ACT-08-0082
Large Aperture, Solid Surface Deployable Reflector

Earth Science Technology Forum

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Crystal City Sheraton

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Project Background

- Deployable RF reflector to provide larger apertures for earth science missions
  - Unique concept design similar to TDRS but using shape memory polymer materialsj
  - Offset-Fed reflector for clear aperture and clean data
  - Intermediate solution between rigid reflectors and deployable mesh reflectors
  - Solid surface for high frequency capability
- Advanced Component Technology (ACT) Funding from ESTO started in February 2009.
- Cross-cutting technology applicable to RF communications, RADAR, and radiometry
  - Technology feasibility demonstrated on internal funding
  - Commercial backing from S/C Prime contractor for tooling
  - Also builds on center-fed reflector demonstration

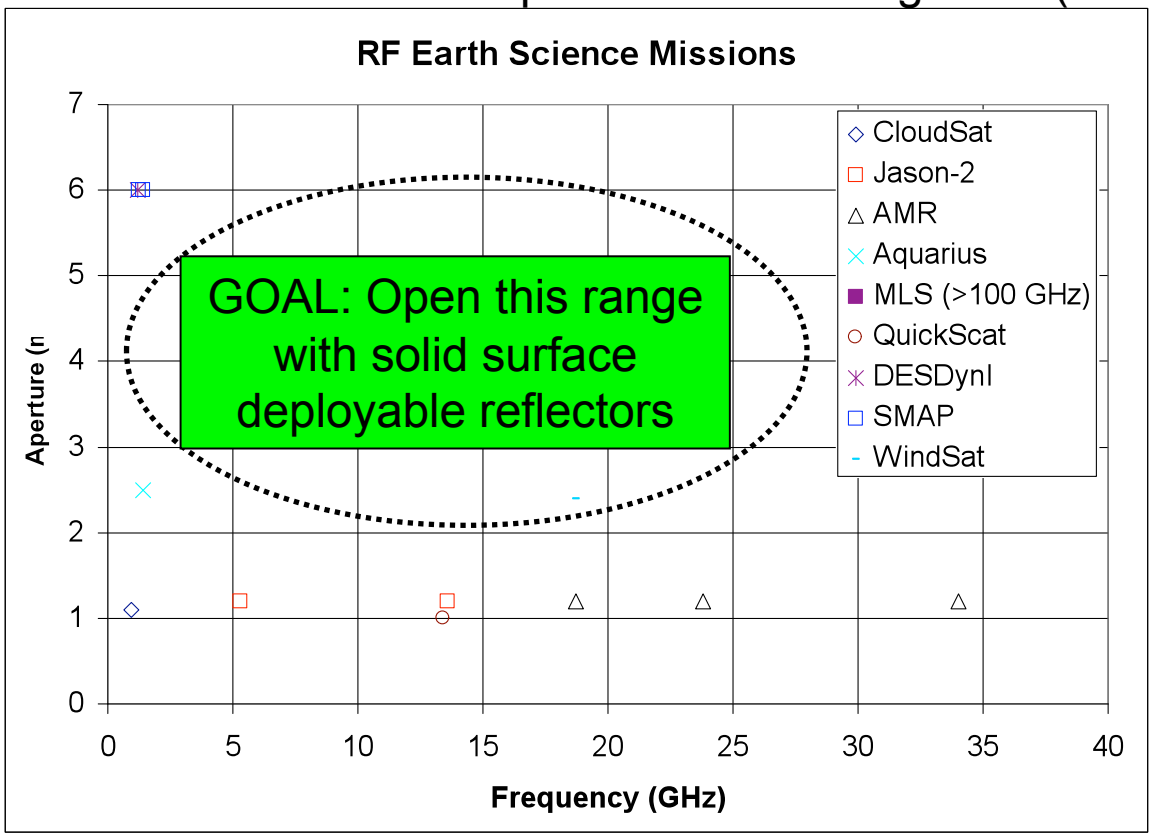
Why larger apertures?

- Performance
  - Optical resolution of an ideal telescope defined by λ/D
    - Larger apertures more critical for lower frequencies
  - Signal strength determined by gathering area
    - Passive RF likely to be dominated by signal/noise ratio
    - Active RF power requirements driven by signal strength
- Why not larger apertures?
  - Missions will only be designed to use what can be built and launched within budget
    - If no one knows you can build it, they won't design for it.

TDRS installed in Delta II Fairing

What Earth Science Missions Have Used So Far

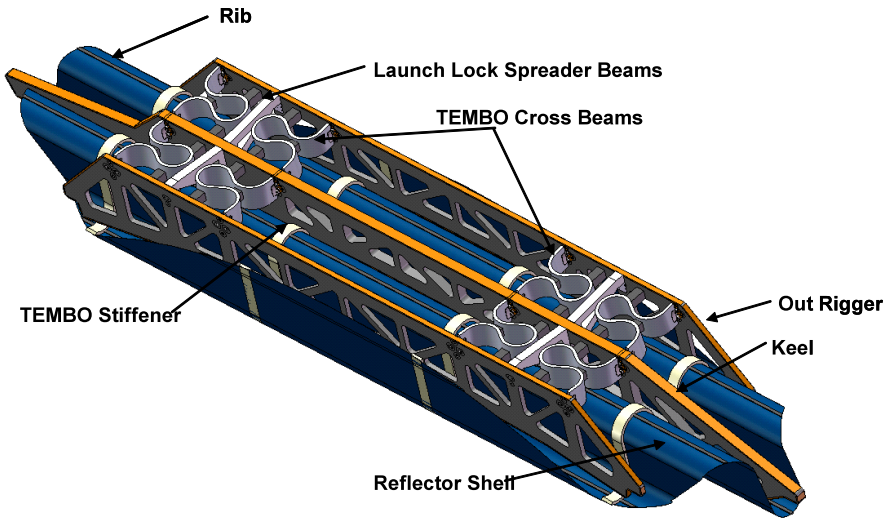
- Nearly all sensors have had small ~1m apertures
  - Some 2.5m apertures for dedicated launches
  - Science missions can't consume larger footprints unless they are a flagship mission
  - 6m and 12m mesh apertures now being used (still small footprint)

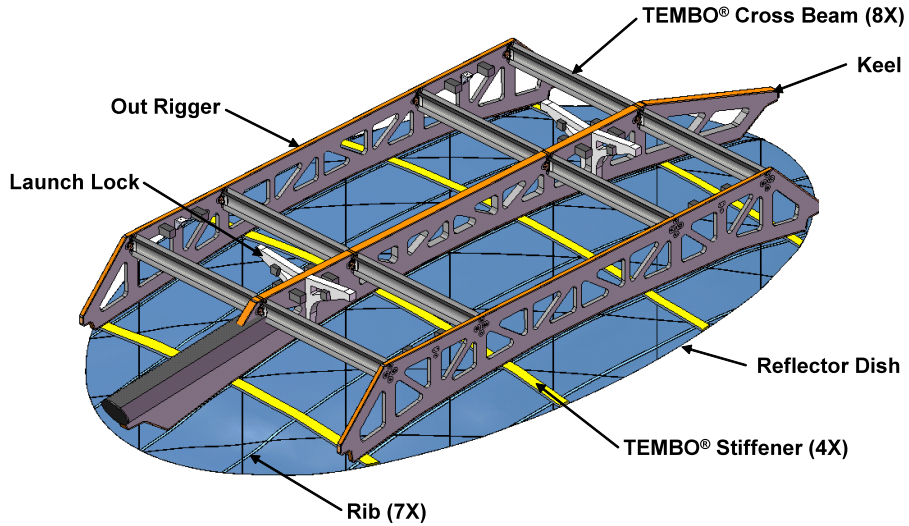


Plot does not show λ/D relationship

Solid Surface Deployable Reflector

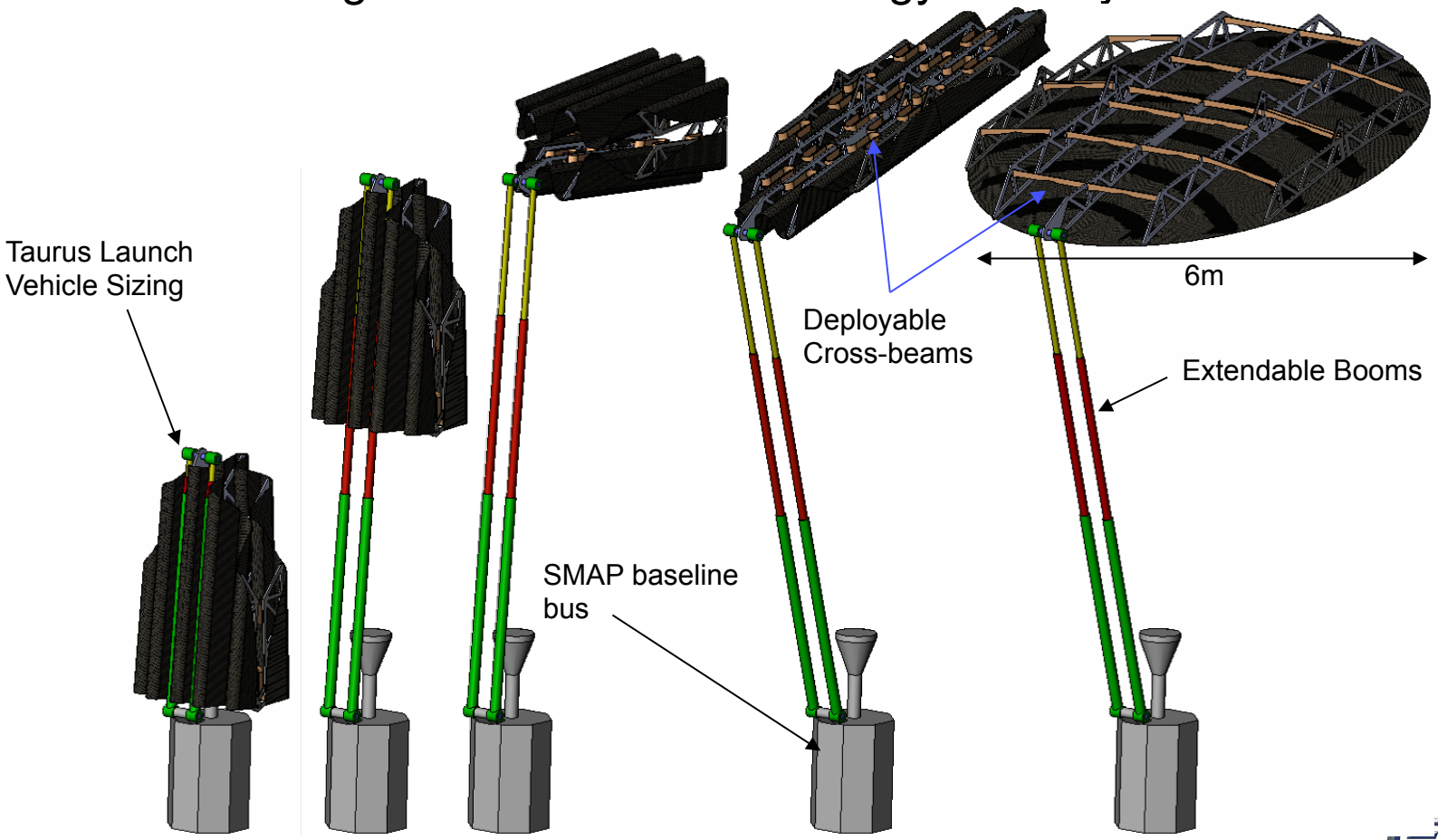
- Offset fed RF reflector that packages to 1/3 width
  - Continuous graphite reflective surface
    - Low CTE
    - Can be metallized for high frequency RF
- Demonstration unit will use reflective surface from available 2.5m by 4m mandrel





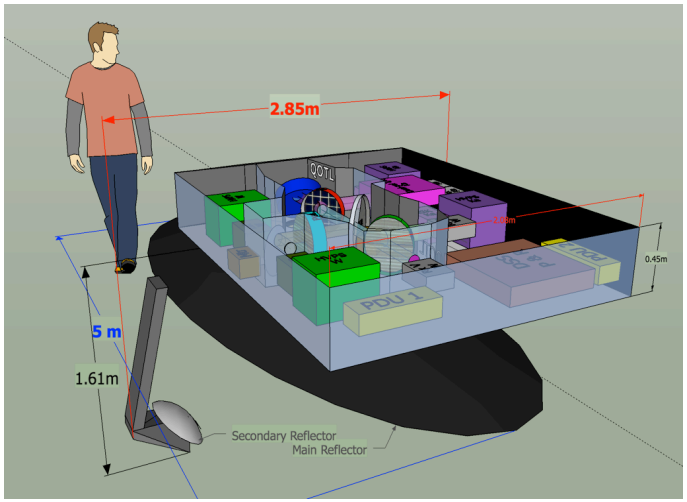
Baseline program was SMAP

- Offset fed provides clean aperture
- Solid surface reflector accurate to Ka band
- SMAP timing not feasible for technology maturity



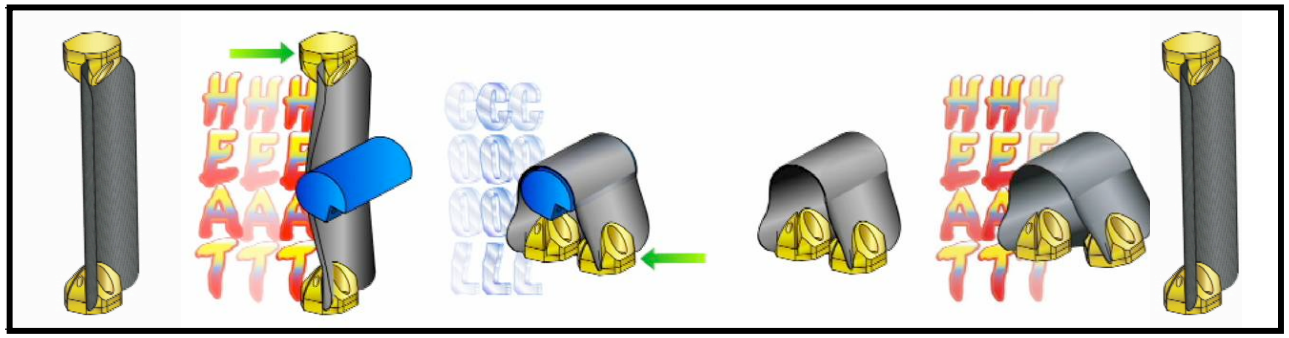
Other Possible Applications

- ACE
  - Baseline for 5m main and secondary reflectors require very large volume
  - High frequency, 94 GHz very challenging
- SCLP
  - Large aperture needed to get resolution required
  - RF frequencies in ideal bands for CTD reflectors
  - No baseline design yet??
- Specific mission definition critical for TRL advancement



Original ACE configuration, Ka and W-Band

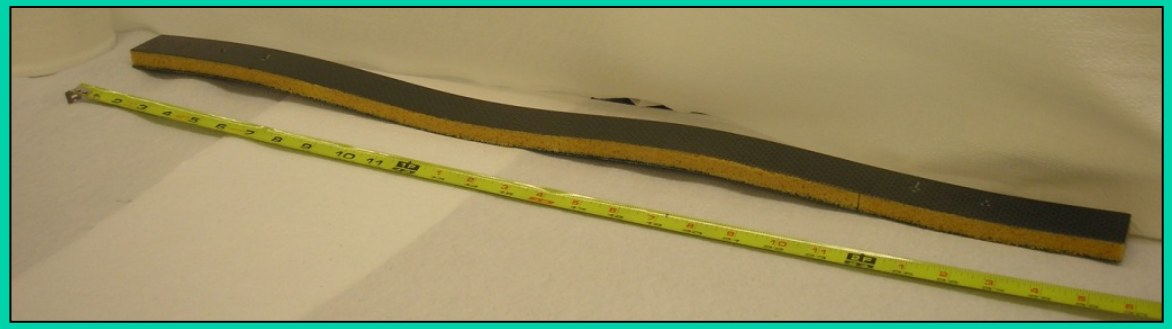
Enabling Technology: TEMBO® Elastic Memory Composites



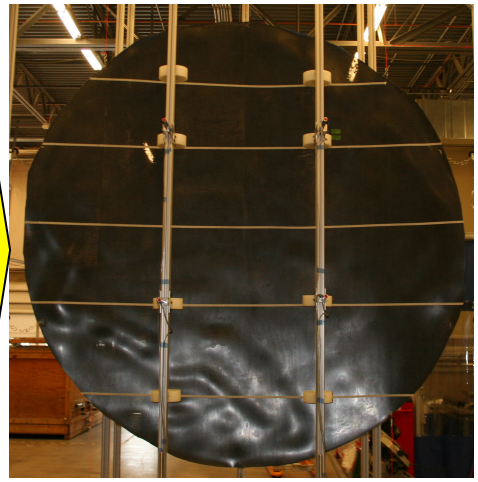
TEMBO® Thermo-mechanical Process

- A Multifunctional Structure/ Actuator
- TEMBO® Elastic Memory Composite (EMC) can be used both as deployment mechanism and deployed structure
- Low Part Count results in low cost
- Repeatable, micron level precision

TEMBO® Stiffener

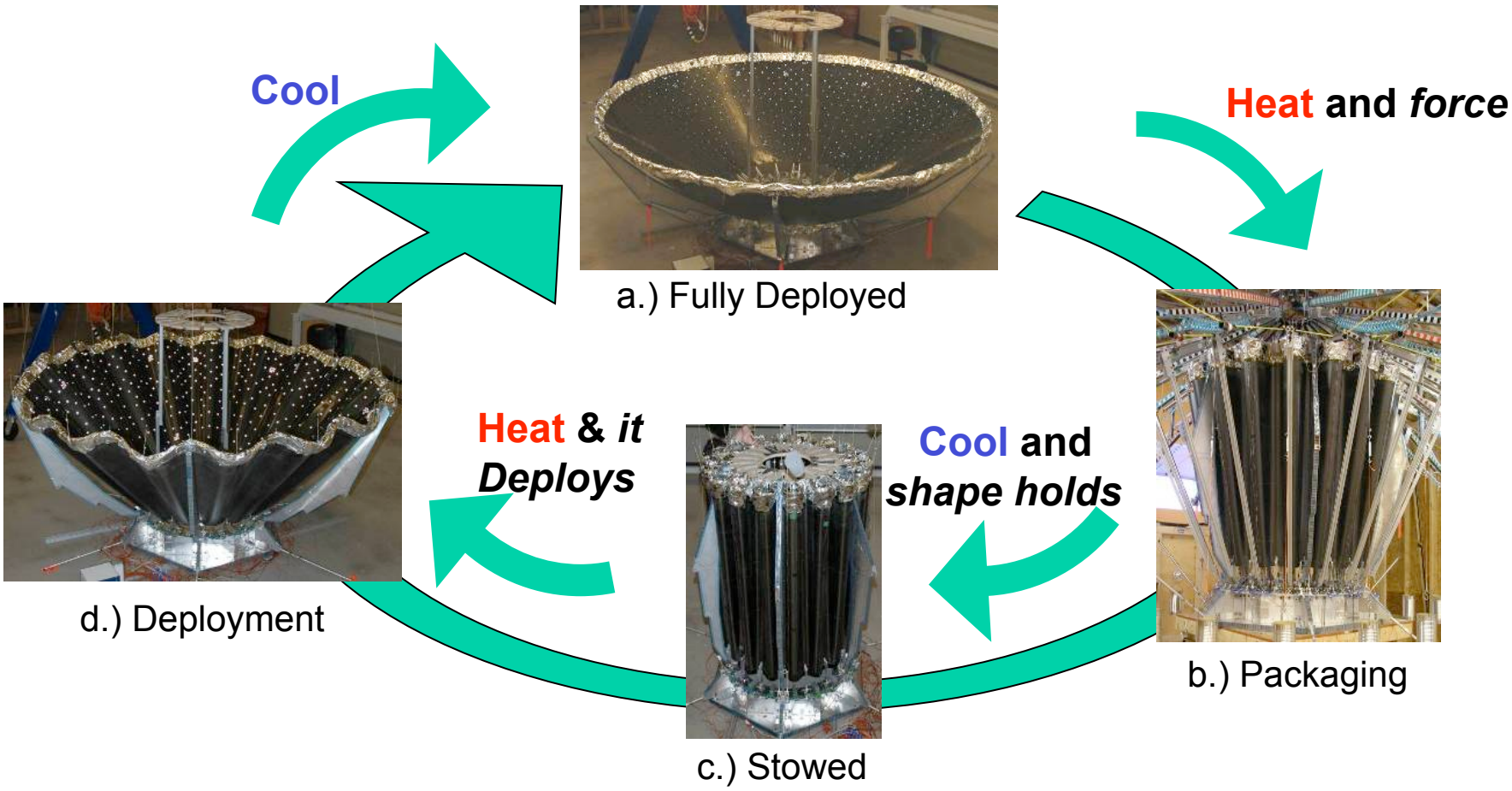


TEMBO® stiffener as manufactured with “shaping”

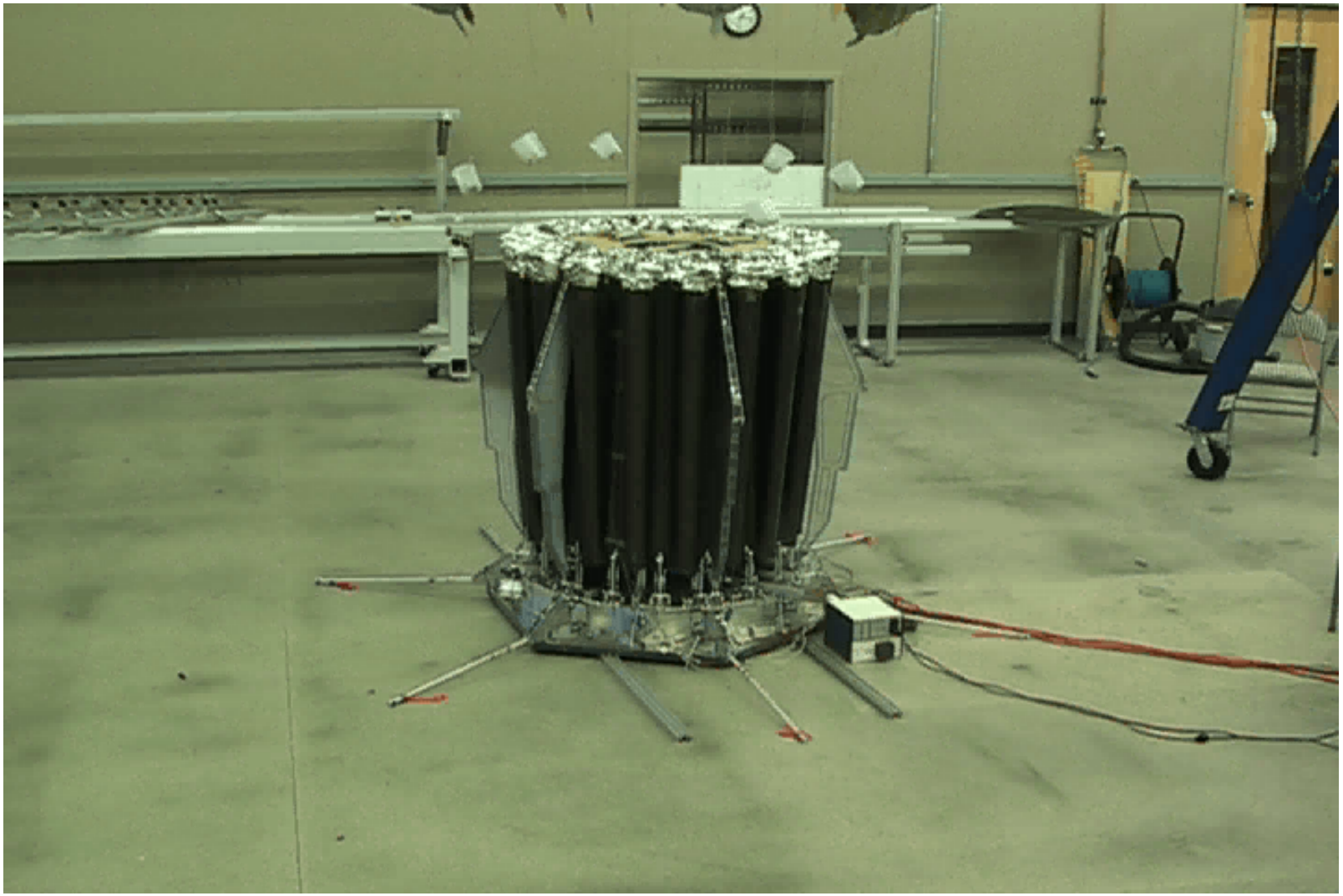


Packaged TEMBO® stiffener with “shaping”

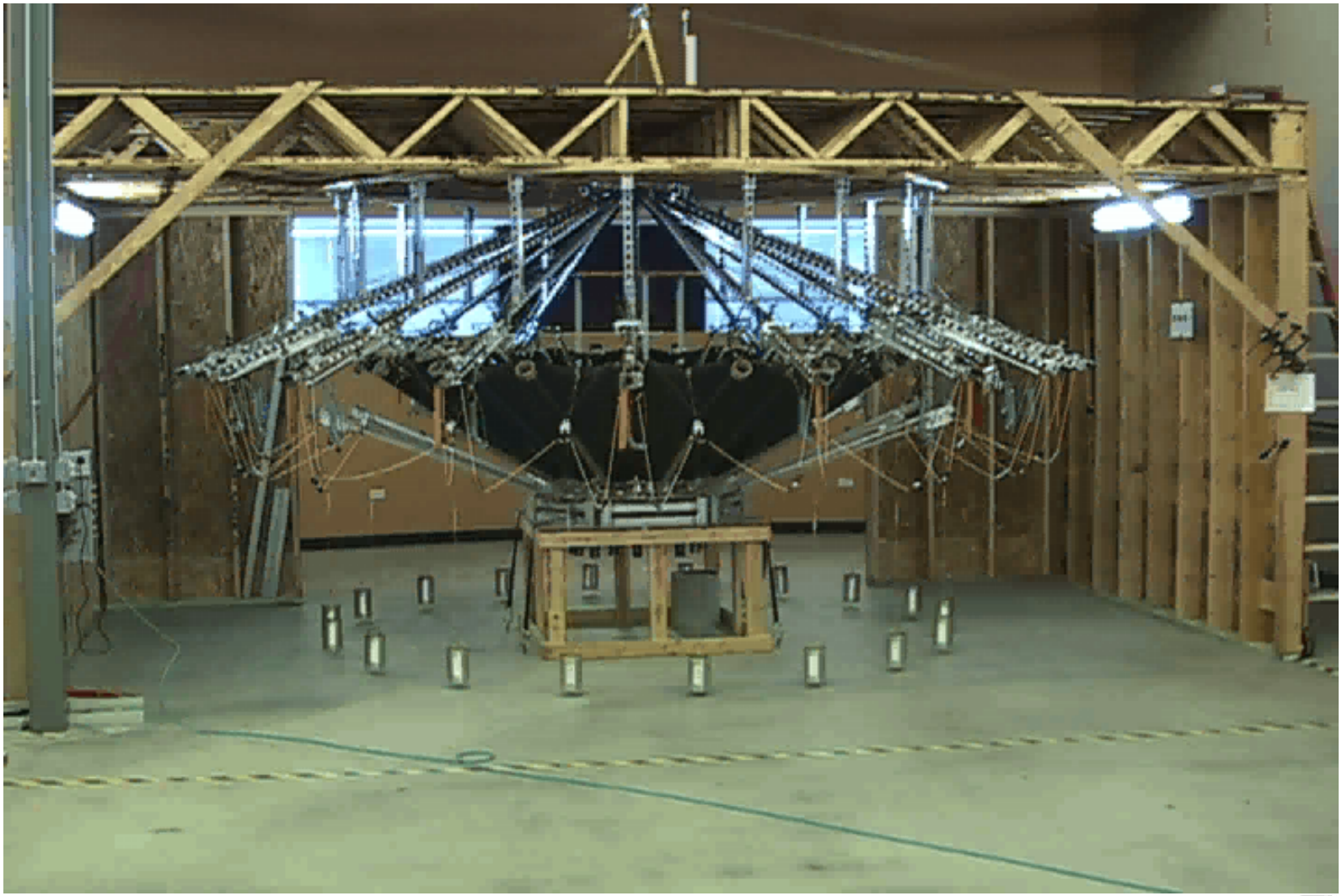
Packaging and Deployment Cycle with Center-Fed Parabolic Reflector



Center-fed Reflector Deployment



Center-fed Reflector Packaging



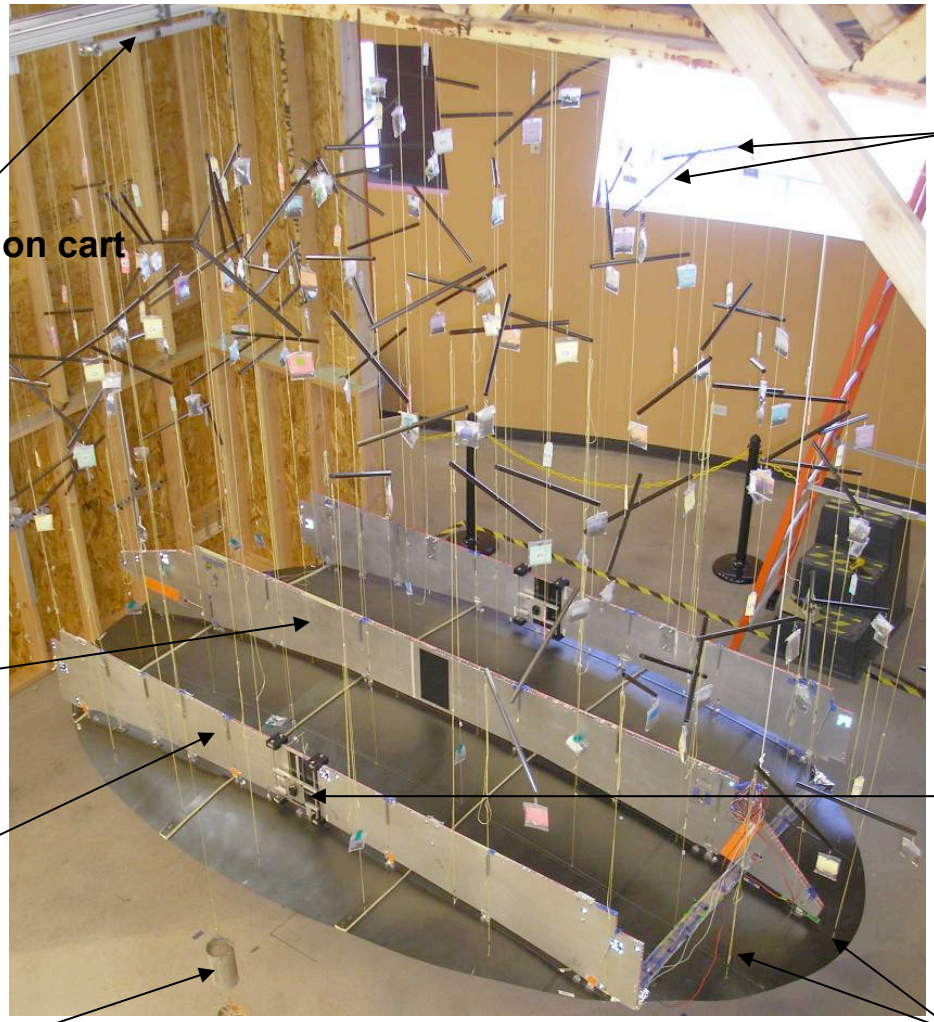
Offset Reflector Packaging

1. Pull tension on edges of reflector (vertical and horizontal)
2. Apply an opposing buckling force at the 5 vertical tooling beams to initiate the wave shape
3. Draw both outer edges in to complete the wave shape
4. Move the beams to drive the reflector into a tighter package
   - The two outboard backside beams move inward towards the center beam which is stationary
   - Front side beams also move towards the center but at half the speed and apply load and moves with the pleat towards the back of the reflector.

Prepackaged: Full cross-section

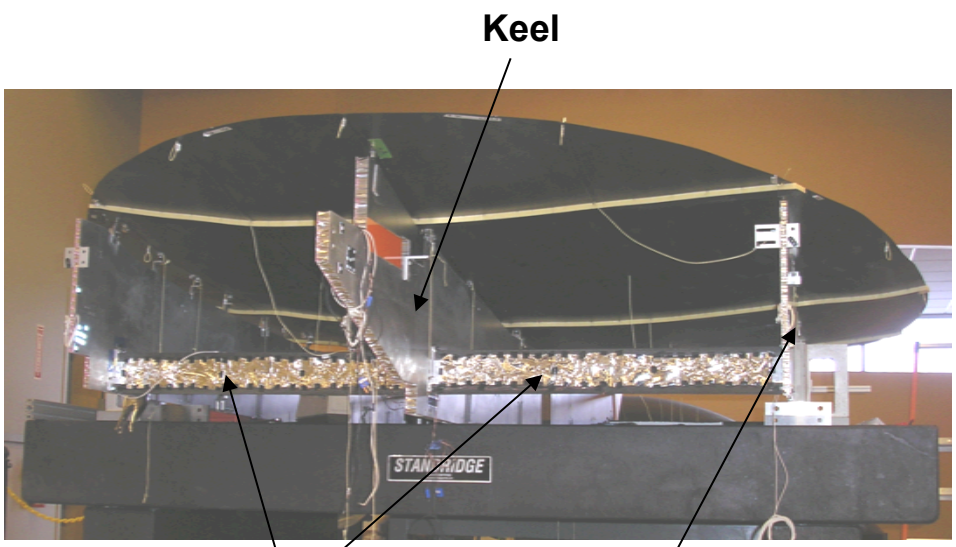
100% Packaged

Offset Fed Reflector and Backing Structure Offloaded



Offset-Fed Reflector Backing Structure Integration

- Cross beams fabricated
  - Eight cross beams manufactured
  - Each cycled through stowage/deployment
  - Match bonded into backing structure



TRL Status and Plans

- Entry TRL = 2
  - Concept defined for specific application
- Current TRL = 3
  - **Achieved at end of third quarter 2009**
  - Demonstration of packaging/deployment of all required elements for reflector including cross beams, gap closers, and reflector shell
- TRL = 4
  - Expected third quarter 2010
  - Proof-of-concept through packaging and deployment of 2.5m by 4m reflector
- TRL = 5
  - Expected end of 2011
  - Completion of packaging, deployment, and environmental testing of a mission specific 4m reflector
  - Requires sufficient definition of representative mission to simulate environment including S/C interface and mounting

Key Milestones

- Identify baseline program and develop specific requirements
- Develop system design for baseline program
- Identify technology gaps and customize technology roadmap
- Complete fabrication of demonstration unit
- Perform RF testing of demonstration unit
- Package and deploy demonstration unit
- If additional funding available from commercial source, environmental testing of demonstration unit