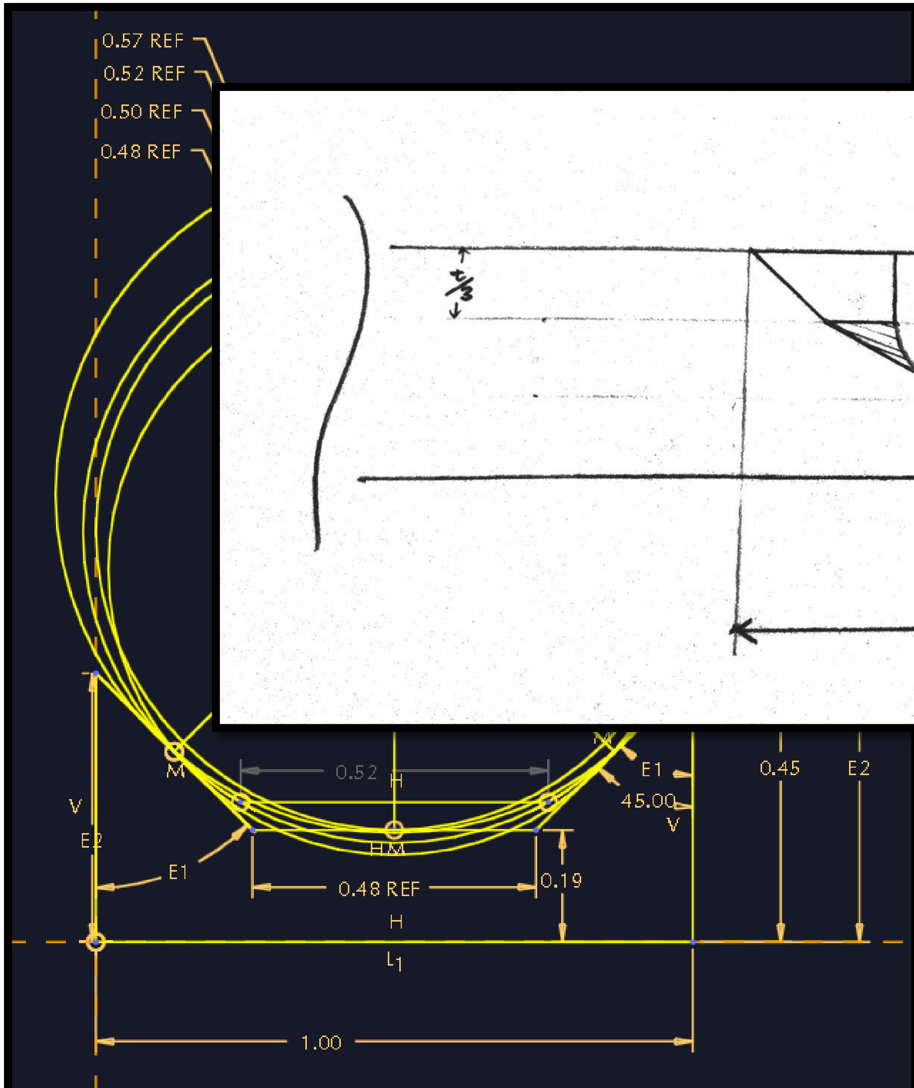


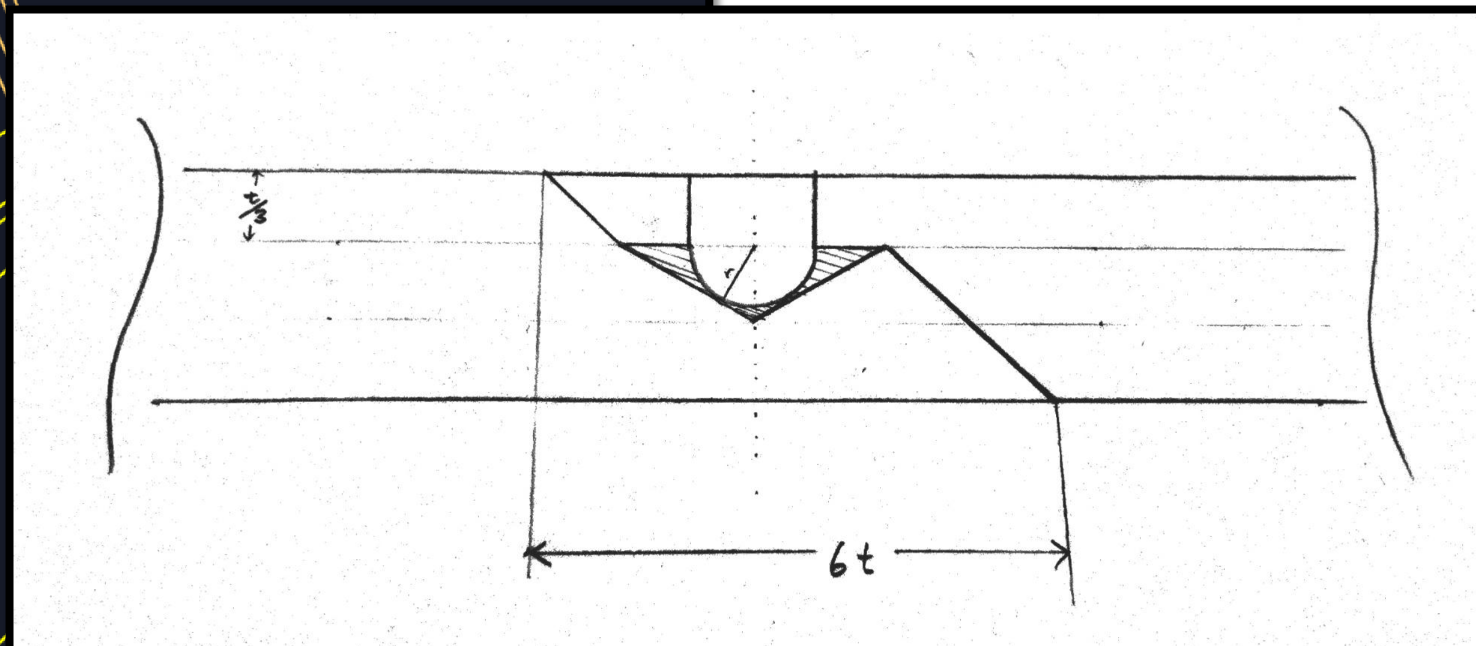
Magnet Assisted Kinematic Interpanel Coupling Mechanism

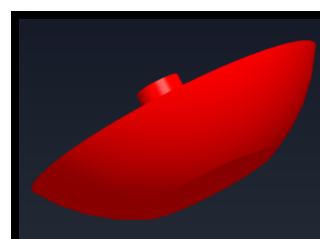




Kinematic Coupling Components







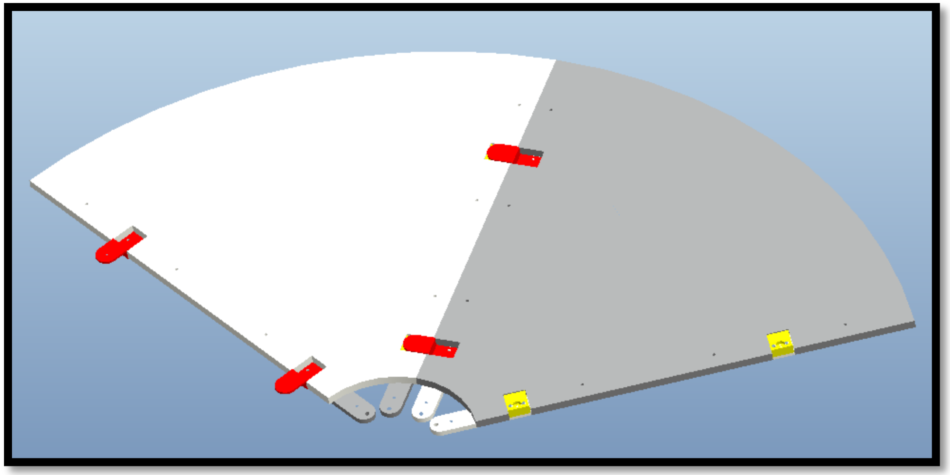
Why Our Design?

Pros

- Simple – no wires /cables
- High positioning accuracy
  - Up to Micron Level
- Active retaining force
- Low profile

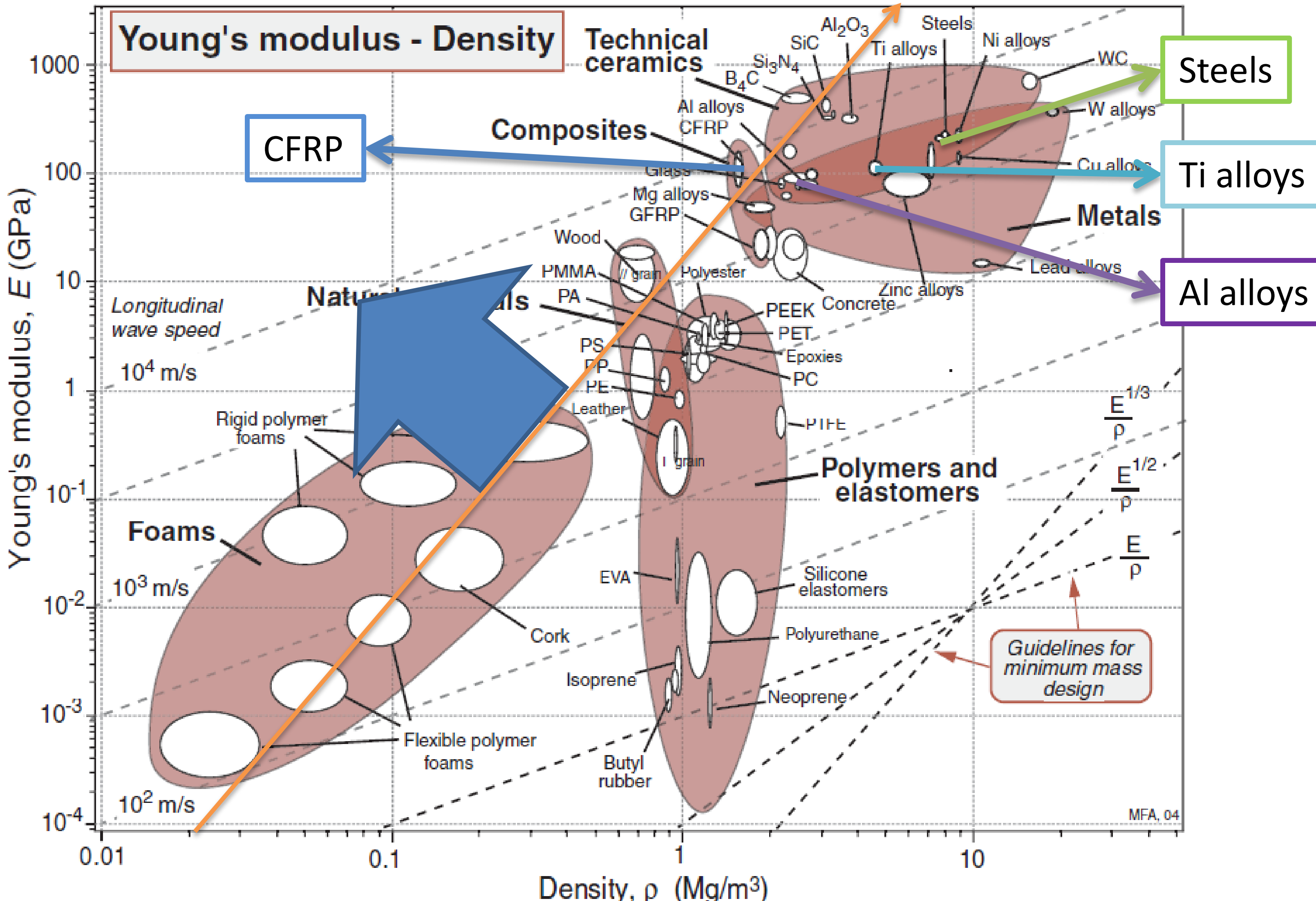
Cons

- Unexplored use of Magnets
- No mechanical latching
- Magnets have temperature limits



Material Selection-Stiff Material 1 of 5

$$M = \frac{E^{\frac{1}{3}}}{\rho}$$



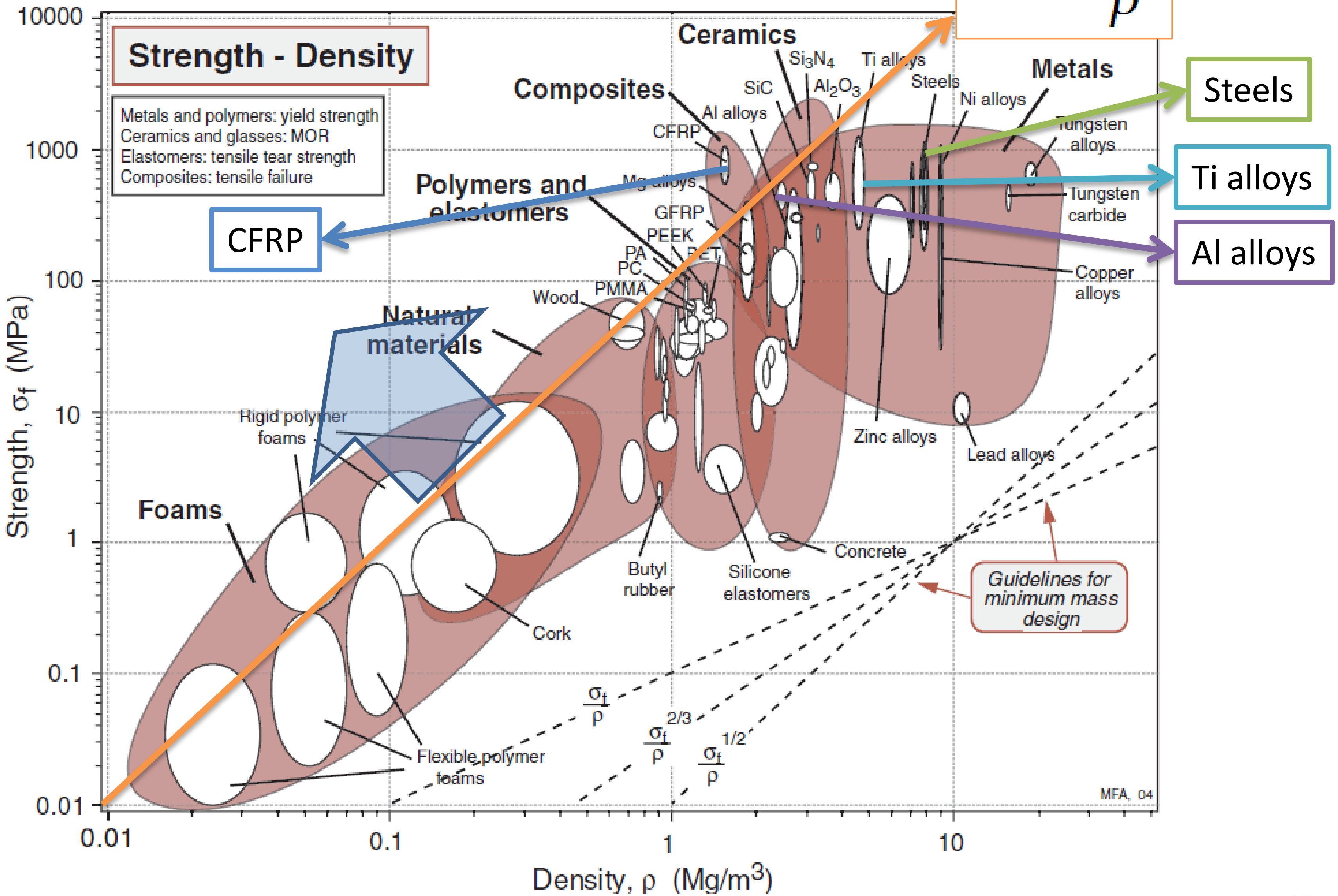
Material Selection 2 of 5

- Stiff Material

Material	Density (kg/m³)	Elastic Modulus (GPa)	Cost ($/kg)
Steels	7,850	201-217	0.85
CFRP	1,550	69-150	42.00
Al alloys	2,700	68-82	1.60
Ti alloys	4,600	90-120	70.00

Material Selection – Strong Material 3 of 5

$$M = \frac{\sigma_y^{\frac{1}{2}}}{\rho}$$



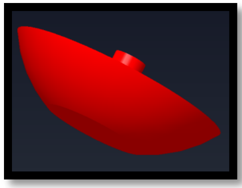
Material Selection

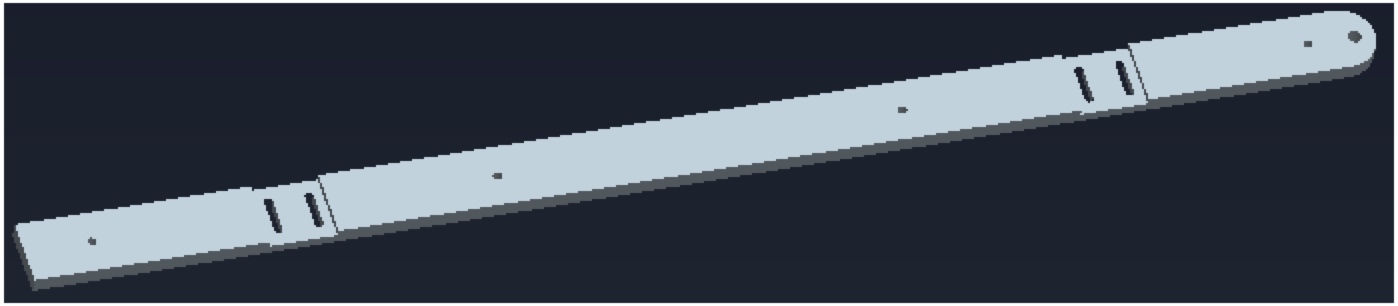
- Strong Material

Material	Density (kg/m^3)	Yield Strength (MPa)	Cost ($/kg)
Steels	7,850	400-1,100	0.85
CFRP	1,550	550-1,050	42.00
Al alloys	2,700	30-500	1.60
Ti alloys	4,600	250-1,245	70.00

Material Selection

- Cone Material – Steel
  - Ferrous, will be needed for magnet attraction
- Cup Material – Aluminum
  - Nonferrous, will not interfere with magnet
- Armature Material – Aluminum
  - Light weight
- Bracket Material – Aluminum
  - Ease of machining, weight





Manufacturing Parts

- Conventional Machining
  - Bracket – requires minimal machining
  - Armatures – requires machining
  - Cone – hemisphere machined from steel sphere/rod
  - V block – machine from Aluminum stock
  - Panels – already built, minimal modifications

Analysis- Magnets 1 of 2

Permanent Magnet Type	Maximum Energy Product (MGOe)	Coercive Force (kOe)	Maximum Working Temperature ºC
Ceramic 5	3.4	2,400	400
Sintered Alnico 5	3.9	620	540
Cast Alnico 8	5.3	1,650	540
Samarium Cobalt 20 (1,5)	20.0	8,000	260
Samarium Cobalt 28 (2,17)	28.0	9.500	350
Neodymium 33UH	33.0	10,700	180
Neodymium N45	45.0	10,800	80

Neodymium

- Pros:
  - -High energy product and coercive force
- Cons:
  - -Low mechanical strength (brittle)
  - -Moderate temperature stability

Samarium Cobalt

- Pros:
  - -High energy product, coercive force and temperature stability
- Cons:
  - -Low mechanical strength (brittle)
  - -Higher cost

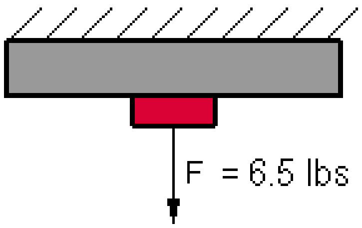
Analysis – Magnets 2 of 2

- Exposed temperature dependent on
  - Orientation to sun
  - Material emissivity
  - Material absorptivity
- Special coatings used
  - Keep temperature range between -129^{o}C and 120^{o}C

Material	Maximum Working Temperature
NdFeB N	80 ºC
NdFeB M	100 ºC
NdFeB H	120 ºC
NdFeB SH	150 ºC
NdFeB UH	180 ºC
NdFeB EH	200 ºC

Magnet Selection

- Neodymium Ring Magnet
  - Grade N42
  - Approximated magnet pull force: 6.5 lbs
  - Nickel-copper-nickel coating
  - Dimensions:
    - Outer diameter: 0.5 inch
    - Thickness: 0.125 inch
    - 0.25 inch x 0.125 inch 90 degree taper countersunk hole
  - Price: $0.99/magnet



Courtesy of Magnet4Less.com

Bill of Materials

Component	Specifications	Vendor	Price per unit	Quantity	Sub Total
Neodymium Magnet	1/8" OD x 1/16" ID x 1/16" thick	K&J Magnetics, Inc.	\$0.79 - \$3.75	12	\$9.48 - \$45.00
Cone	Steel	Bal-tec	\$9.90 - \$31.50	12	\$118.80 - \$378.00
Aluminum 6061 (Bracket)	1/4" x 1" x 6'	McMaster Carr	\$16.02	5	\$80.10
Aluminum 6061 (V-block)	1/2" x 1" x 3'	McMaster Carr	\$17.23	1	\$17.23
Sheet Aluminum (Z-Arm)	0.10” thick, 12” x 24” plate	Speedy Metals	\$16.85	3	\$50.55
Screws	1/8", Flat Head, pack of 100	Home Depot	\$4.65	1	\$4.65
Bolts	1/8“, pack of 100	Home Depot	\$4.24	1	\$4.24
Epoxy	1.7 oz, Clear	The Binding Source, LLC	\$15.52	1	\$15.52
				TOTAL:	**\$300.57 – \$595.29**

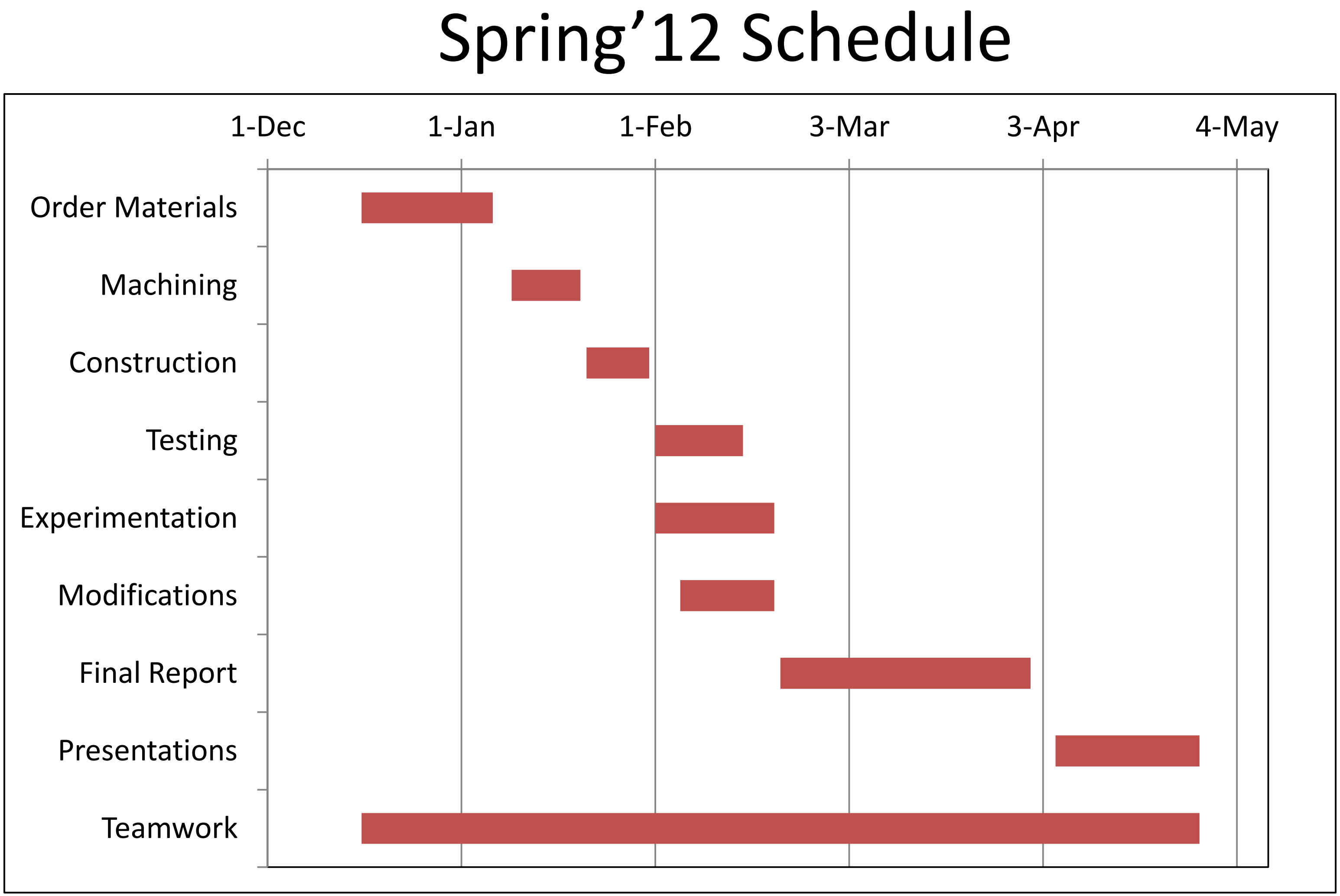
Future Plans – Testing 1 of 3

- Answer the question: *Is it feasible*?
  - Kinematics: Show concept can be constructed. Show tangential deployment can be achieved.
- Answer the question: *What is there to be gained?*
  - Higher Surface Accuracy (Harris already knows this)
  - Packing Volume – Show concept can be implemented with similar volume and fairing constraints
- Answer the question: *What are the limitations?*
  - What loading conditions will cause separation?
  - What temperature conditions will cause failure?
  - Will launch require extra preparations?
  - Any unpredicted issues?

Future Plans - Goals 2 of 3

- General Goals:
  - Work with sponsor to continue developing Postprocessing plans
  - Work with school shop to develop fabrication plan and finalize part sources
  - Order Parts
  - Assemble
  - Conduct Postprocessing

Future Plans - Schedule 3 of 3



Conclusions

- Straightforward approach to satisfying client needs
- Simple, Cost Effective Design
- Design is passive, adjustable, utilizes recycled material

Safety Concerns 1 of 2

- Magnet Safety
  - Risk 1: Pinching
    - Risk Assessment:
      - Pinching becomes a serious risk to fingers and skin as magnet size increases.
      - Pinching should not be a concern give the size of magnets being considered.
    - Precautions:
      - If pinched, a brass wedge may be insert to prevent the magnets pinching further as the magnets are removed

Safety Concerns 2 of 2

- Risk 2: Chipping
  - Risk Assessment:
    - Some magnet formulas are more prone to chipping than others.
    - Magnets should not receive high mechanical loads.
    - Risk increases with magnet size.
    - Chipping should not pose much risk due to magnet size.
  - Precautions:
    - Be aware of the risk, know what magnet formulas and situations can lead to higher risk levels
    - PPE Eyewear is recommended

Acknowledgements

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- Bill Starch, Shop – Fabrication Research

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Questions?