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

Earth Science Technology Forum

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Outline

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  - Tembo® Shape Memory Composites
  - Solid Surface Deployable Reflector
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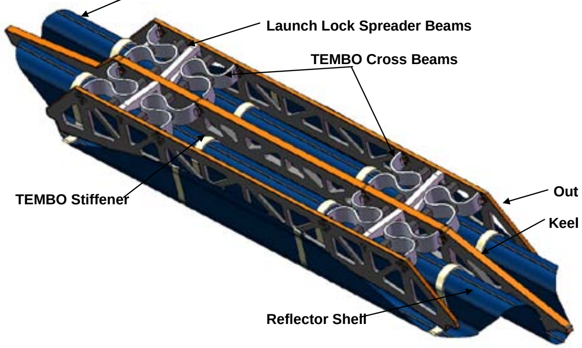
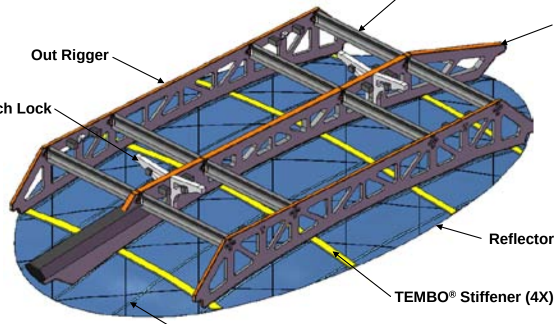
  - Thermal analysis
  - Full-scale deployments
- ACE Conceptual Study
  - Packaged and deployed configuration
  - Thermal analysis
  - Structural analysis





CTD Company Overview

- Founded 1988: 37 Employees - 90% technical, 30% with M.S. or Ph.D.
- Goal: Commercialize novel or disruptive products into a variety of markets
- The development of novel materials is core to this process

Novel Materials + Engineering Innovation + Creative Manufacturing = Enabling Products

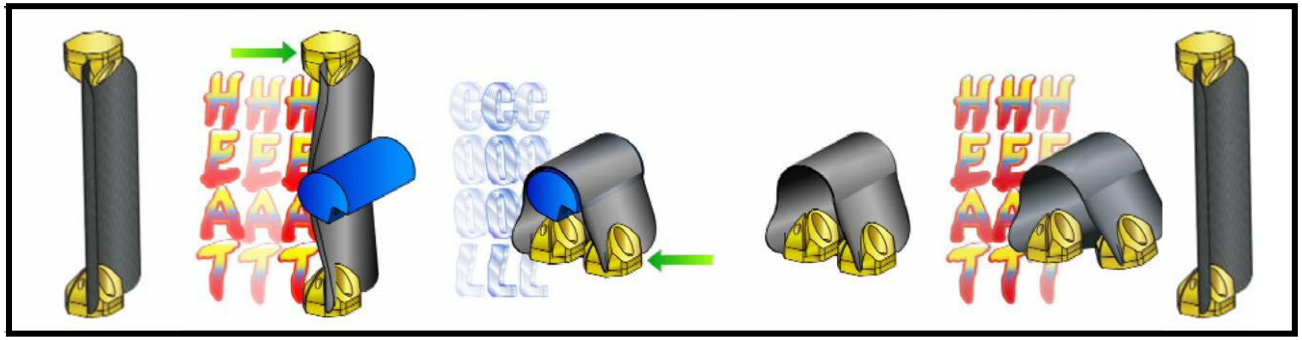
ERNST & YOUNG ENTREPRENEUR OF THE YEAR®

Winner 2007

CTD President
Dr. Naseem Munshi

- Purpose-designed materials - part of engineering process
- Innovative engineering methods and analysis validated through test
- Creative Manufacturing of prototypes - demonstrates product benefits

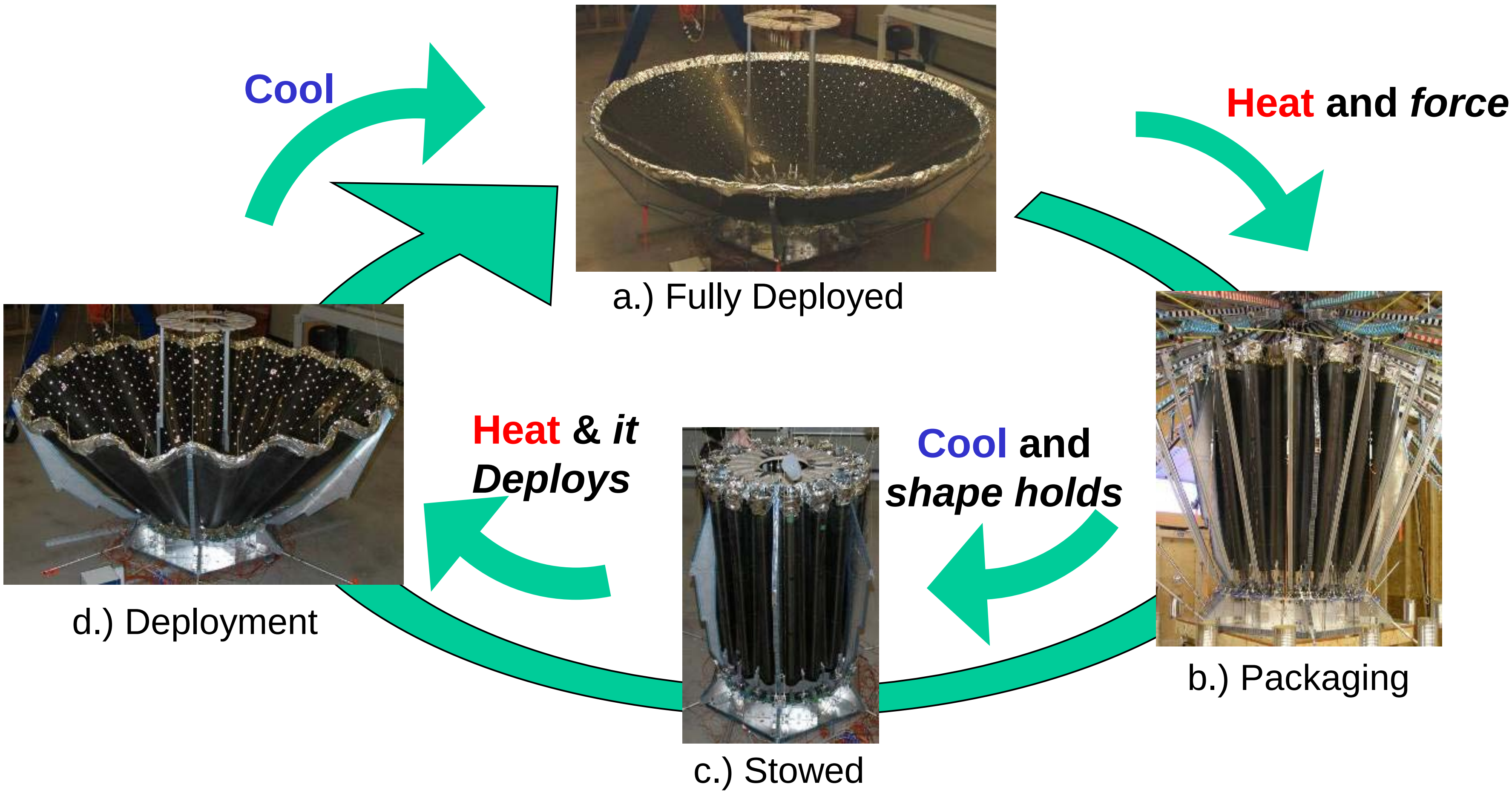
Enabling Technology: TEMBO® Elastic Memory Composites



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

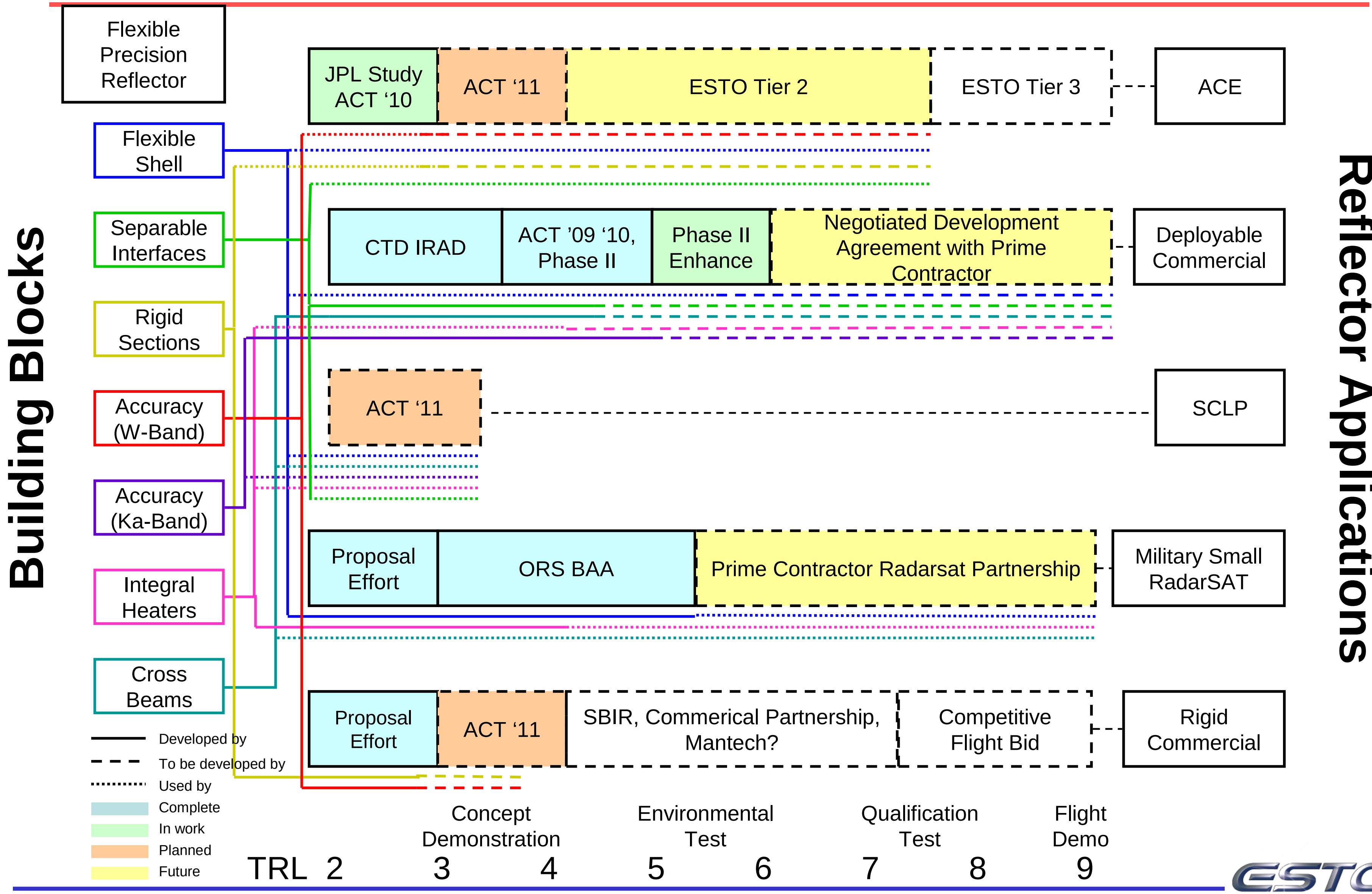
Packaging and Deployment Cycle with Center-Fed Parabolic Reflector



Solid Surface Deployable Reflector Background

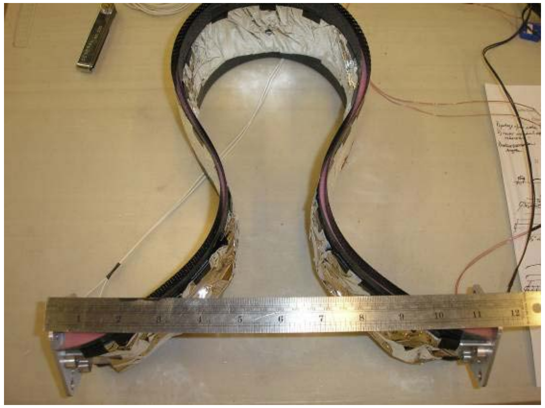
- Deployable RF reflector to provide larger apertures for earth science missions
  - Unique concept design using continuous flexible graphite composite reflective surface
  - Shape memory polymer used to create deployable structural elements
  - Family of reflector technologies to meet different mission needs
  - Intermediate solution between rigid reflectors and deployable mesh reflectors
- Advanced Component Technology (ACT) Funding from ESTO started in February 2009.
- Cross-cutting technology applicable to RF communications, RADAR, and radiometry
  - Funding from S/C Prime for extended testing of offset reflector
  - Cooperation with APL for deep-space reflector technology
  - Original development funded by Navy for small spacecraft radar

Task 1: Flexible Precision Reflector Technology Roadmap

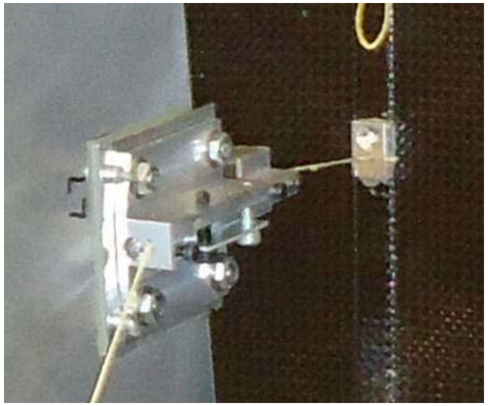


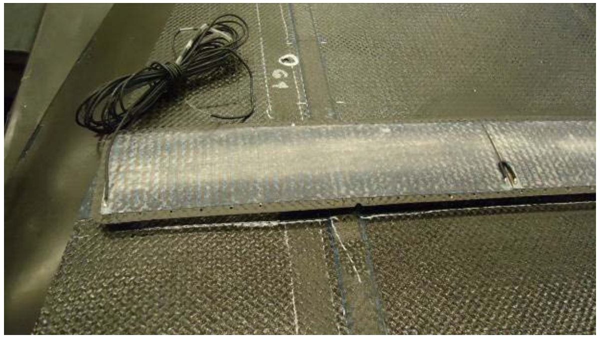
Building Blocks

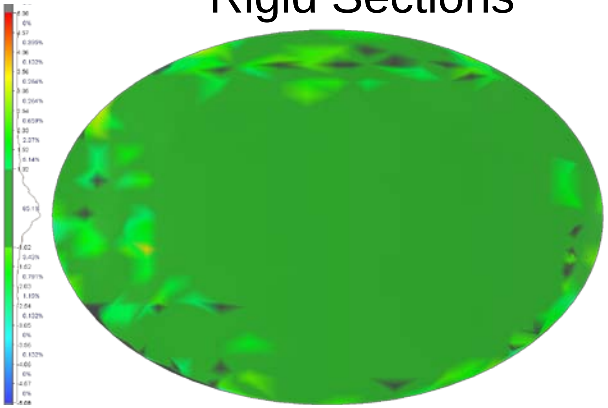

Flexible Shell


Crossbeams


Rigid Sections

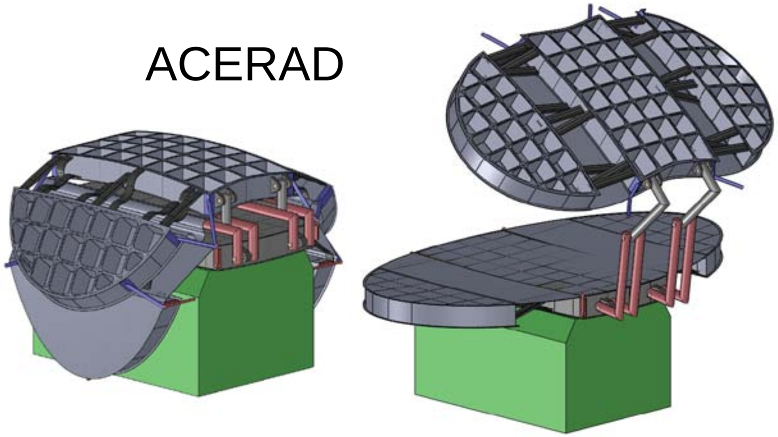

Separable Interfaces


Integral Heaters

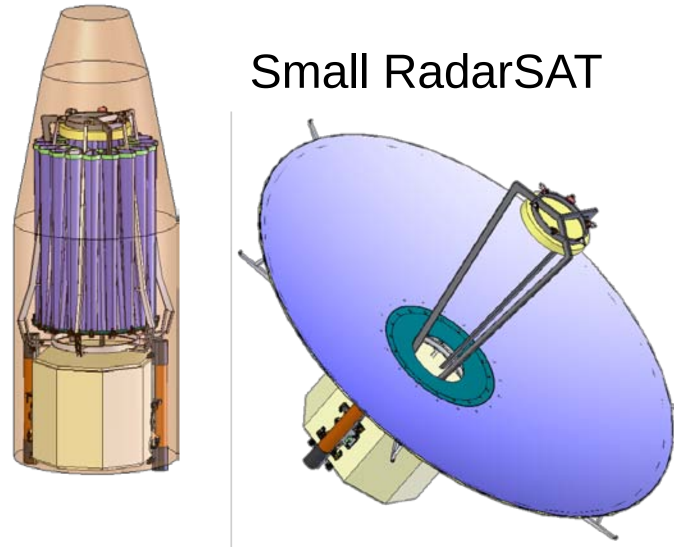

Surface Accuracy/Tuning

Reflector Applications

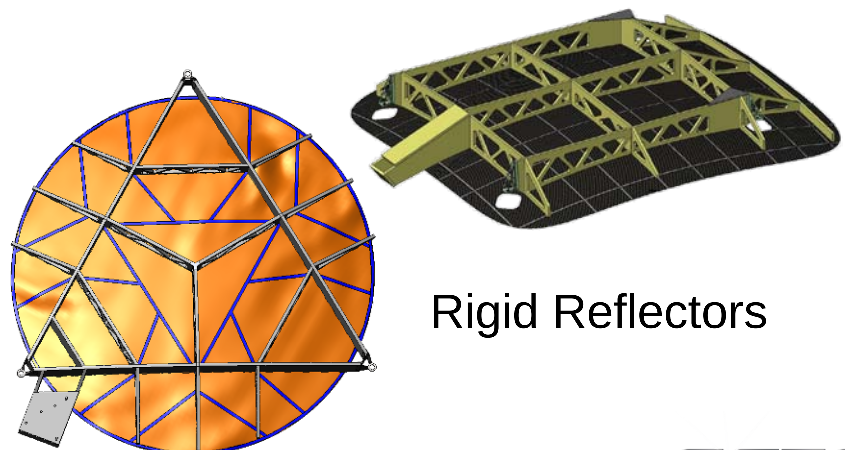
ACERAD



Small RadarSAT



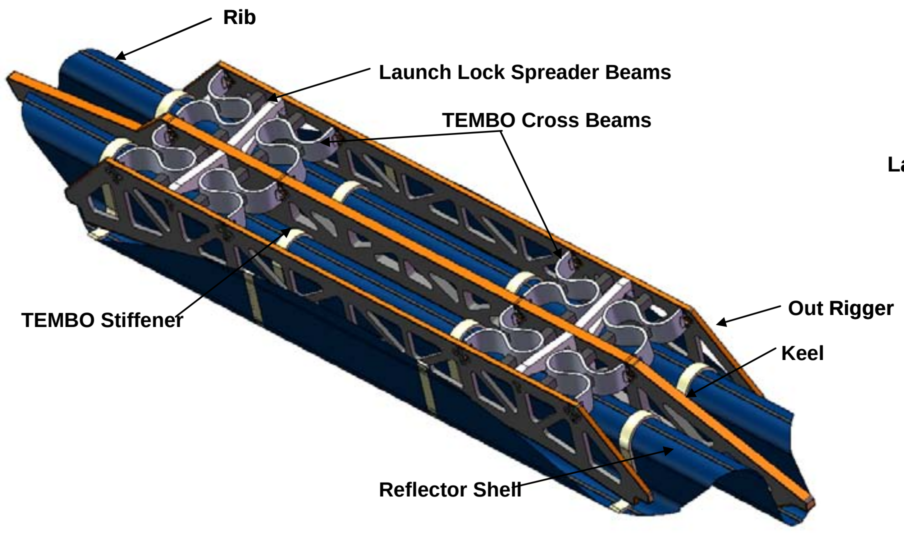
Commercial Deployable

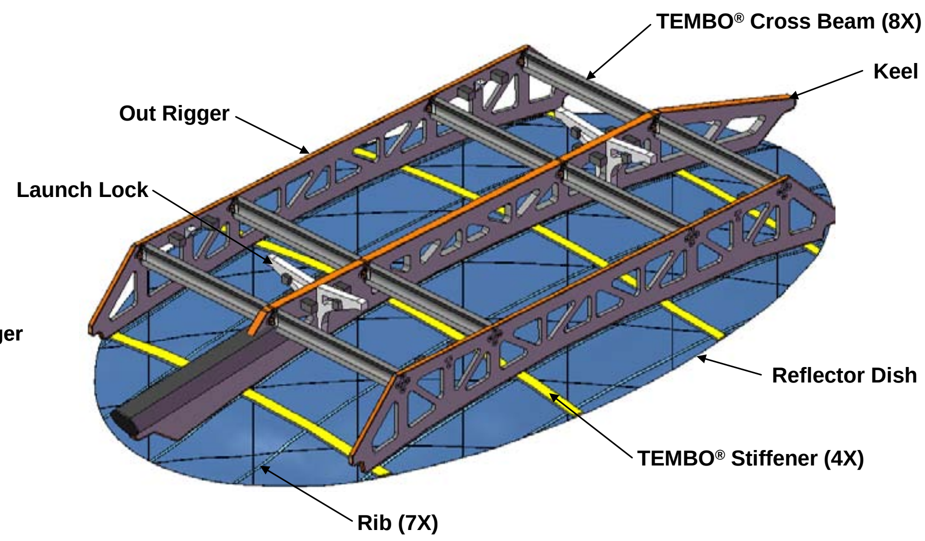


Rigid Reflectors

EDU Reflector Development

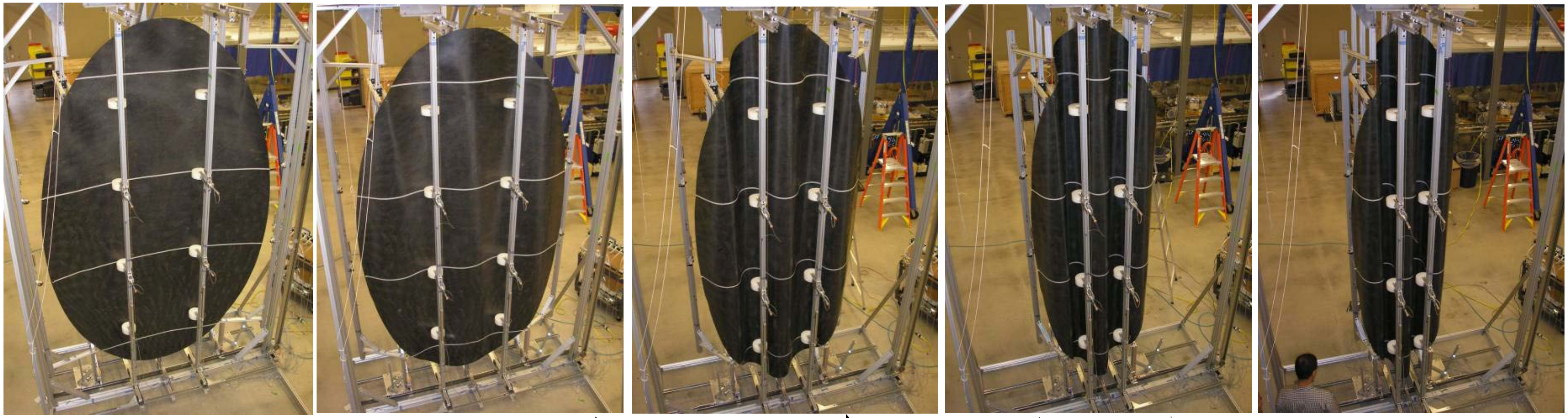
- Demonstration of full-scale reflector to reach TRL 4
  - Cross beams, flexible surface, integral heaters, and separable interfaces
- Offset fed RF reflector that packages to 1/3 width
- Configuration is offset-fed parabolic, mold includes shaping





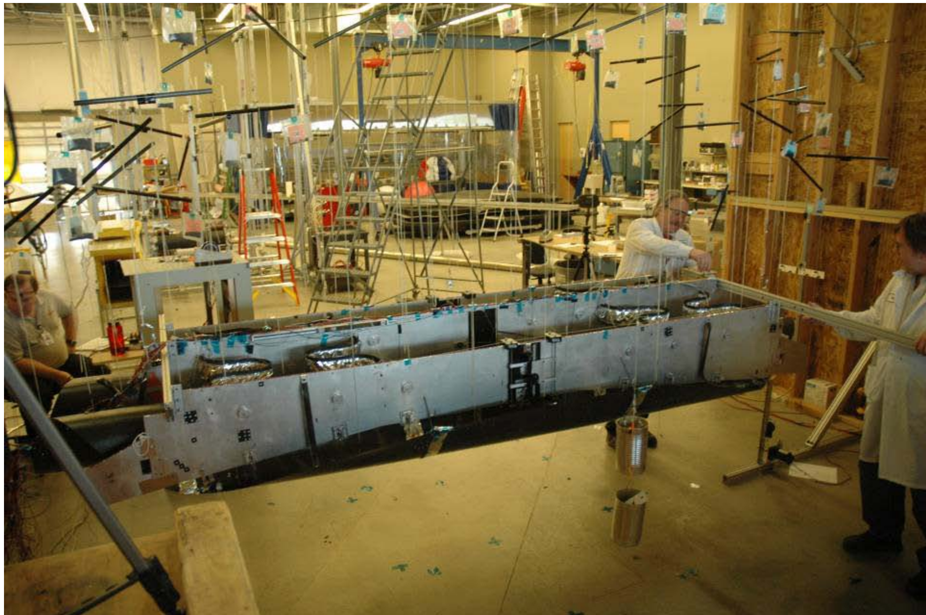
EDU Reflector Packaging

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.

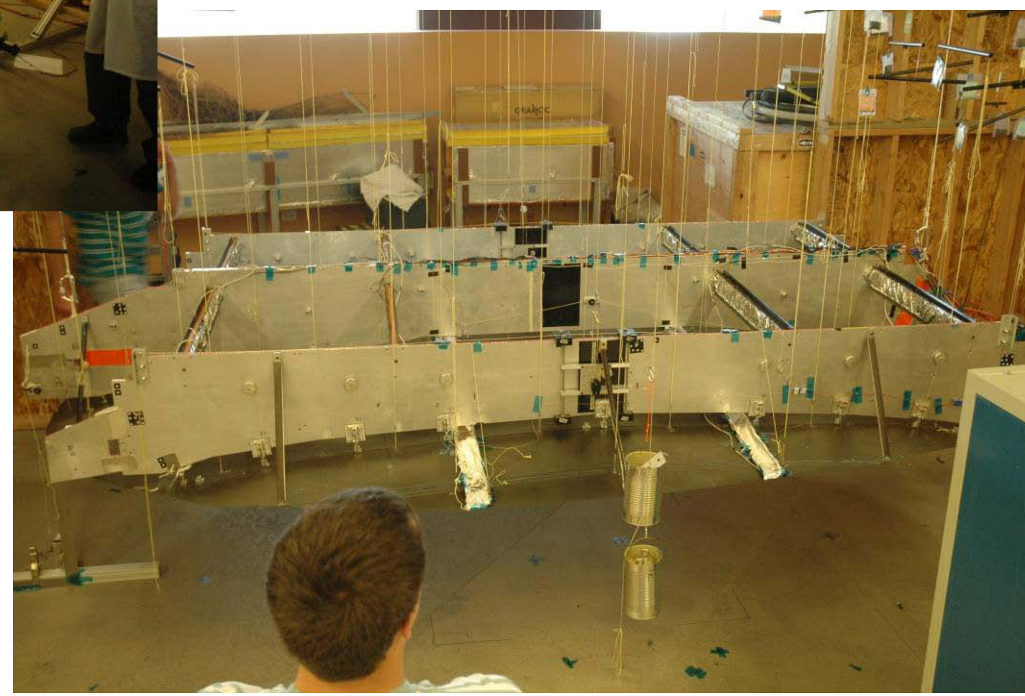


Prepackaged: Full cross-section → → → → **100% Packaged**

EDU Deploment #2

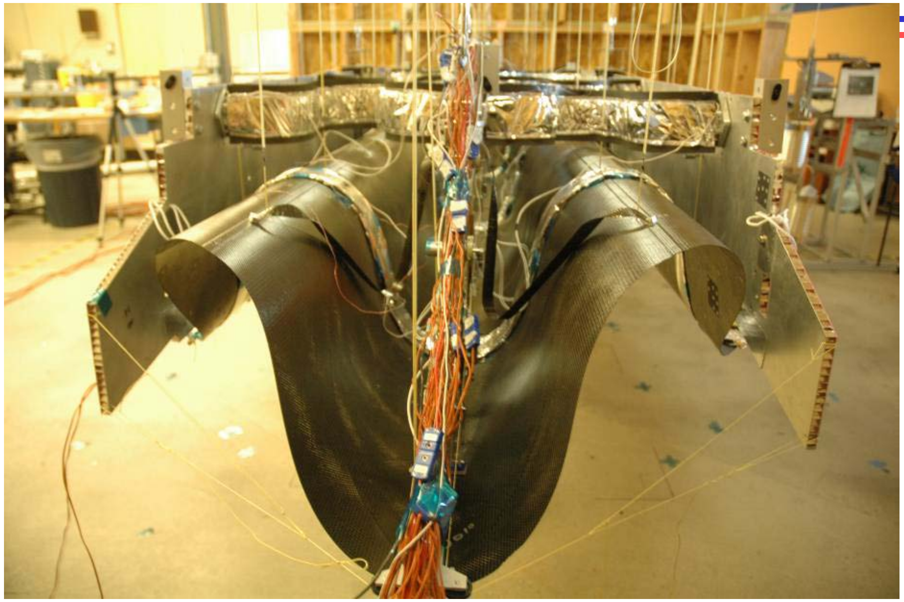


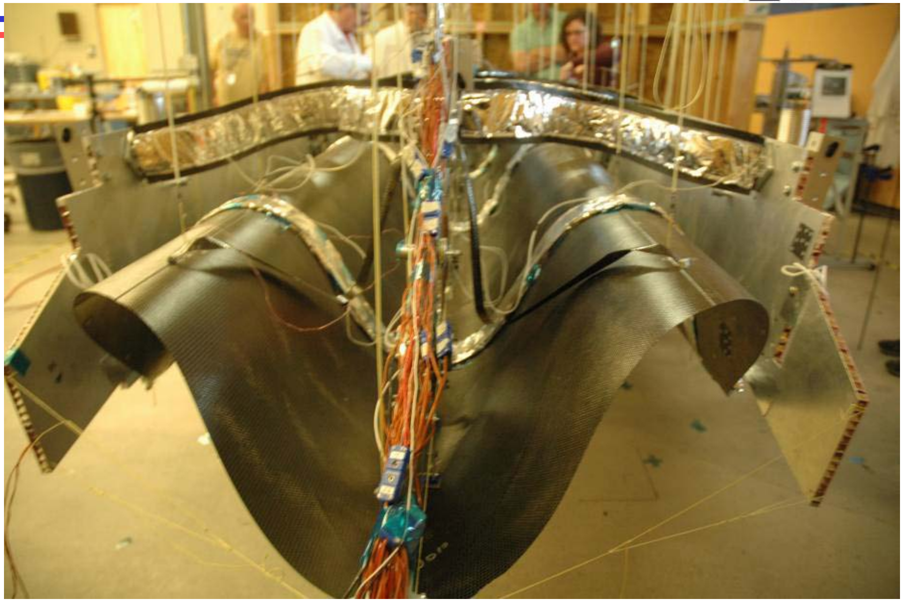
- Initial position, 0.9m wide

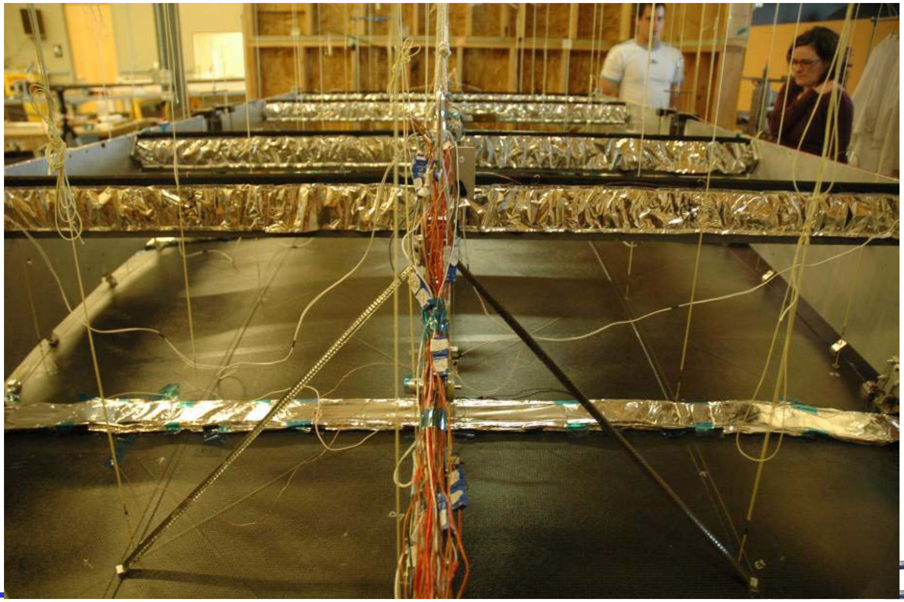


- Final position, 2.5m wide

EDU Deployment #2 – End View

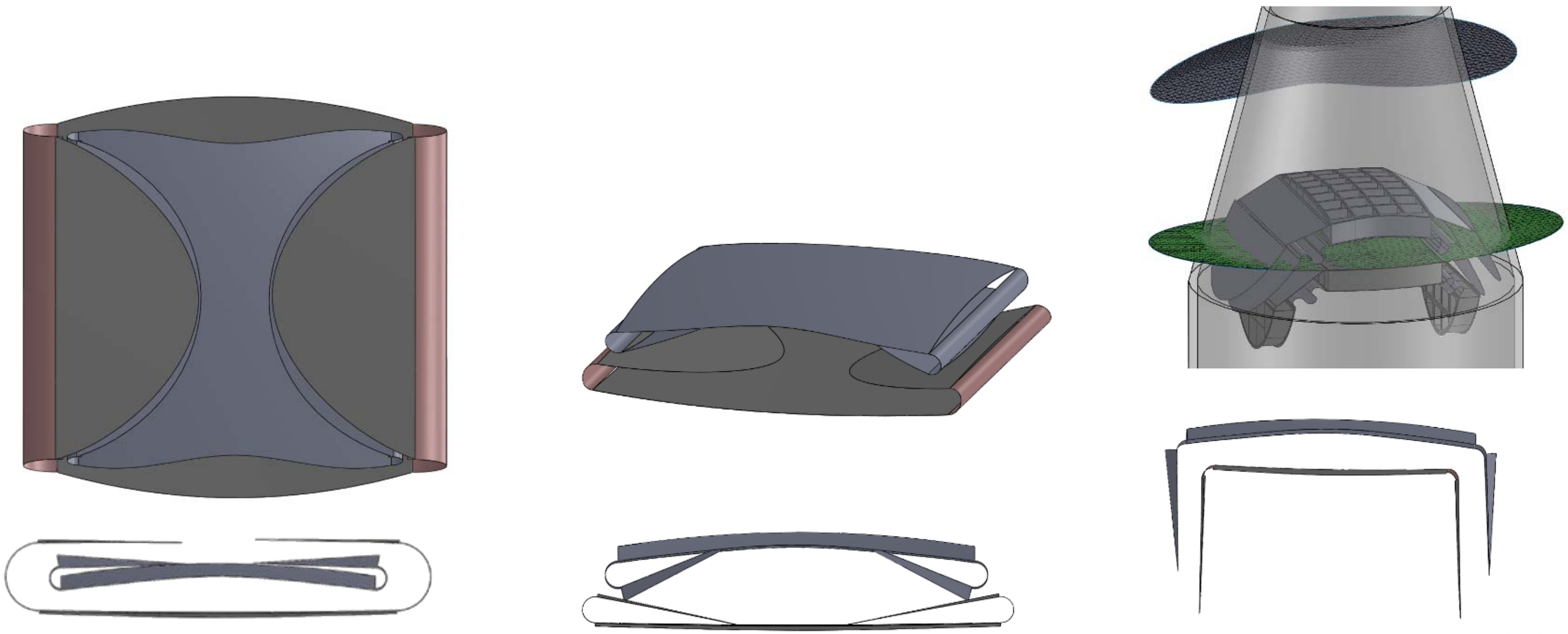






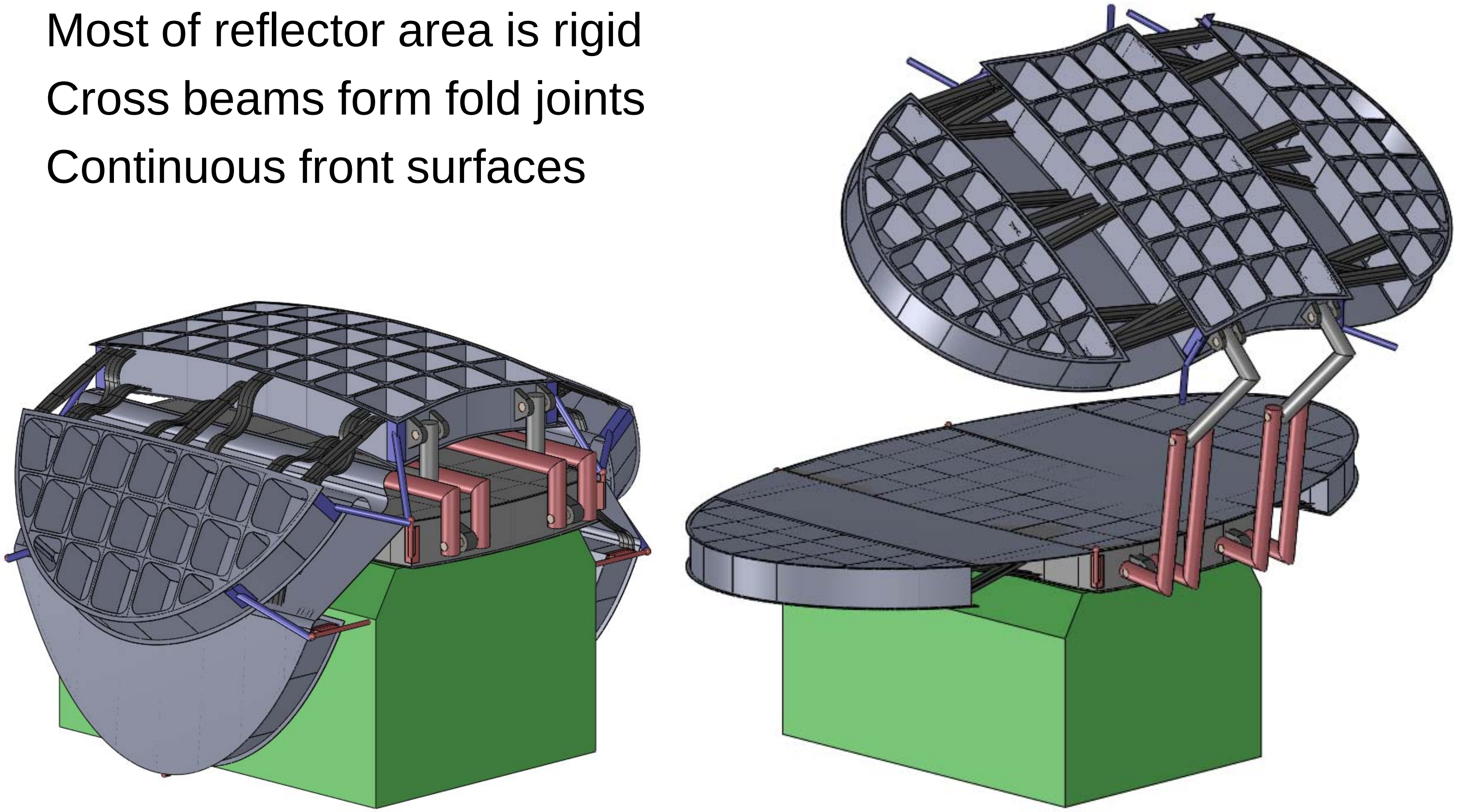
ACERAD Concept Study

- Examined several different folding schemes
- Goals
  - Fit into 4m launch vehicle fairing
  - Maintain large areas rigid
  - Allow thick backing structure



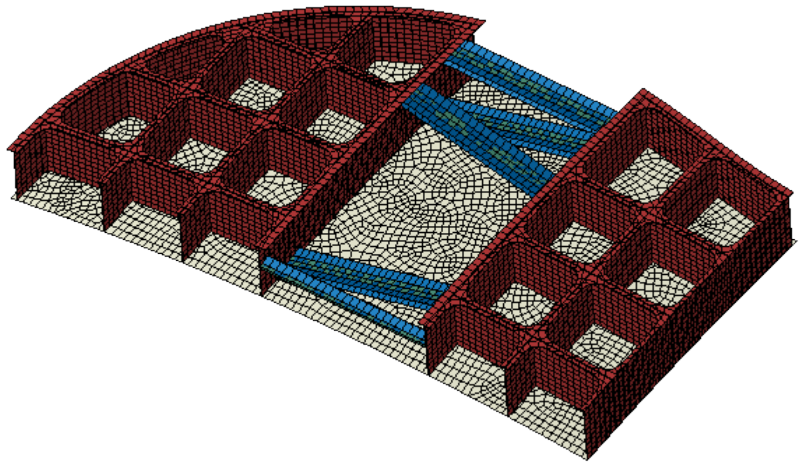
Final Selected Concept

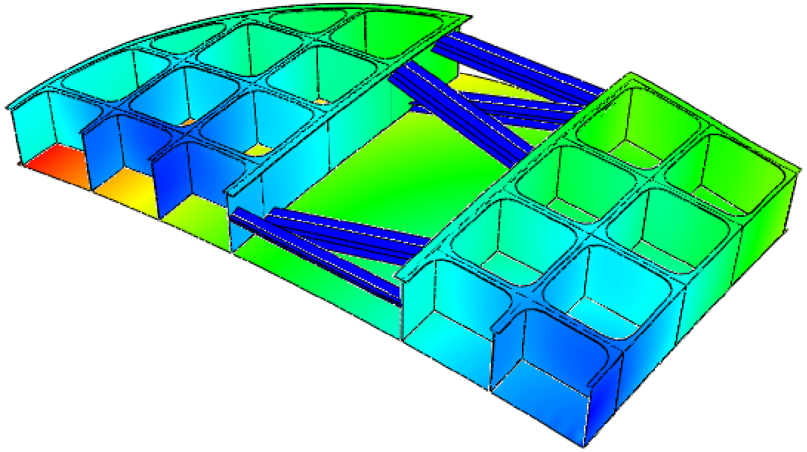
- Reflectors both fold downward around payload
- Simple rotation deployment to raise subreflector
- Most of reflector area is rigid
- Cross beams form fold joints
- Continuous front surfaces



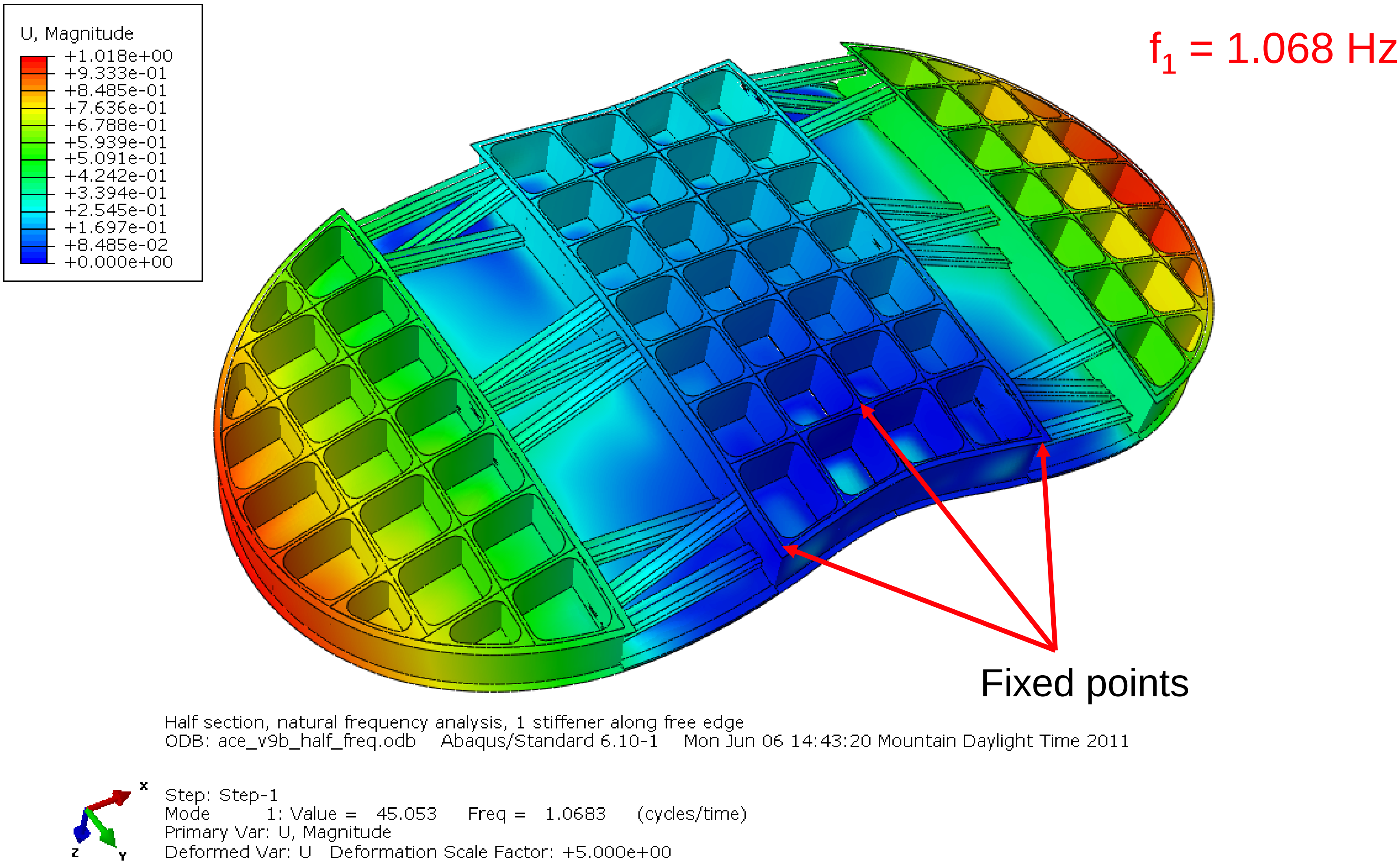
Thermal Distortion Analysis

- Quarter section Finite Element model of the deployed structure
- Composite layup with proper material orientations
- Temperature variation of -250º F and 250º F
- Analysis to predict RMS thermal distortion of the reflector
- Results show capability to meet requirements but further development required





First Natural Frequency



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
  - Achieved first quarter 2011
  - Proof-of-concept through packaging and deployment of 2.5m by 4m reflector
- TRL = 5
  - Thermal distortion test planned August 2011
  - Looking for funding to perform vibration and acoustic testing
  - Requires sufficient definition of representative mission to simulate environment including S/C interface and mounting

Remaining Work on ACT

- 4M EDU support complete
- Specific building block development
  - Customized to ACERAD requirements
  - Rigid sections technology development and coupon-level feasibility study (manufacturing, analysis, thermal distortion testing)
  - Improved cross beam development and testing (modification of existing design, analysis, deployed repeatability testing)
  - 2-skin fold concept development and coupon-level feasibility testing (manufacturing, analysis, deployed repeatability testing)
- Develop preliminary SCLP concept

Questions?