Panel Interlocking Mechanism for Solid Reflector

Sponsor
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Overview

- Introduction
- Needs Assessment
- Functional Diagram
- Concept Generation
- Final Design
- Economics
- Testing
- Results
- Conclusions
- Questions

Introduction

Time: 0.0

Concept:

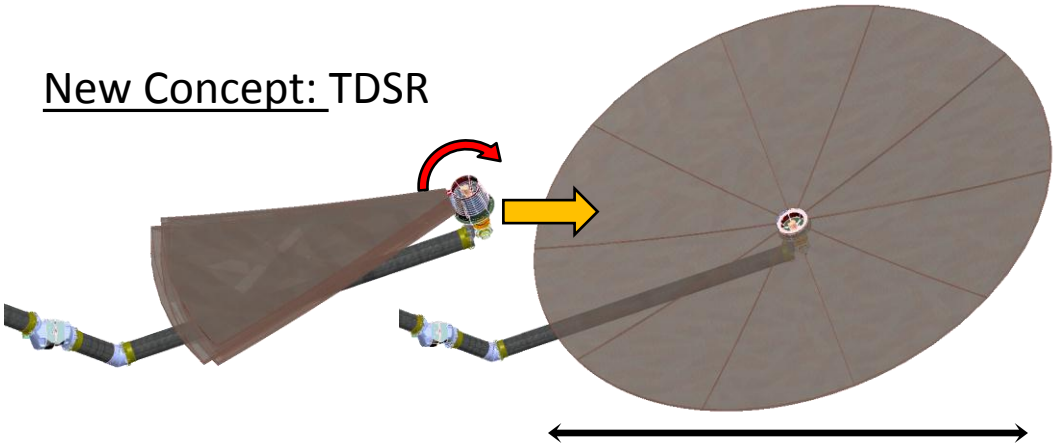
Interlocking Mechanism (IM) for a Tangentially Deployable Solid Reflector (TDSR)

Important Concept Details

- Two stage deployment
- Panels attach to hub
- Panels connect to each other

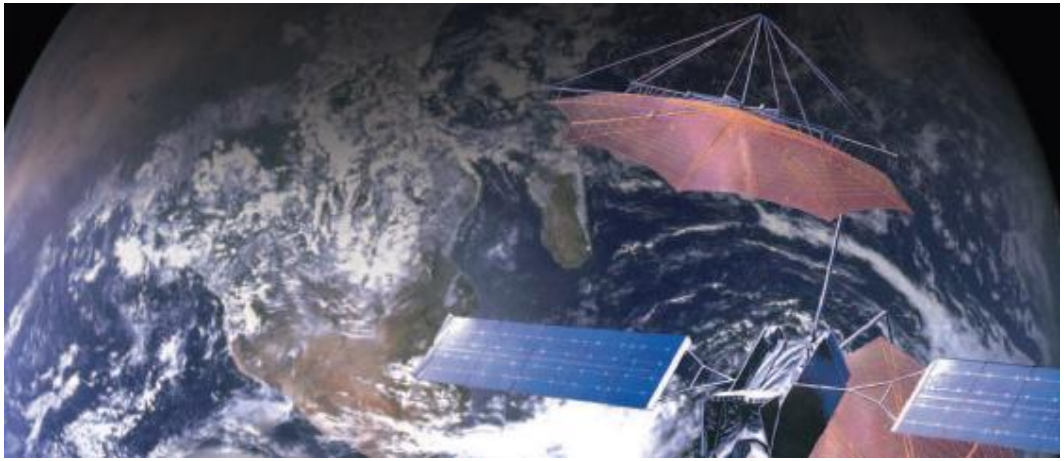
Introduction

New Concept: TDSR



3-18m

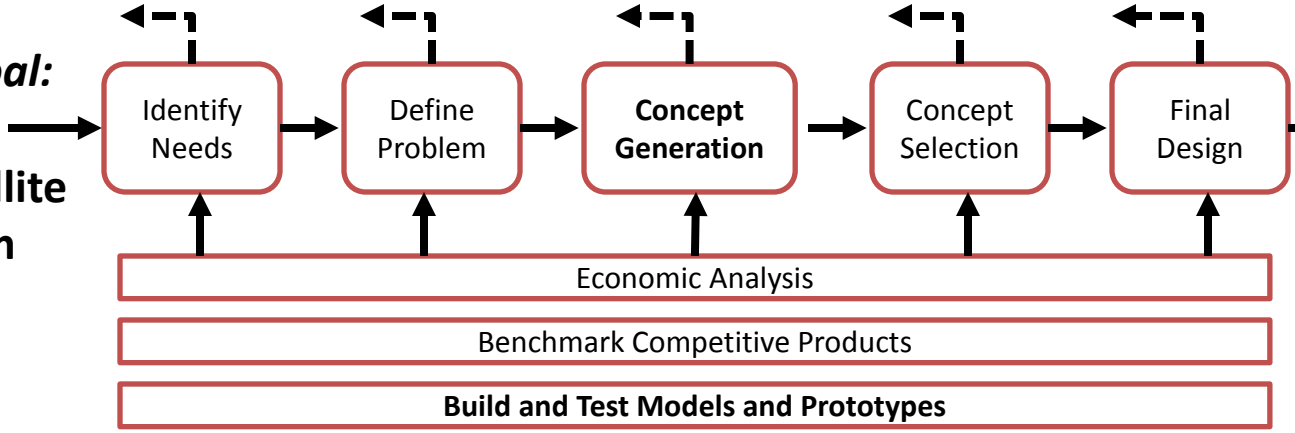
Existing Approach: Unfurlable Mesh-Rib Reflector



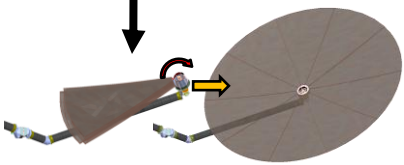
Credit: (Top) Gustavo Toledo, ME, Harris (Bottom) www.harris.com

Harris' Goal:

New Satellite Subsystem



New Concept ready for production



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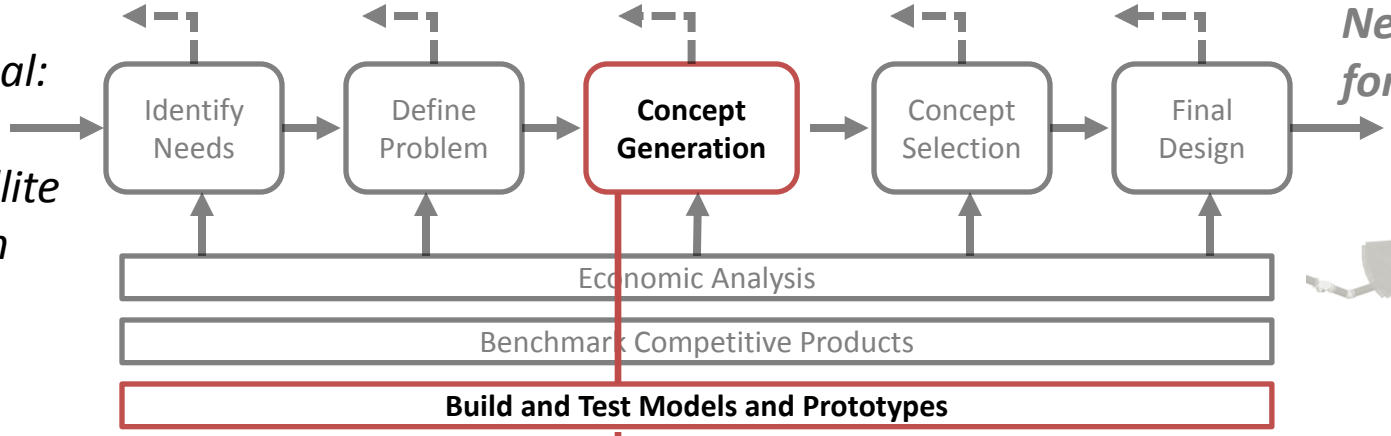
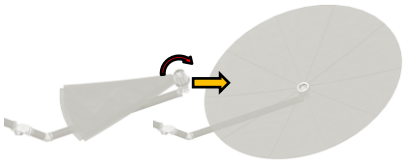


New Concept read for production

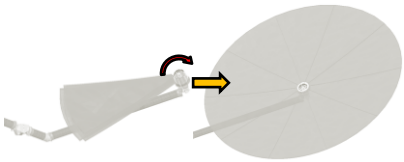


Our Goal: Prototype of particular concept

Harris' Goal:

New Satellite Subsystem

Identify Needs → Define Problem → **Concept Generation** → Concept Selection → Final Design → *New Concept ready for production*

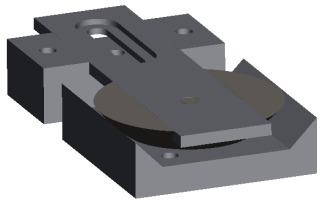


Economic Analysis

Benchmark Competitive Products

Build and Test Models and Prototypes

Our Goal: Prototype of particular concept



Identify Prototype Needs → Define Problem → Prototype Concept Generation → Prototype Concept Selection → Final Prototype Design

Economic Analysis

Benchmark Competitive Products

Build and Test Models and Prototypes

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Needs Assessment

Concept Needs

(goes into space)

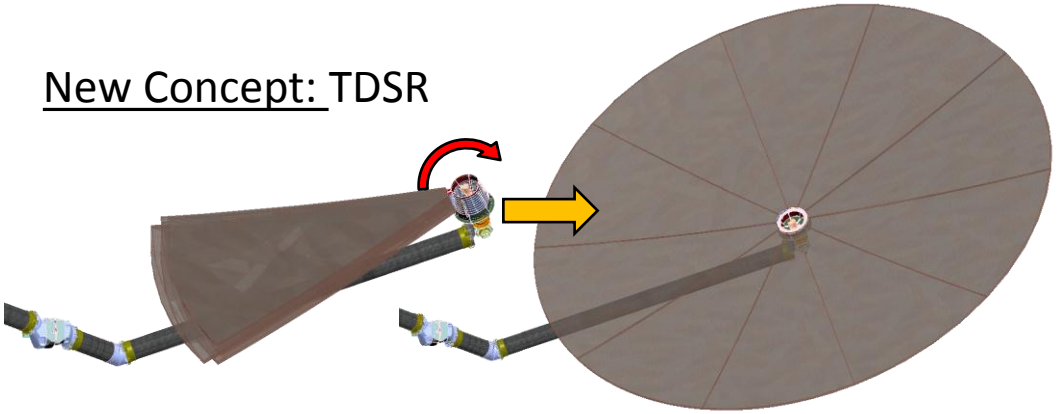
- Works in space
- High Surface Accuracy
- Competitive Stowed volume, weight

Prototype Needs

(Does not go into space)

- Demonstrate Dual Motion Deployment
- Demonstrate Interlocking of Panels

New Concept: TDSR



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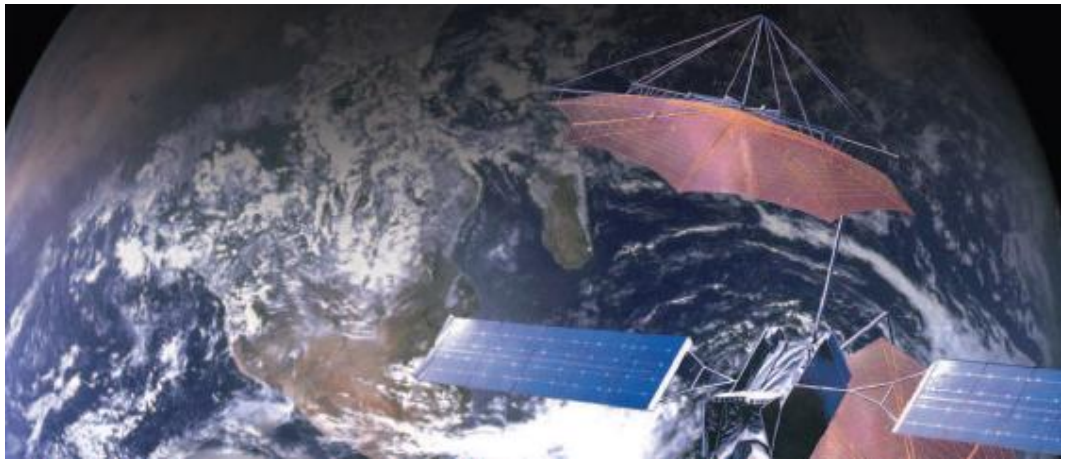

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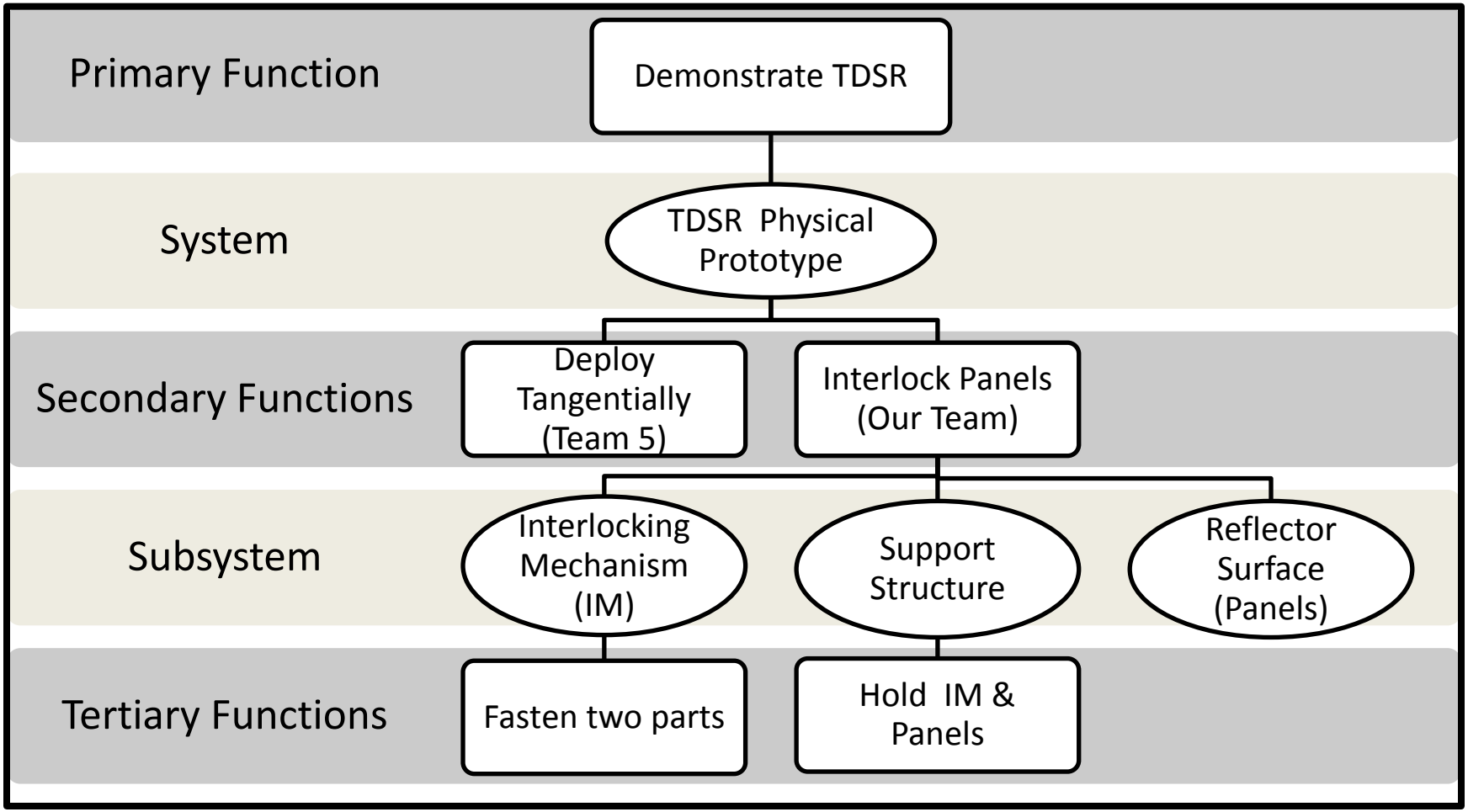
Functional Diagram

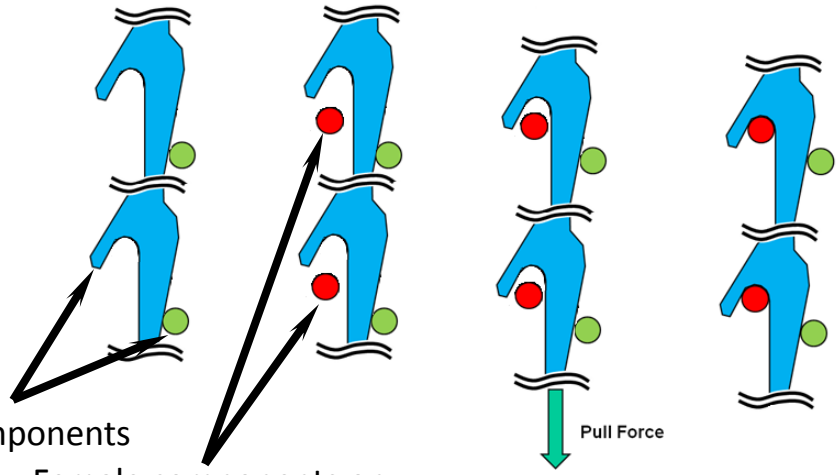
Tangentially Deploying Solid Reflector (TDSR)



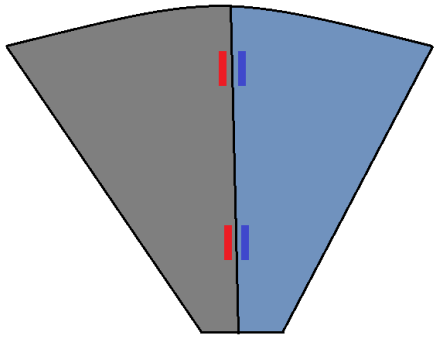
Concept Generation

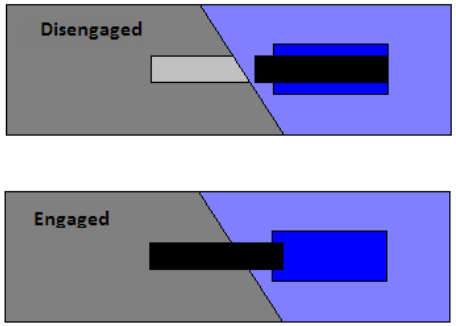
"Active" Concepts:

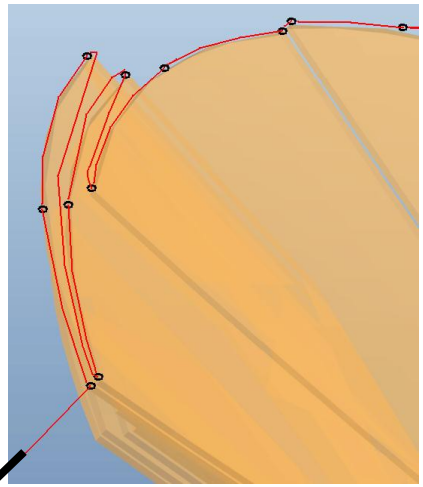
Interlocking Mechanism (IM) assists hub in positioning panels and interlocking.



- Motorized Latches
- Cables
- Solenoid
- Magnet







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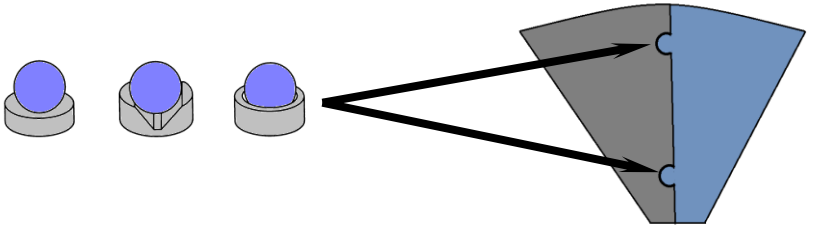
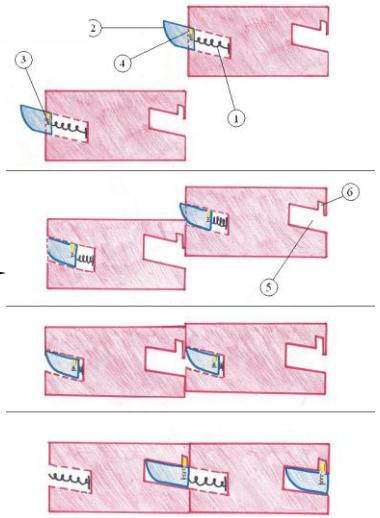
Concept Generation

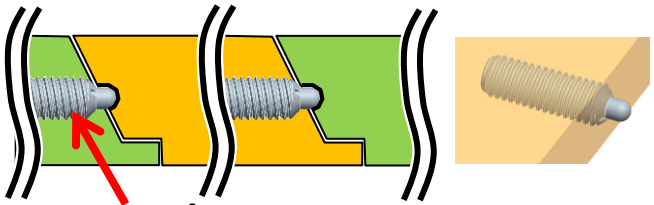
“Passive” Concepts:

Hub alone positions panels and drives interlocking

- Geometric Features
- Mechanical Latches
- Adhesives
- Spring assisted cam
- Spring Loaded latch







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Selection Criteria

Alignment (Reliability)

- Engagement Proximity
- Engagement Force

Structure (Security)

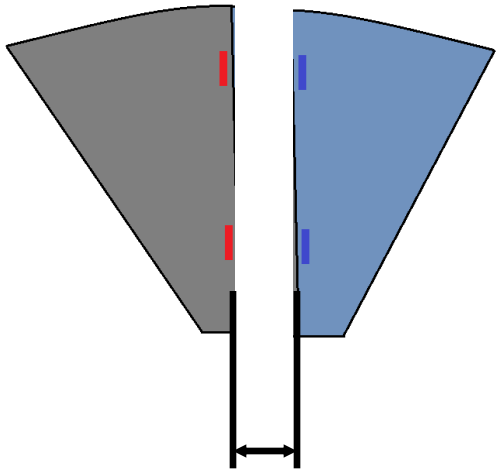
- Separation Force

(Separation Failure)

- Stability
- Gapping

Implementation

- Reversibility
- Complexity
- Price



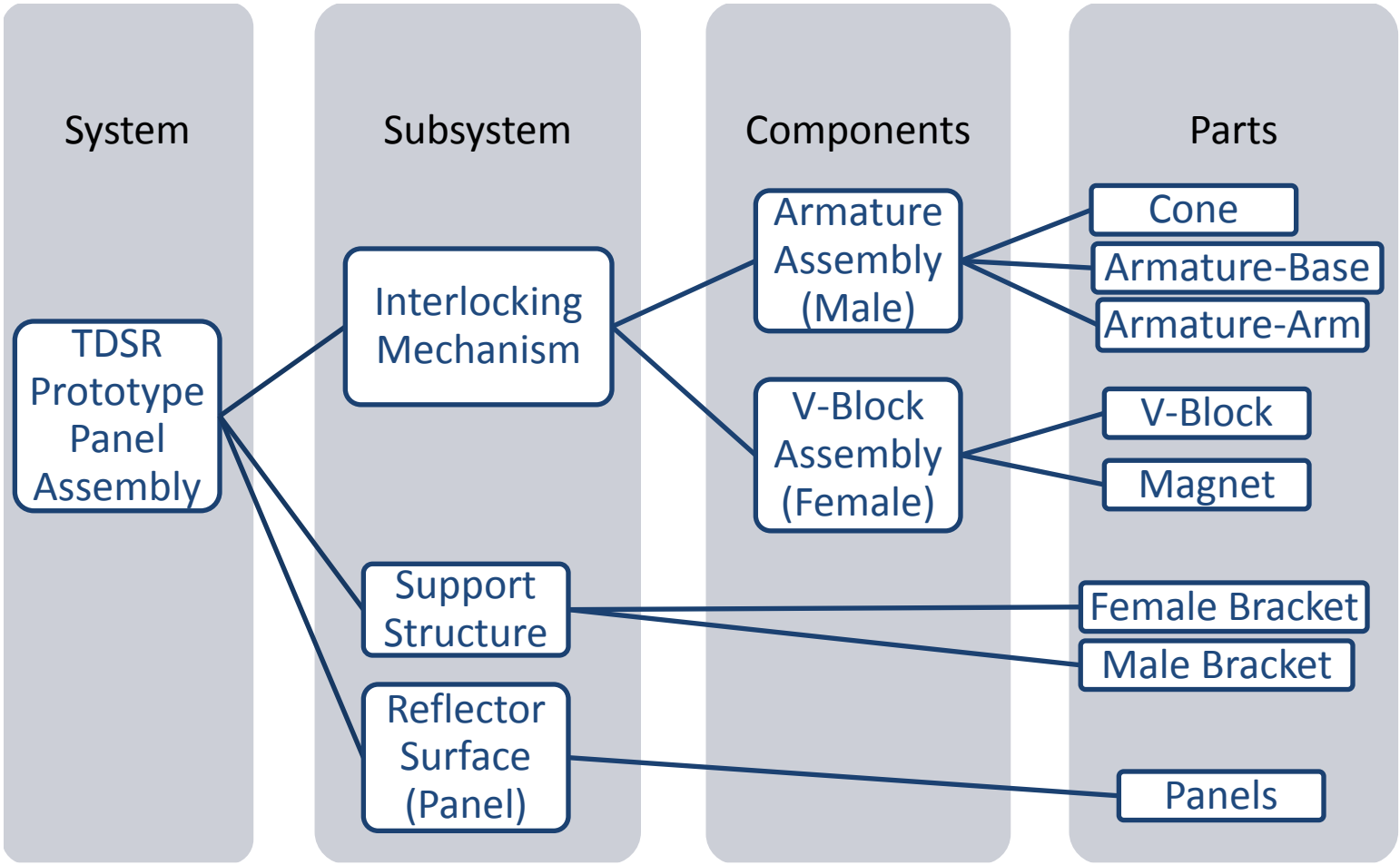
Force

Selection Matrix

		Flat Plate		Cup and Cone		Solenoid		Magnets	
Specifications	**Weight Factor**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Reliable									
Engagement Proximity	0.15	4.00	0.60	4.00	0.60	4.00	0.60	5.00	0.75
Engagement Force	0.15	3.00	0.45	4.00	0.60	4.00	0.60	5.00	0.75
Security									
Separation Failure	0.10	2.00	0.20	4.00	0.40	5.00	0.50	5.00	0.50
Stability	0.10	3.00	0.30	4.00	0.40	4.00	0.40	4.00	0.40
Gapping	0.10	3.00	0.30	5.00	0.50	4.00	0.40	4.00	0.40
Reversibility	0.20	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00
Complexity	0.10	5.00	0.50	5.00	0.50	4.00	0.40	5.00	0.50
Price	0.10	5.00	0.50	5.00	0.50	4.00	0.40	4.00	0.40
		Total:	**3.85**	**Total:**	**4.50**	**Total:**	**4.30**	**Total:**	**4.70**

Magnets and Cup and Cone were rated the highest
Design will incorporate both mechanisms

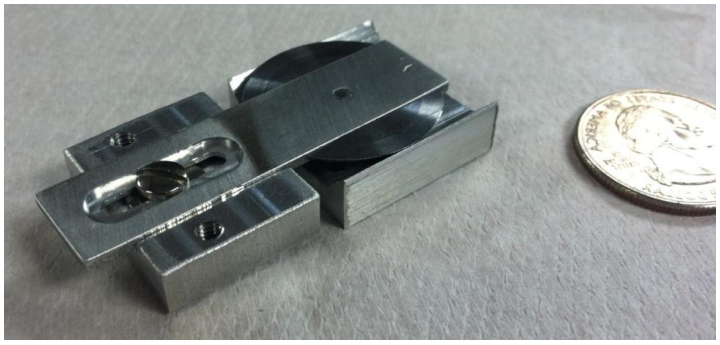
Final Design



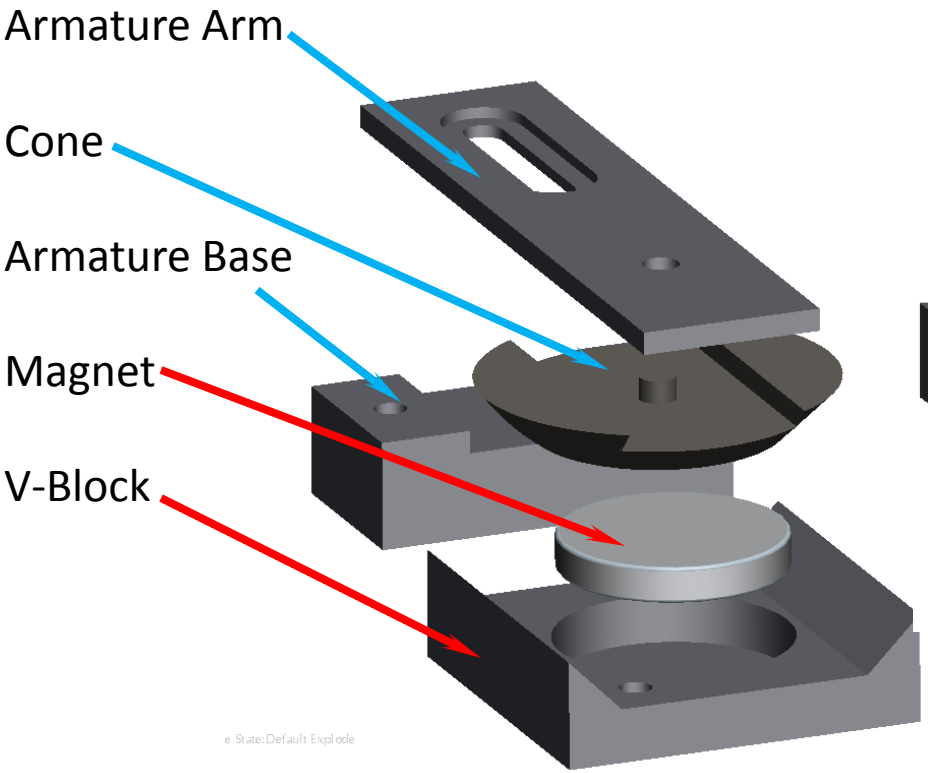
Design Objectives for Subsystems

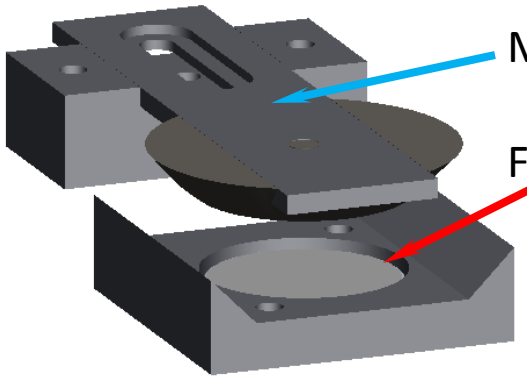
- Interlocking Mechanism (IM)
  - Joins panels and locks
- Support Structure
  - Prototype must be rigid
  - Provides mounting surface for IM
  - Interfaces with hub mechanism
- Reflector Surface (Panel)
  - Prototype resembles a parabolic, continuous dish
  - Reuse materials

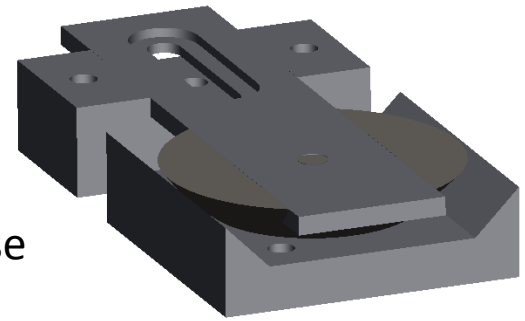
Interlocking Mechanism



Final design compared to a quarter





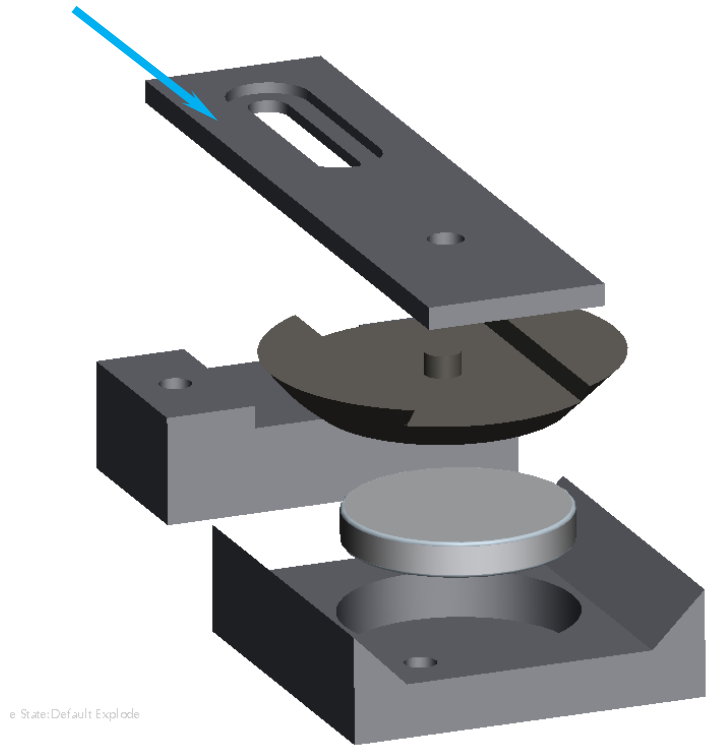


Mated assembly

- Consists of 2 assemblies: Male and Female
- **Male Assembly** (3 parts): Cone, Armature Arm, Armature Base
- **Female Assembly** (2 parts): Magnet, V-Block

Interlocking Mechanism

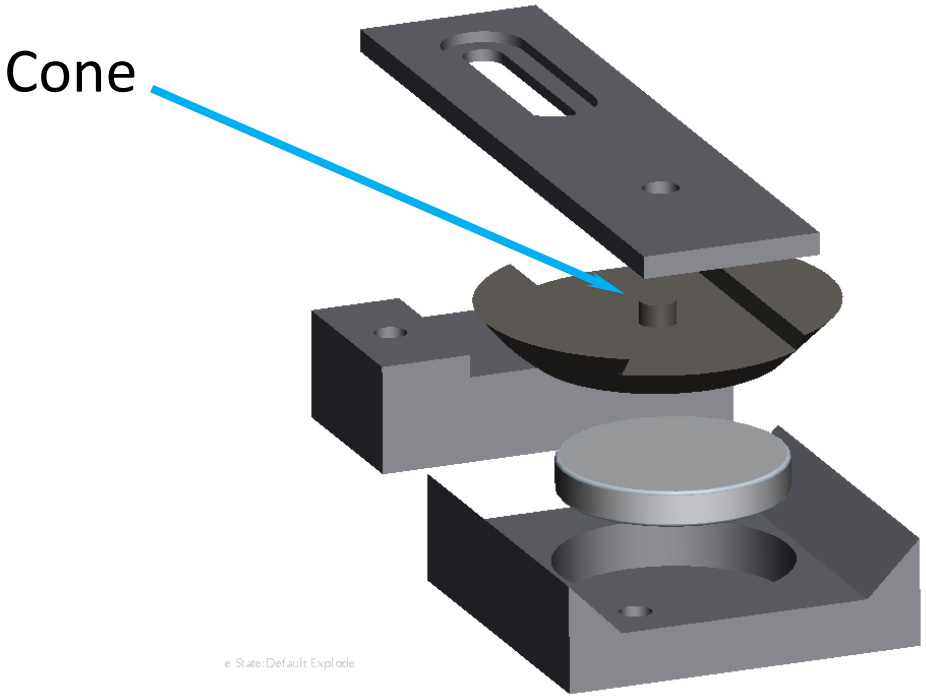
Armature Arm



Function:

- Holds Cone

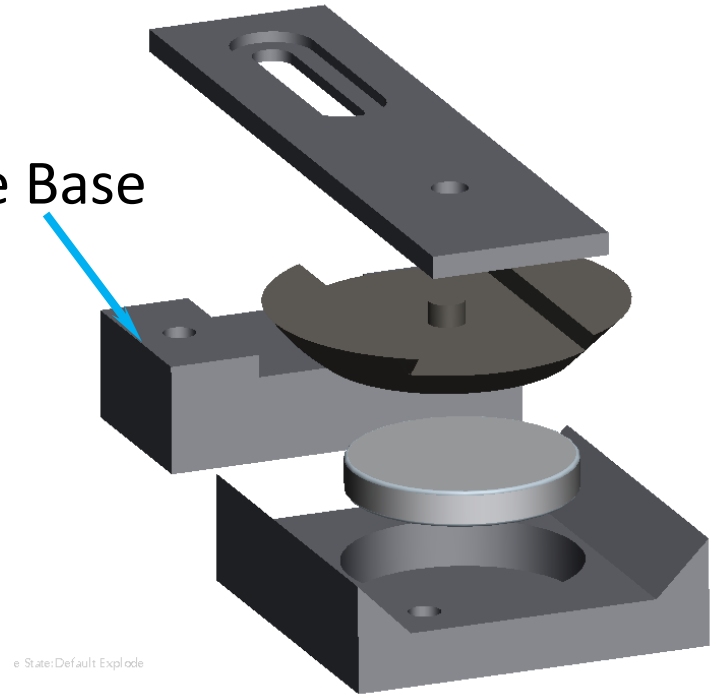
Interlocking Mechanism



Functions:

- Assists with alignment
- Mate with V-Block

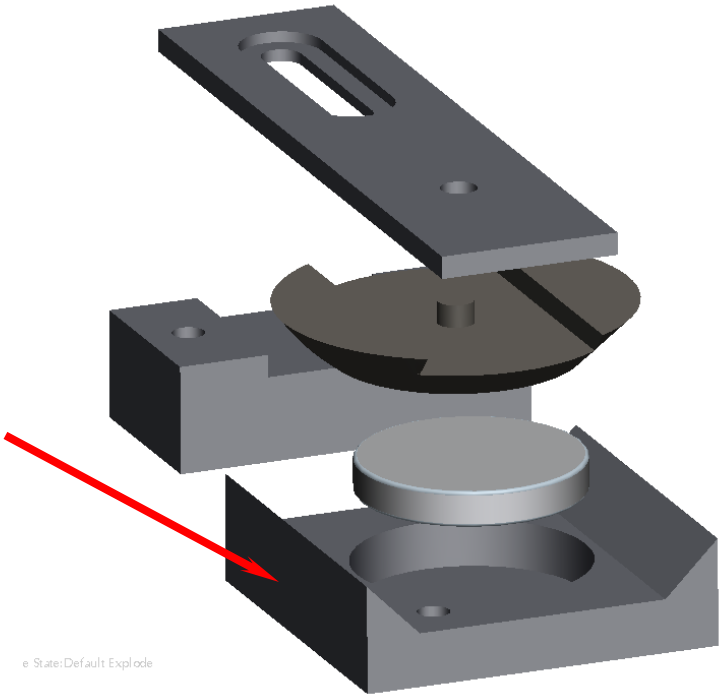
Interlocking Mechanism



Function:

- Houses Armature Arm to adjacent panel

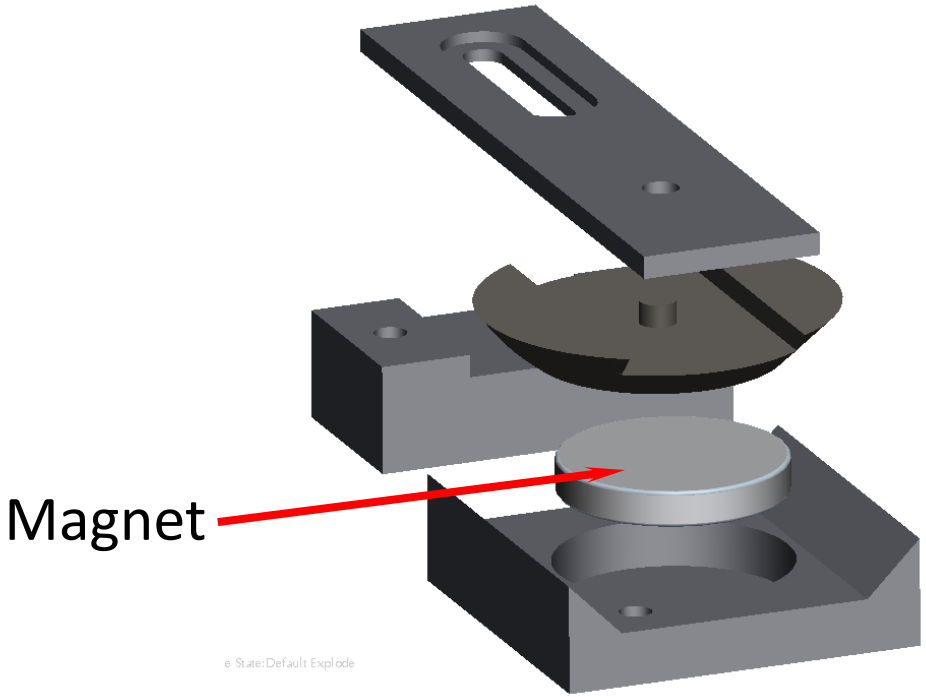
Interlocking Mechanism



Functions:

- Assists with alignment
- Holds Magnet

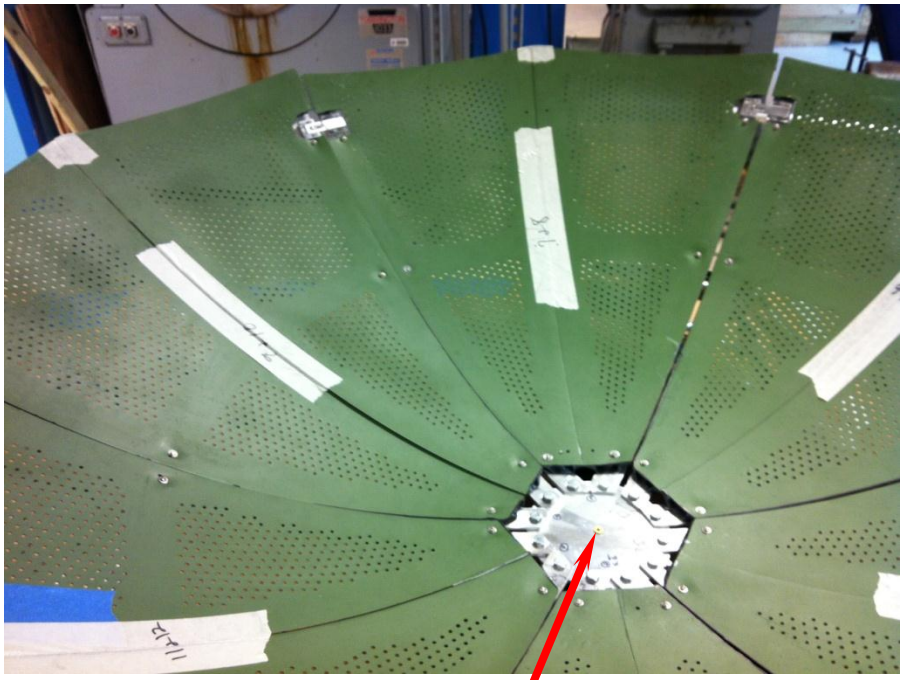
Interlocking Mechanism

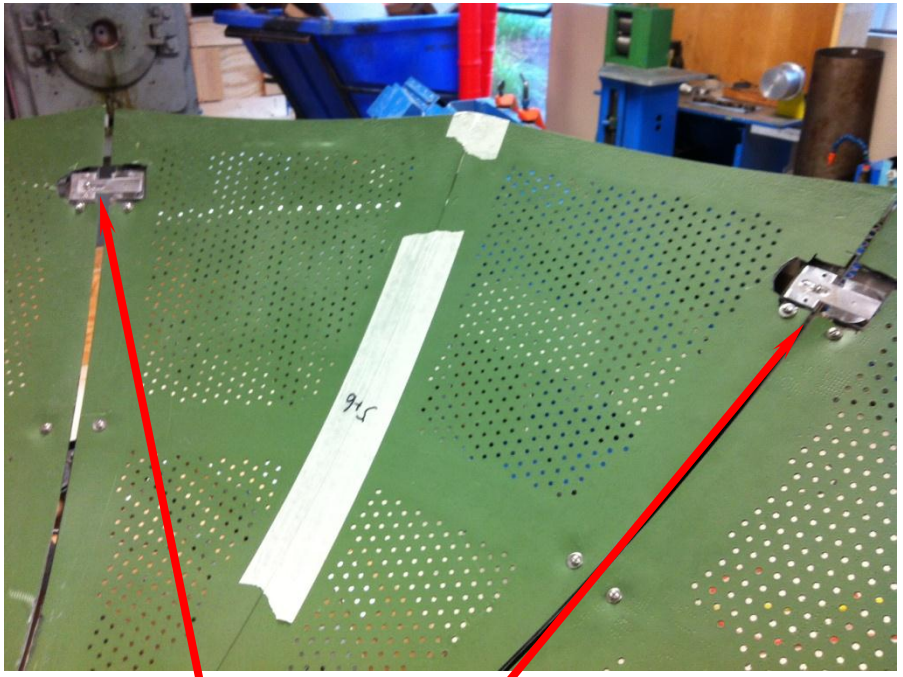


Functions:

- Assists with alignment
- Attracts Cone to V-Block
- Locks assembly

Interlocking Mechanism cont.



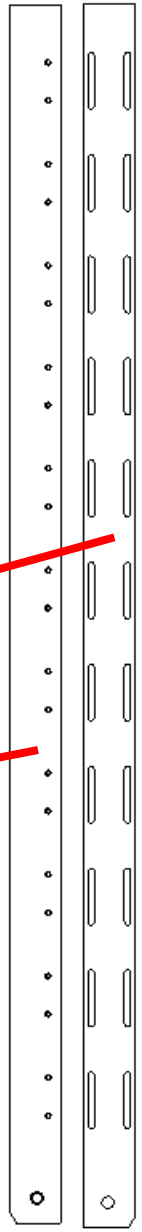


Mount Plate

Interlocking Mechanism

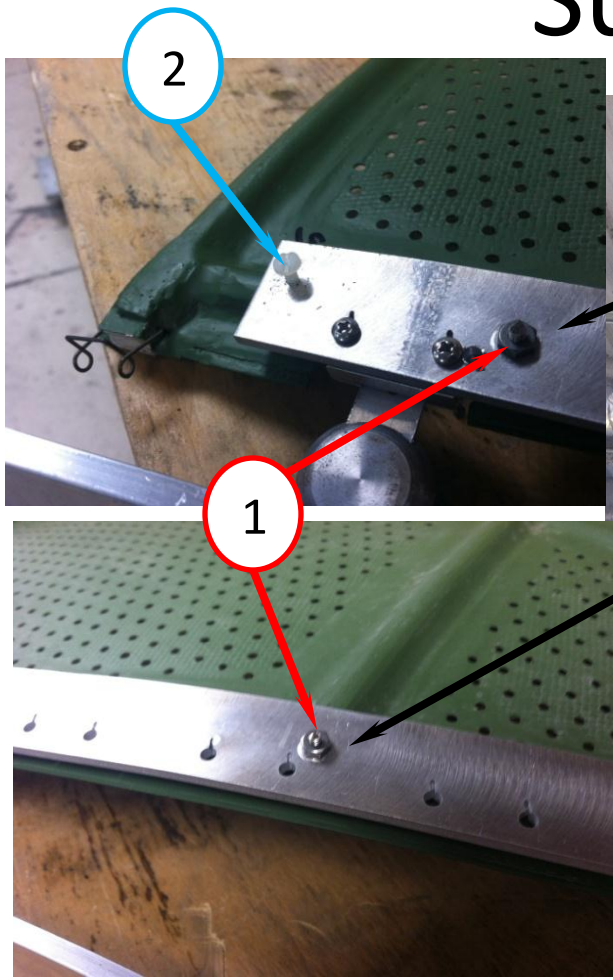
Support Structure

Panel-to-Panel interlocking



Support brackets provide mounting surface for IM

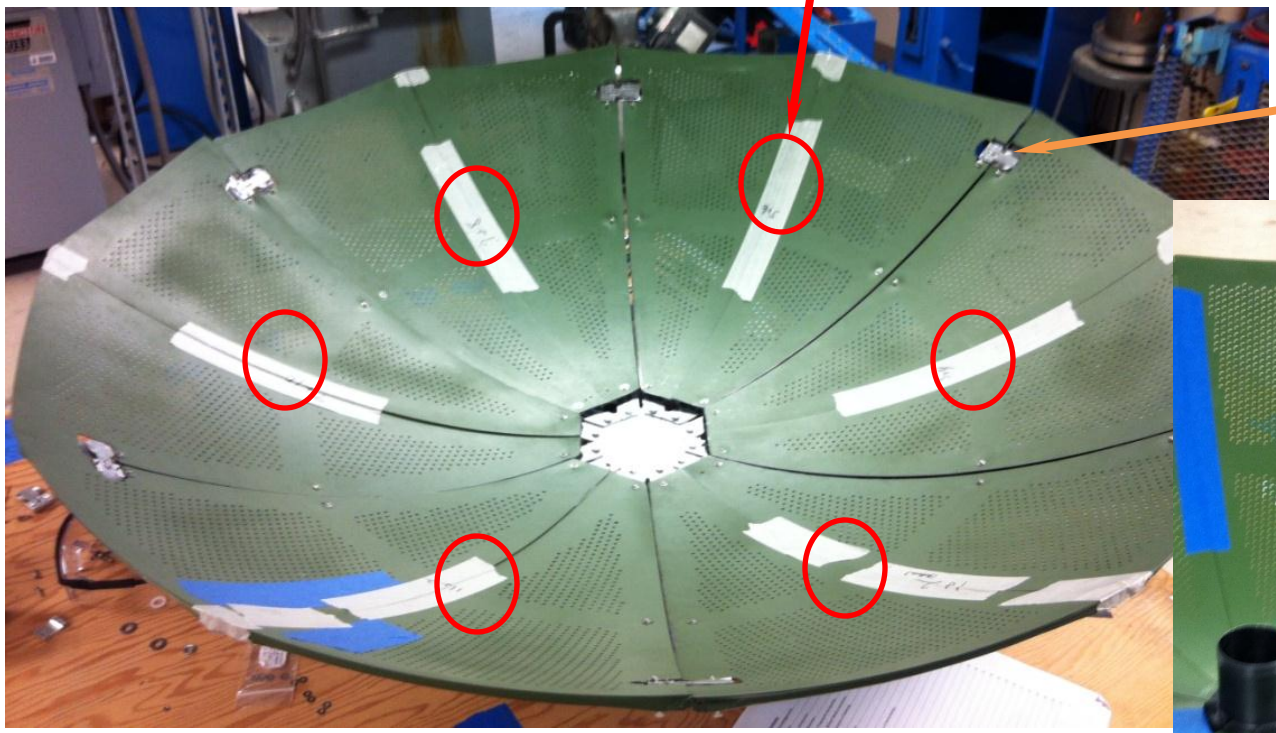
Support Structure



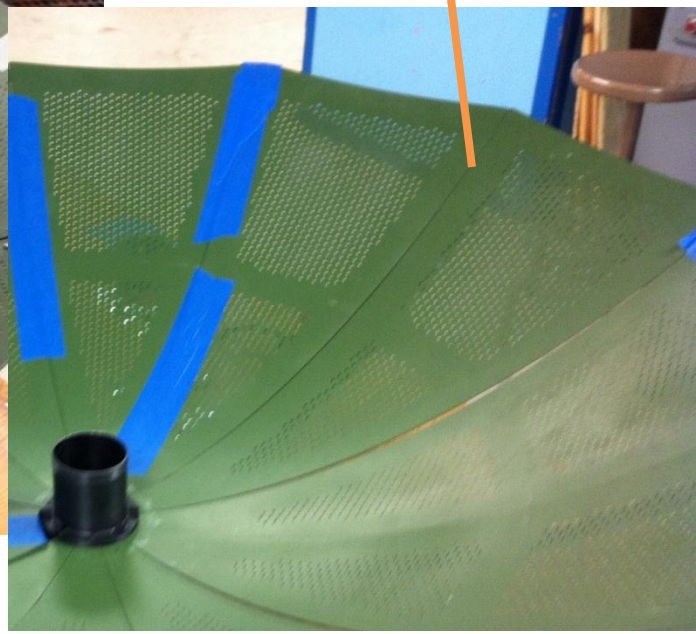
1. Nuts and bolts used to fasten support brackets to panels
2. Plastic screw prevent panels snagging in stowed position

Reflector Surface (Panels)

- Provided with 12 panels by sponsor
- Combined pairs to form 6 rigid panels
  - Tape used for easy removal

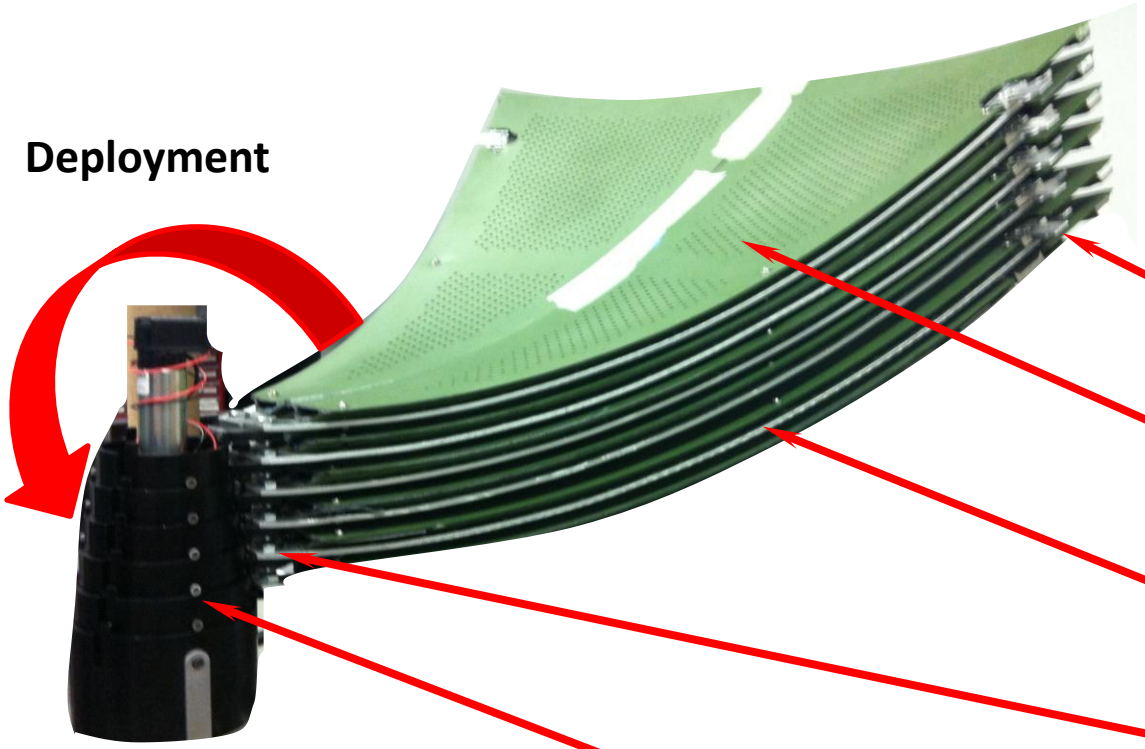


Material removed for IM



Parabolic, continuous dish from reused panels

System



- Interlocking Mechanism
- Stowed Panels
- Support Structure
- Attachment to hub
  - ¼-20 bolt
- Hub mechanism

System Video

Engineering Economics

Vendor	Item Description	Quantity	Unit Price ($)	Total Cost ($)
McMaster Carr	Multipurpose Aluminum Alloy 6061 Rectangular Bars (1/2” x 1” x 3’)	1	17.73	17.73
	Multipurpose Aluminum Alloy 6061 Rectangular Bars (1/8” x 1” x 6’)	4	9.97	39.88
	Multipurpose Aluminum Alloy 6061 Rectangular Bars (1/16” x 1/2” x 6’)	1	2.04	2.04
	Machine able 1117 Low-Carbon Steel Rods (1” diameter x 1’)	2	10.35	20.70
K&J Magnetics, Inc.	Grade N42-Nickel Plated Magnets (5/8” diameter x 1/10” thick)	6	1.40	8.40
			TOTAL:	**88.75**

- Spent $303.20 of allotted $2,500 budget
- Table shows details of funds spent solely on materials used in final prototype
- In making the prototype, cheaper materials still capable of demonstrating the functionality of the system were chosen as opposed to more expensive materials typically used in space

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Magnet Selection

Approximate Permanent Magnet Specifications		
Magnetic Material	**Maximum Working Temperature (°C)**	**Coercive Force (kOe)**
Alnico	540	1,650
Ceramic	400	2,400
Samarium Cobalt	300	9,500
Neodymium	140	10,800

- Coatings can be applied to metals in space to keep "touch temperatures" within a range of -129 to 120°C
- All magnets fall into this range
  - Neodymium magnets have the greatest resistance to becoming demagnetized

Testing

- Neodymium Magnets (3 Variations):
  - Grade N42, thin (5/8” diameter x 1/10” thick)
  - Grade N42, thick (5/8” diameter x 1/8” thick)
  - Grade N52, thick (5/8” diameter x 1/8” thick)
- Two separate tests measuring:
  - Engagement proximity
  - Separation Failure

Engagement Proximity

- Engagement proximity:
  - The minimum distance between the male and female interlocking parts (magnet and cone) before the latching mechanism engages
- Testing method:
  - Using 2 panels, keep one stationary while moving the second towards the first
  - Record distance between top of magnet and bottom surface of cone when latching mechanism begins to engage
  - Repeat using all 3 variations of magnets

Separation Failure

- Separation Failure:
  - The force required to separate the magnet from the cone once the latching mechanism has engaged
- Testing Method:
  - Connect the male and female interlocking assemblies
  - Connect a weight to the bottom of the female assembly
  - Keeping the base of the v-block perpendicular to the ground, increase the amount of weight until separation of the latching mechanism occurs
  - Measure and record the amount of weight required
  - Repeat using all 3 variations of the magnet

Results

Magnet Type	Separation Force Required (Newtons)	Approximate Engagement Proximity (mm)
1/10” thick N42	**7.8**	**6**
1/8” thick N42	**15.7**	**7**
1/8” thick N52	**26.5**	**7**

- Considerable strength increase from N42 to N52 grade
- Engagement Proximity did not improve from N42 to N52 grade
  - Affected more by size of magnet

Conclusions

- Constructed working prototype that demonstrates Tangentially Deploying Solid Reflector (TDSR) concept as sponsor requested
- **Interlocking Mechanism (IM)**
  - ✓ Joins panels and locks
- **Support Structure**
  - ✓ Prototype is rigid
  - ✓ Provides mounting surface for IM
  - ✓ Interfaces with hub mechanism
- **Reflector Surface (Panels)**
  - ✓ Prototype resembles a parabolic, continuous dish
  - ✓ Reused materials

Questions?