National Aeronautics and Space Administration

# Early Stage Technology Workshop

*Astrophysics and Heliophysics*

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## Deployment Control for an Occulter

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TECHNOLOGY DRIVES EXPLORATION

www.nasa.gov

Non-Proprietary

This work was performed under contract with NASA-JPL

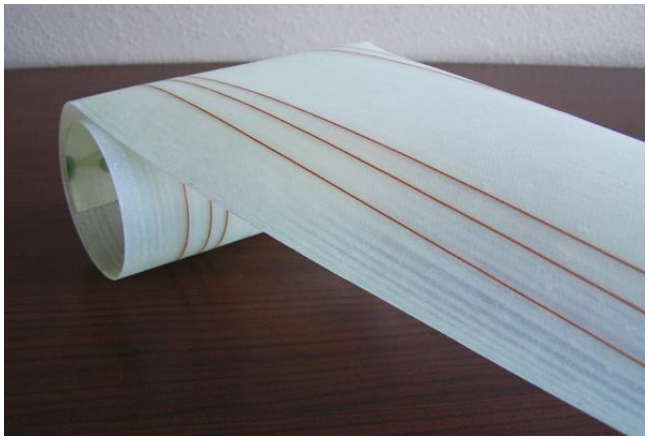
# Company Overview

- Roccor, LLC, Louisville, Colorado
- Established in 2011
- Current staff ~10 FTE
- Core Competence – *High-strain composite and ultra-stable mechanisms for deployable RF and optical structures*
  - Deployable boom for DARPA Phoenix
  - HiMast system for NovaWurks HiSat System

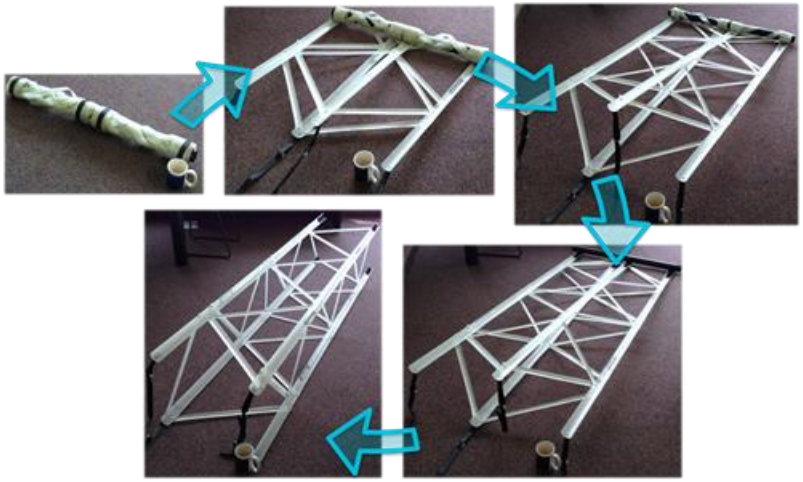
- Past Programs – Roccor principals were substantially involved in development of:
  - Assembly methods for ISS primary structure
  - Design of AstroMesh Antenna
  - Mechanisms and materials for JWST primary mirror metering structure
  - Structures for RAPDAR and ROSA roll-out solar arrays

# Company Overview

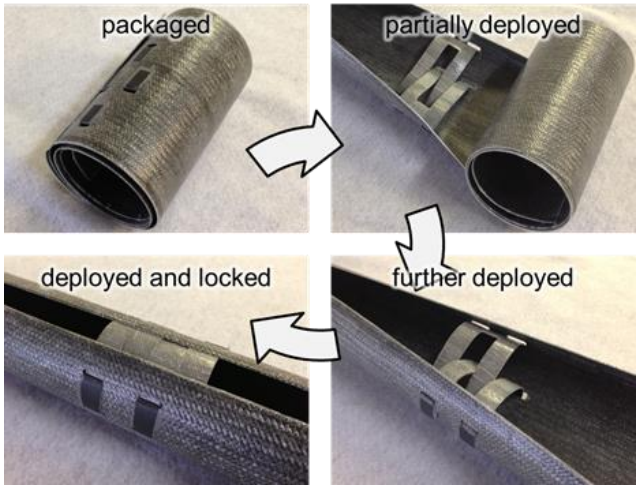
Composite Slit-tube booms



Embedded Conductors



Roll-out Composite Truss

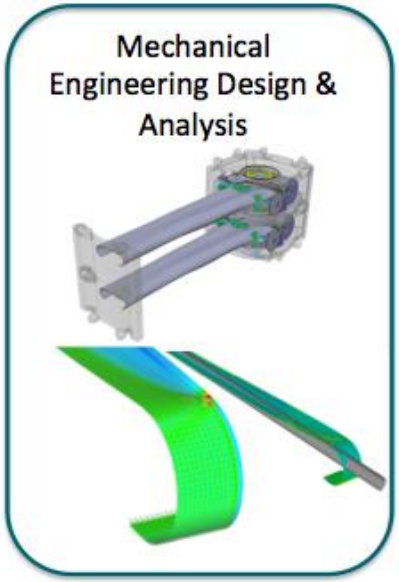


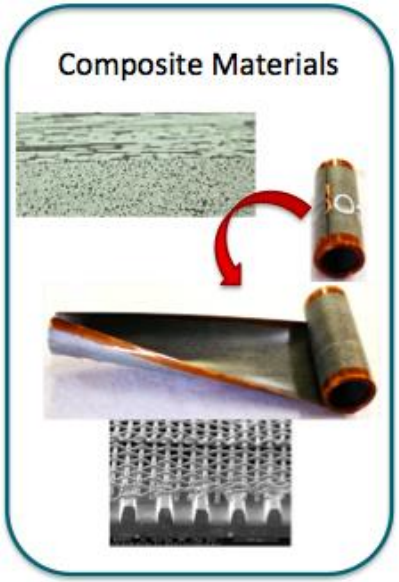

Seam-Lock, (enhanced shear rigidity)

https://www.youtube.com/watch?v=TSK8uhSnFuE

# Roccor, LLC Capabilities

- Core technical competencies & expertise



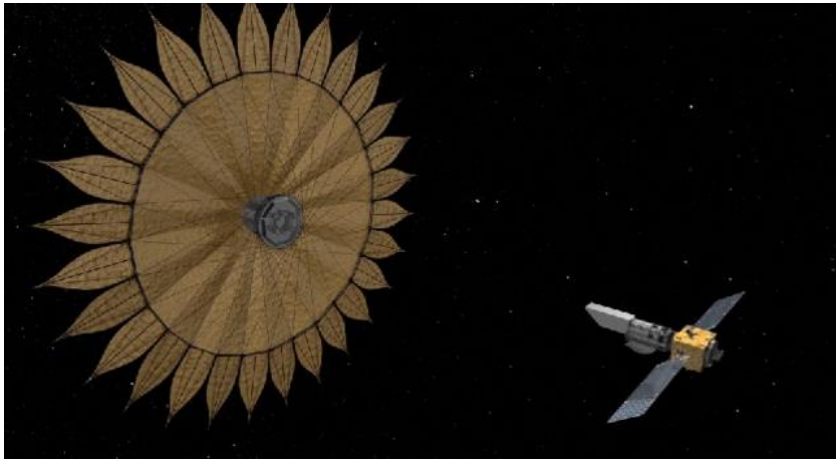
- Manufacturing & facility capabilities

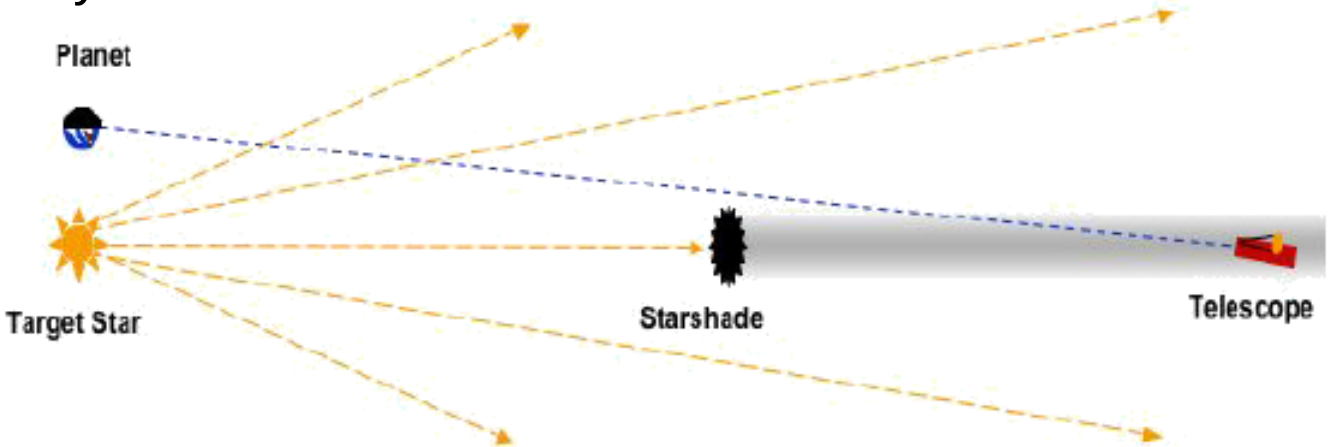
1800 sqft: Fumehood, layup tables, cutting tables, vacuum, freezers

1500 sqft: 18' oven, 20 ft overhead clearance, basic fabrication equipment

# The Problem: The Starshade Occulter

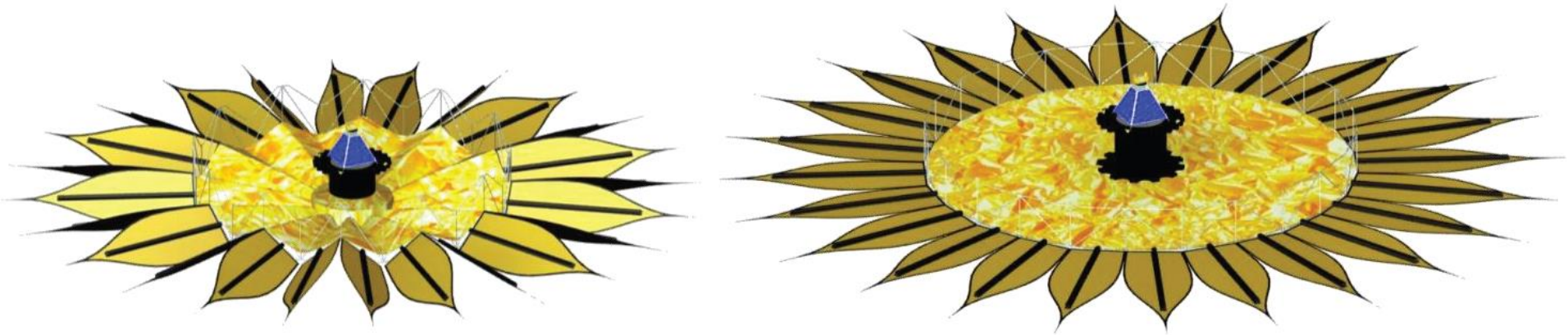
- An occulter is a shade used in a telescope to block the view of a bright object in order to allow observation of a fainter one.
- JPL is proposing to use this technique to view exoplanets
- The task is to design a lightweight, deployable occulter structure with adequate dimensional precision and accuracy





# JPL's "Starshade" Program

- JPL's Advanced Deployable Structures Group has developed a structural concept for an occulter to meet this challenge.
- ROCCOR is working with JPL to develop a petal furling, and support system to manage deployment.



# Objectives and Approach

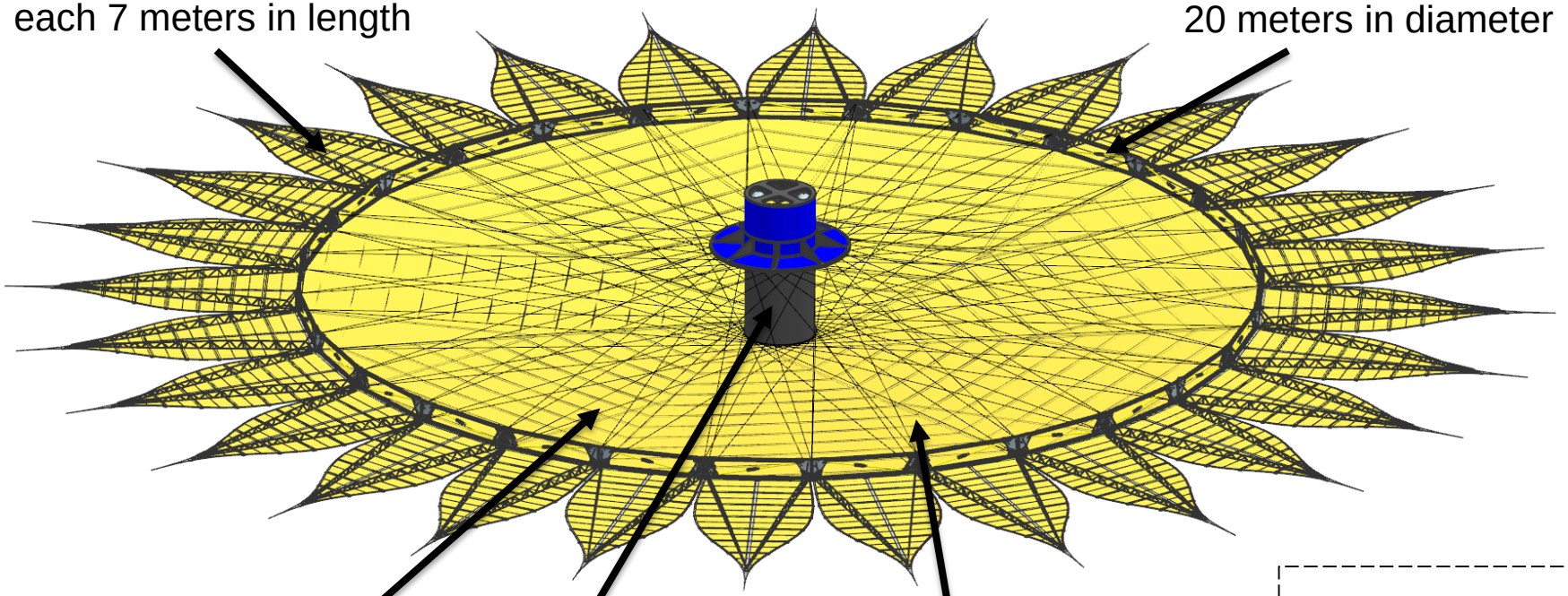
## Objectives

- Retire risk of developing a Flight Occulter system by:
  - Exploring kinematics / dynamics of petal deployment approaches
  - Evaluating strain energy management and non-linear effects
  - Developing initial concepts for key structural components and deployment mechanisms

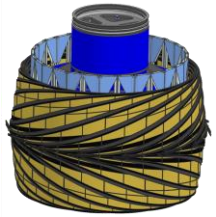
## Approach:

- Utilize combination of non-linear FE modeling and sub-scale petal furling testbed
  - Instrument petal with accelerometer(s)
  - Off-load petal to eliminate gravity induced torsional modes
  - Mock-up mechanical constraints deployment-control mechanisms
- Investigate a series of deployment release test cases
  - Single petal
    - With and without blanket
  - 3 petals
    - Explore kinematics
    - Evaluate petal slam

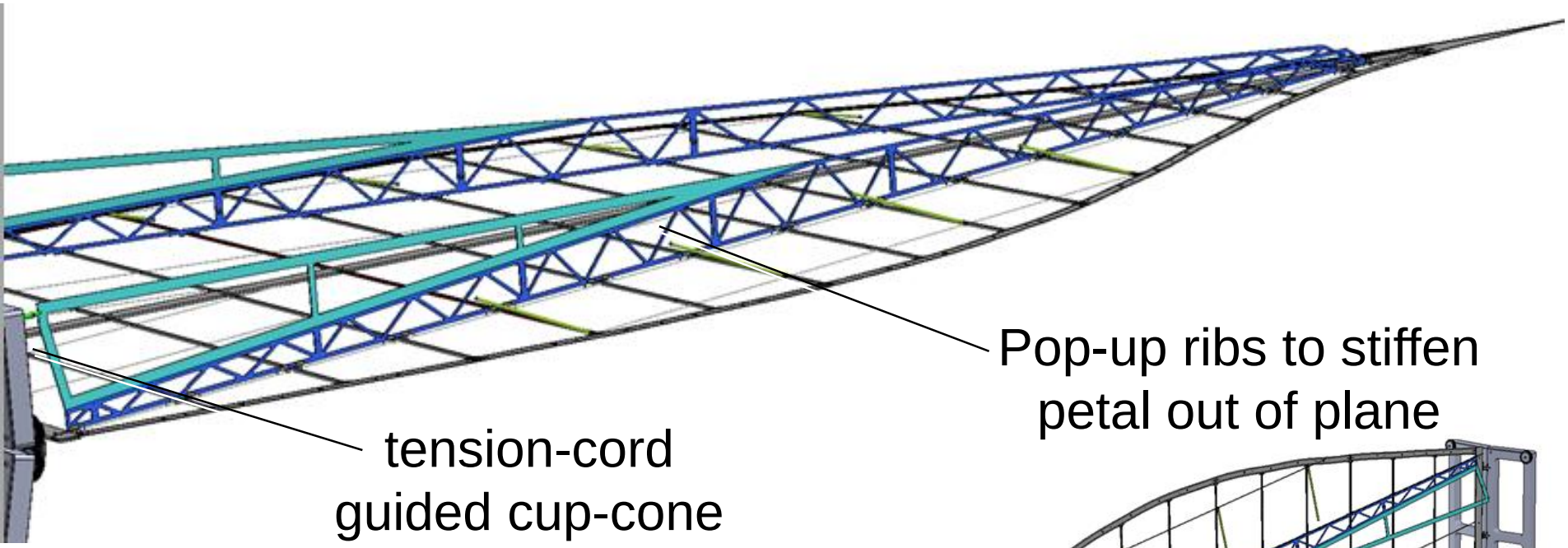
# Occulter Petal Structural Concept

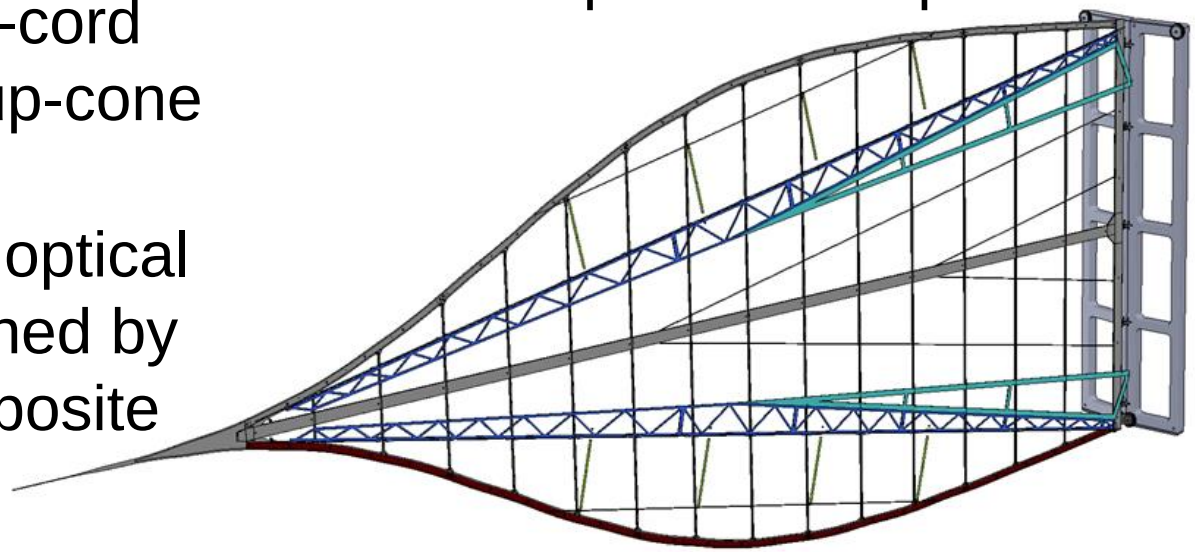



Stowed System



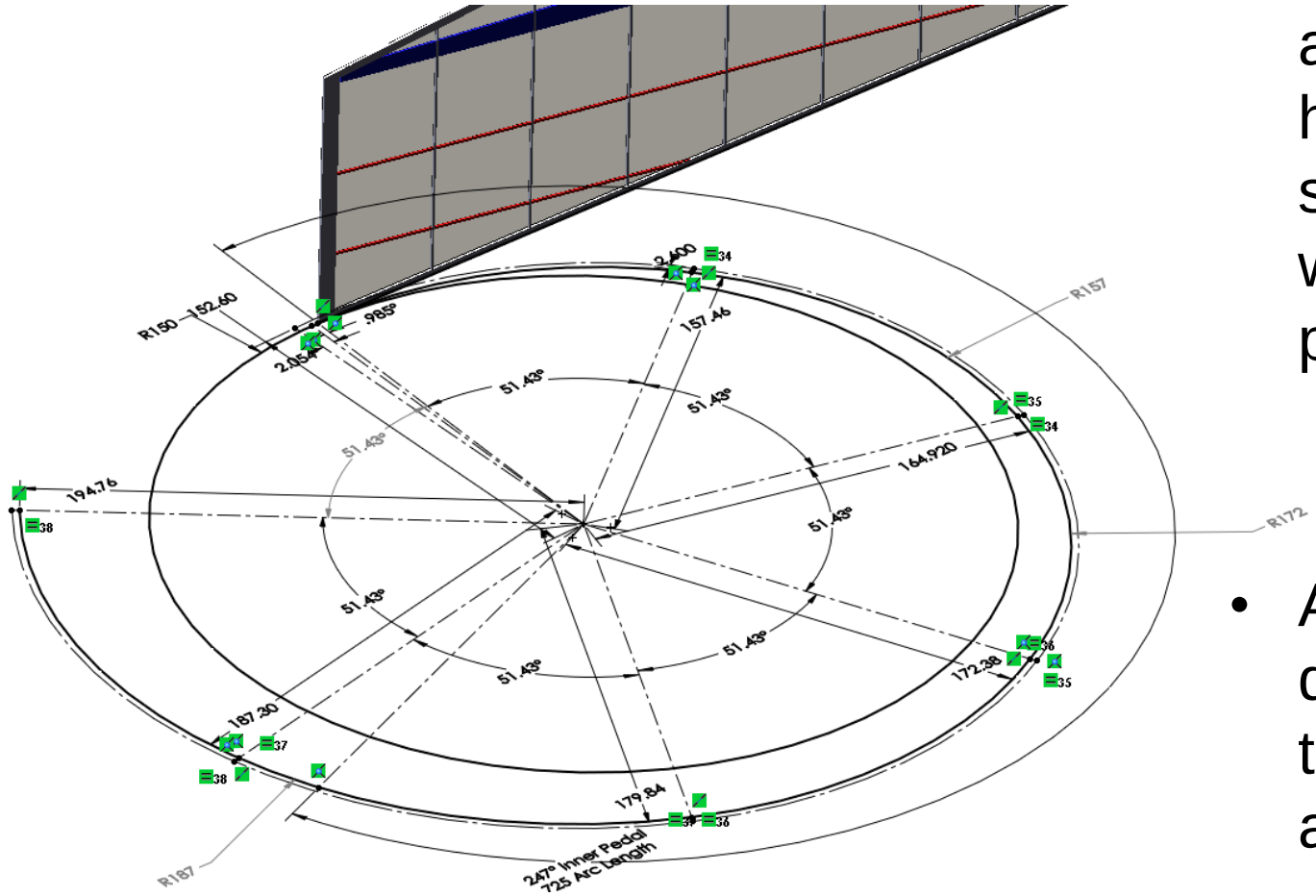
# Occulter Petal Structural Concept



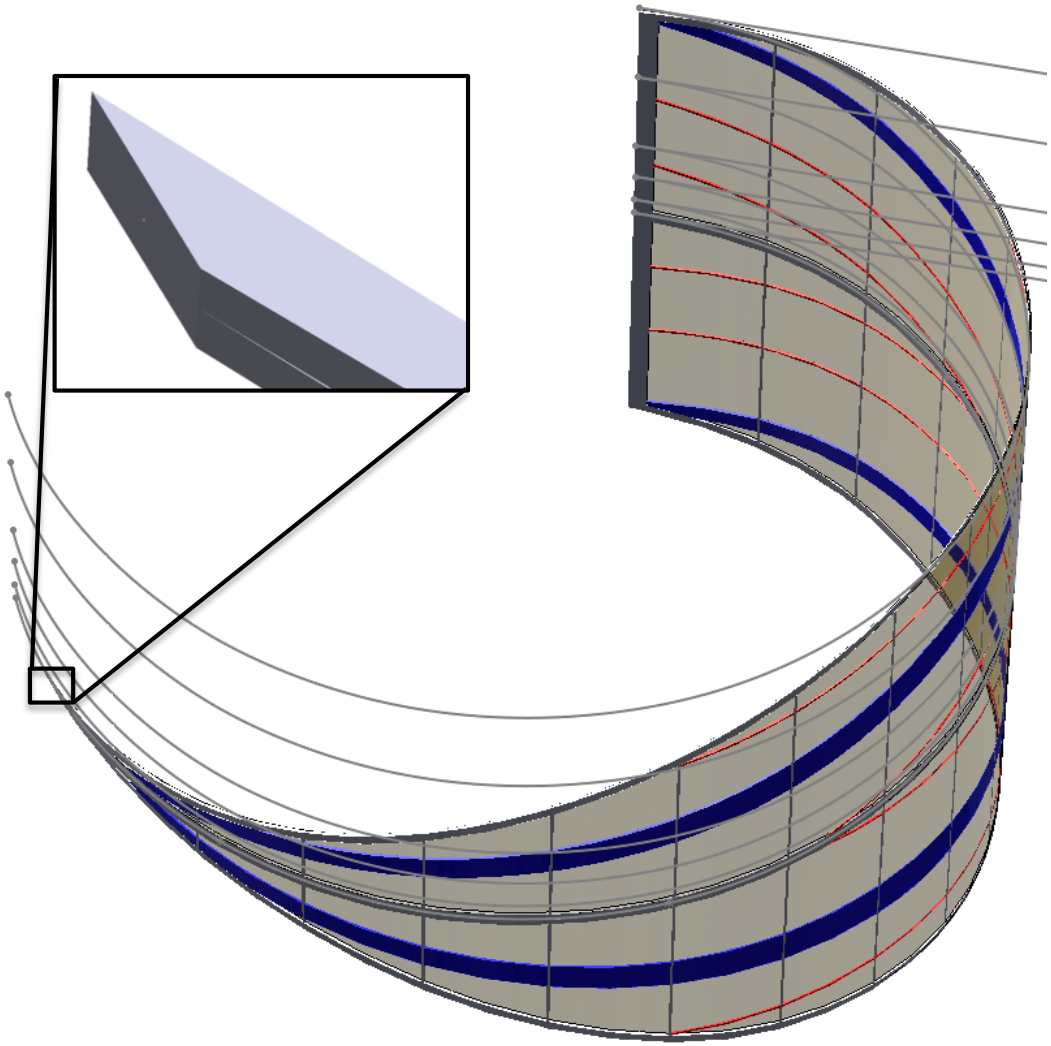
High-precision optical profile maintained by low-CTE composite frame

# Furled Petal Geometry



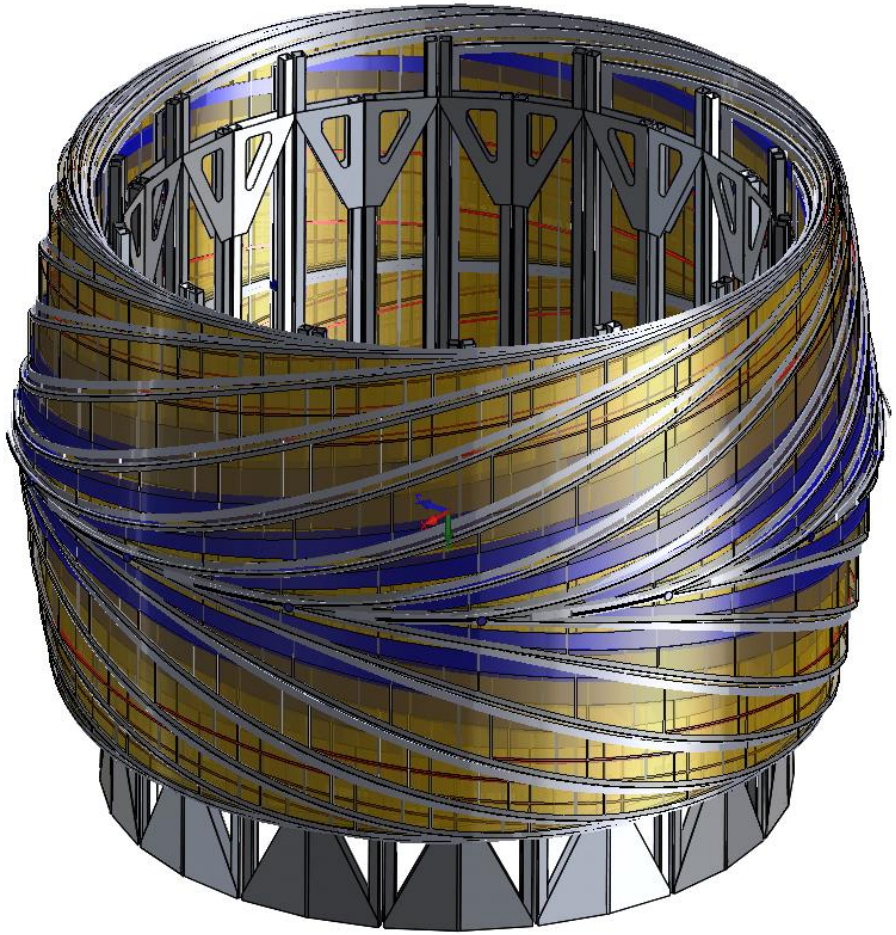

- Each petal furls around the center hub in a shape similar to a spiral with adjacent petals interleaving
- Arc of spiral is defined by petal tie-down points and hinge lines

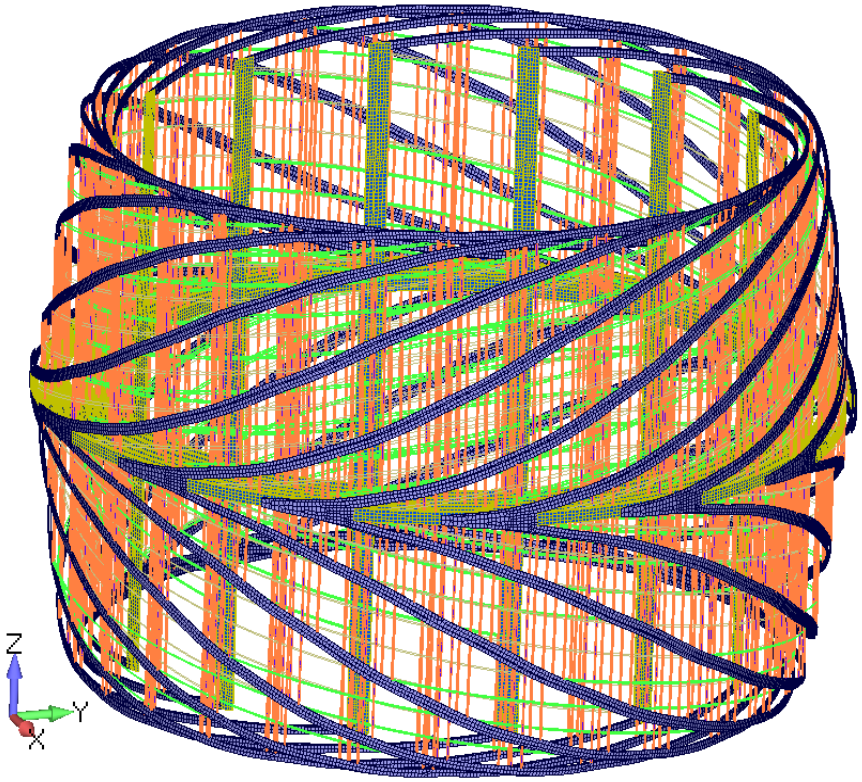
# Furled Petal Modeling



- Accurate modeling of furled strain energy is key to adequate design of restraint, preload levels and release system.
- Variance in petal tie-down preload and blanket compression stiffness yields to modeling challenges.

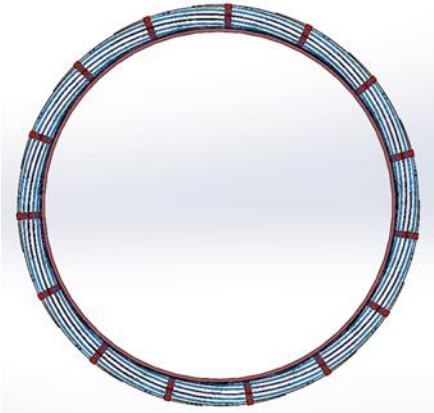
# Furled System Simulation

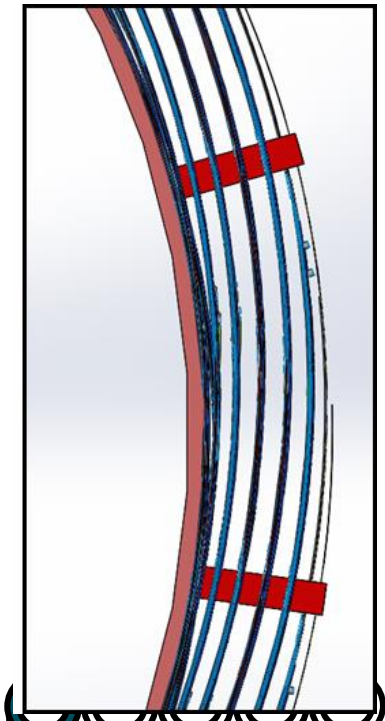




# Launch Control System Design and Analysis

- Stowed FEA model with all 28 furled petals
- Petal-to-petal interfaces along with snubbers, hinge points and launch restraints
- Preload effects due to clamp band tensioning and damping between petals
- Culminate in petal margin of safety during launch.





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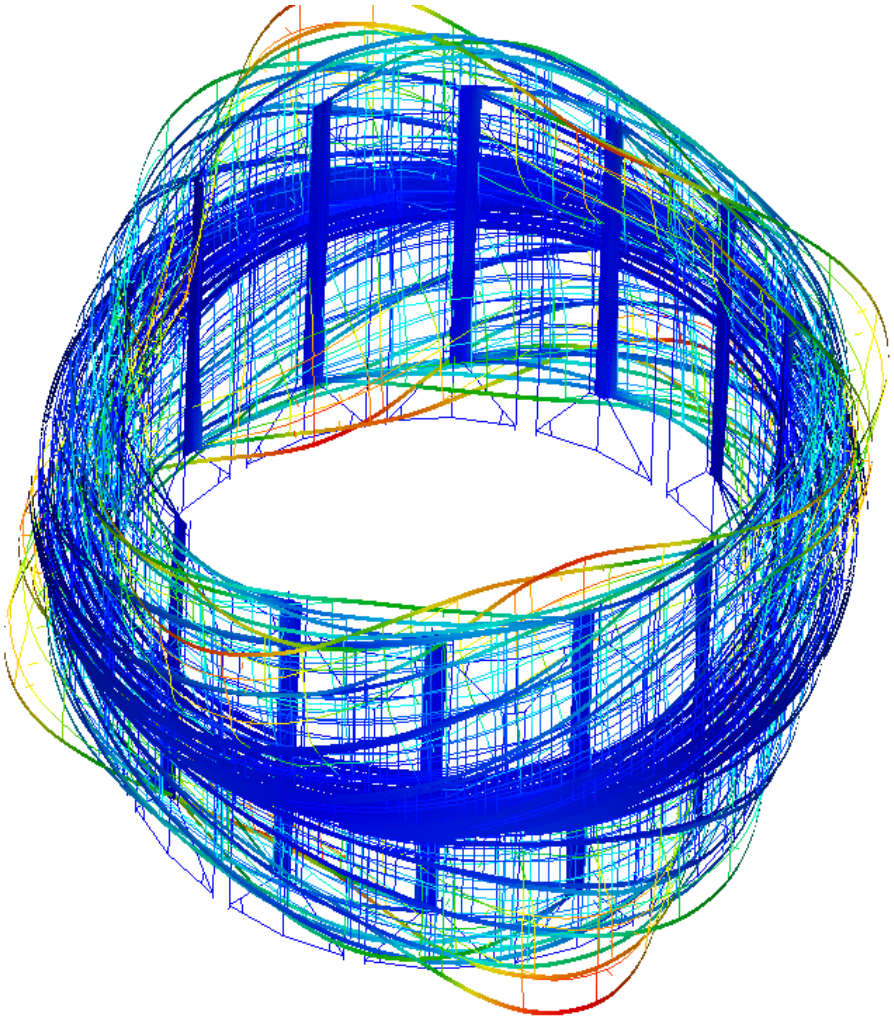
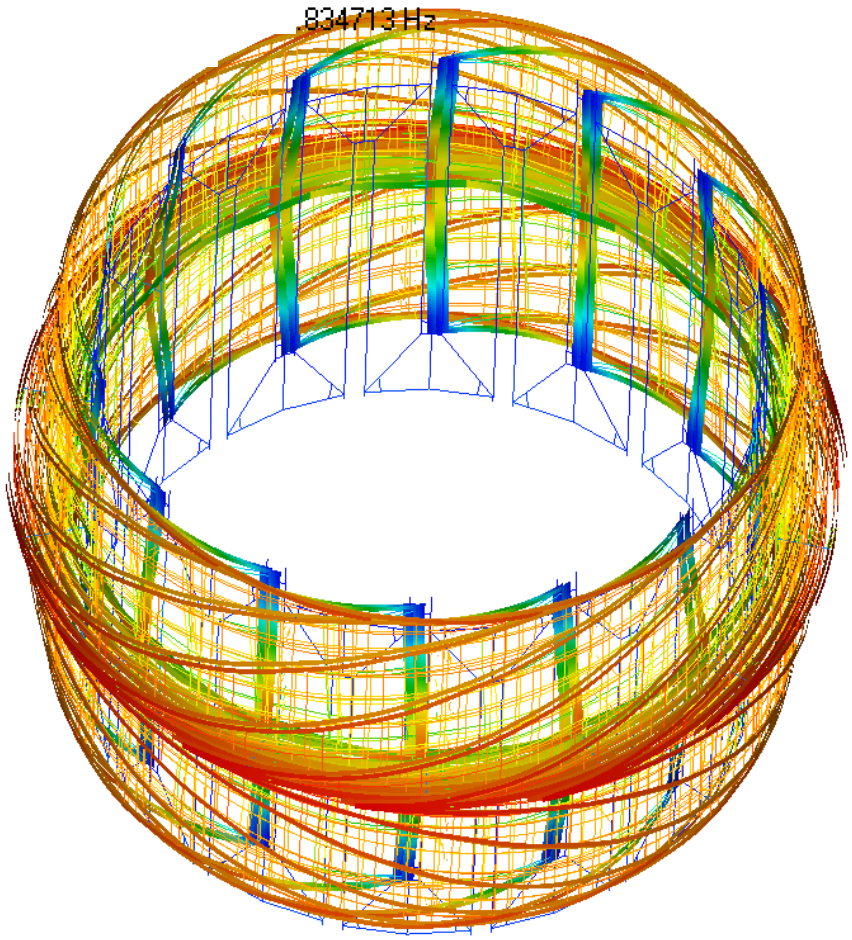
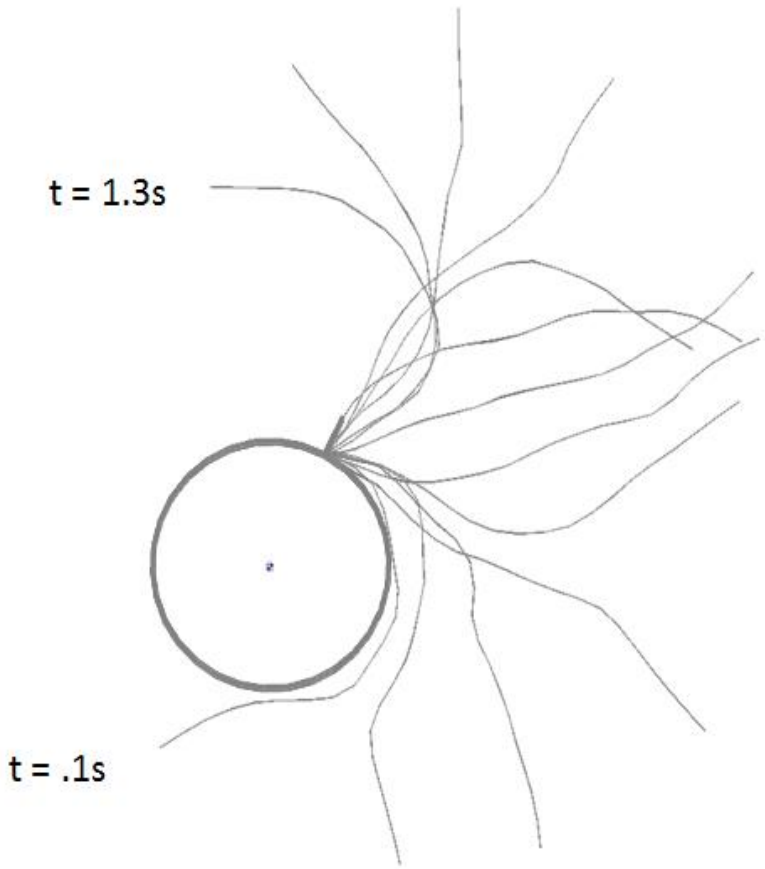




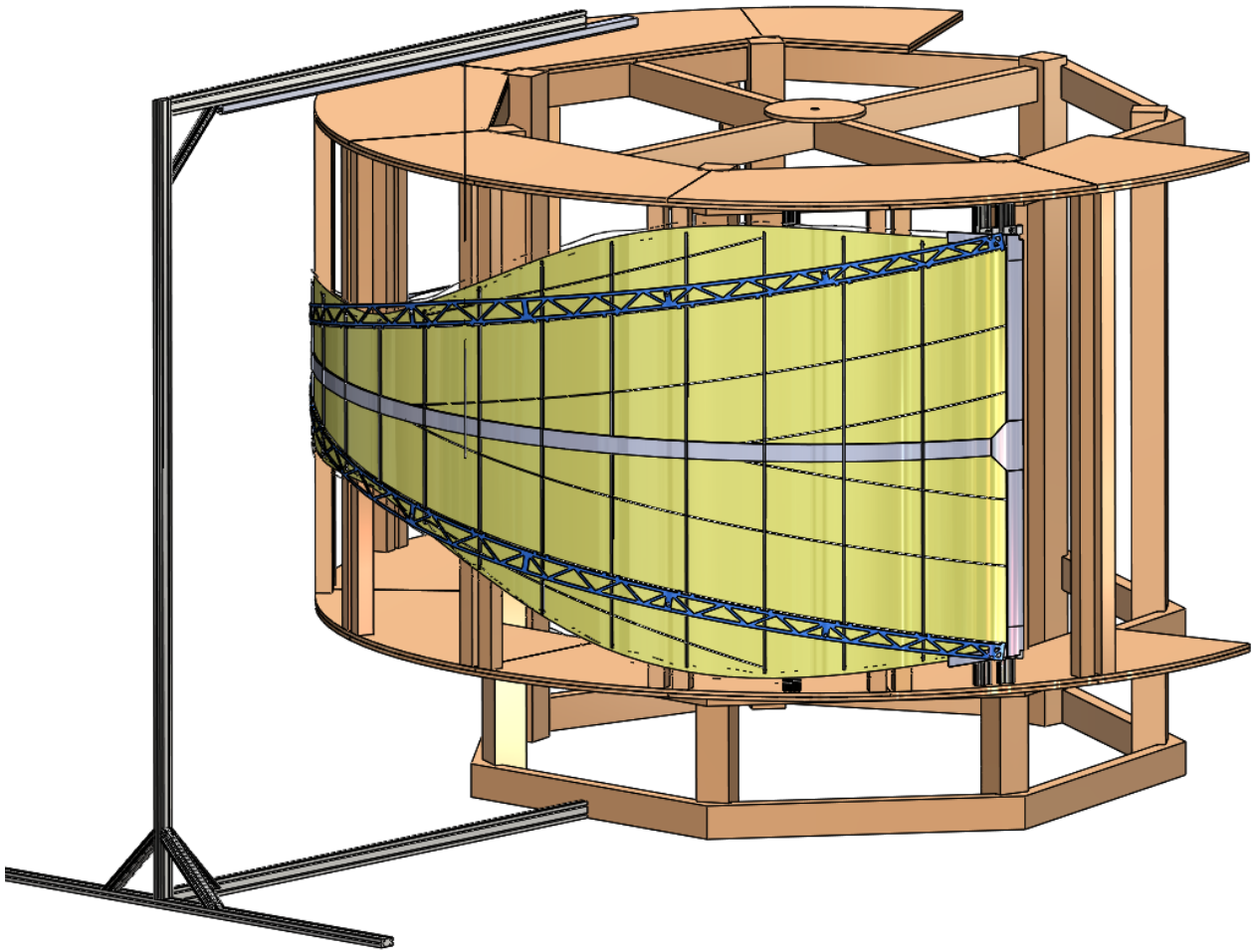
# On-Orbit Petal Unfurling Analysis

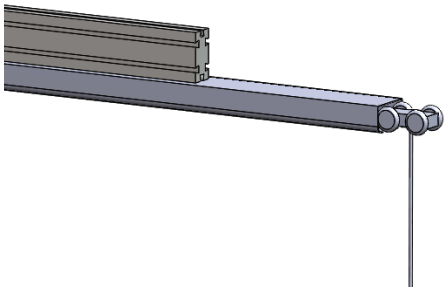
- Early study was performed to characterize the uncontrolled release of a single petal
  - Results showed a high tip velocity and semi-chaotic response
  - Problem aggravated by simultaneous release of all petals

- Baseline approach has evolved for a more controlled release
  - Limit the dynamic release via segmented tie-downs OR
  - enable a fully controlled sequential release system



# Single Petal Scale Model With Offloader





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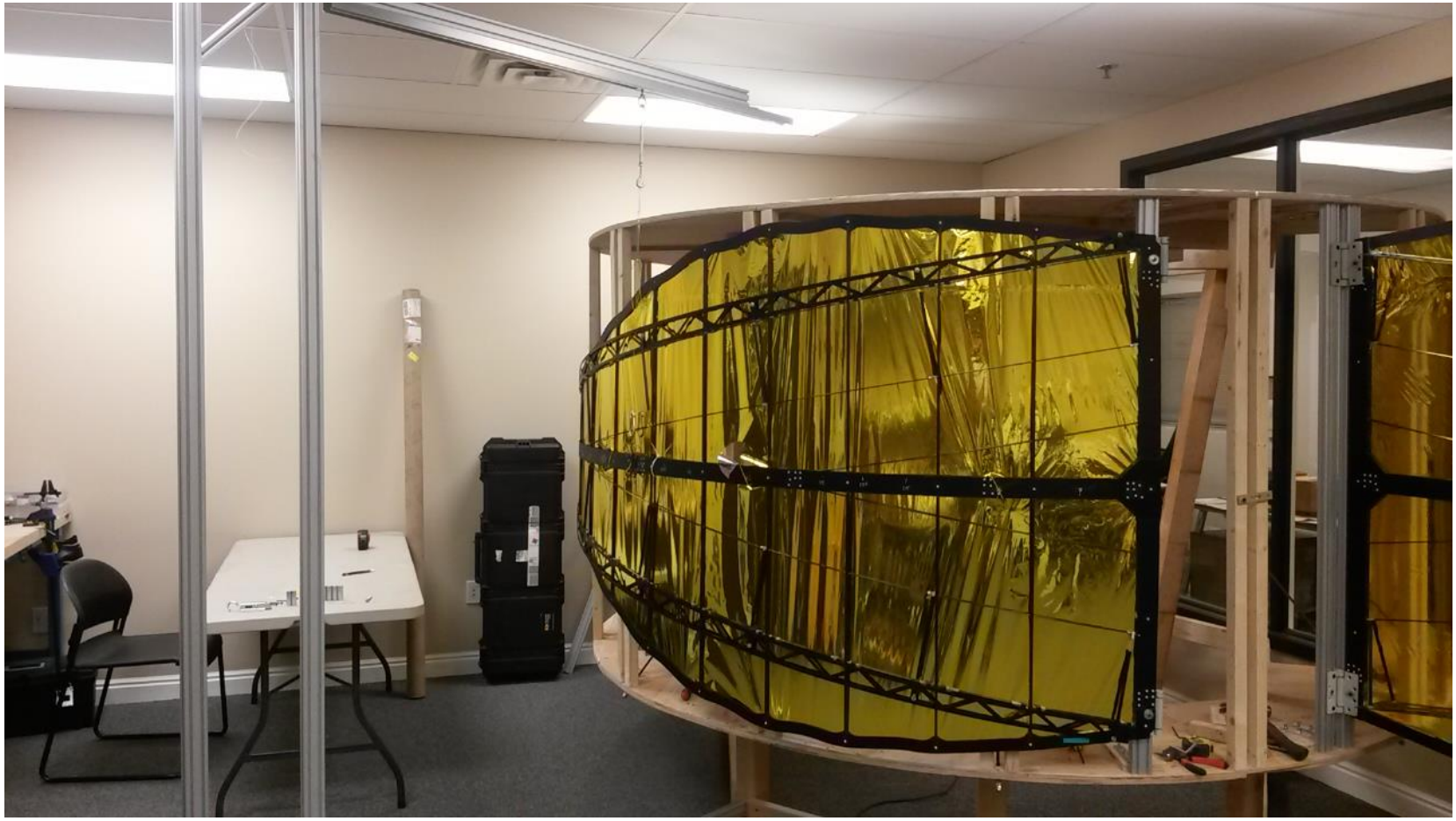
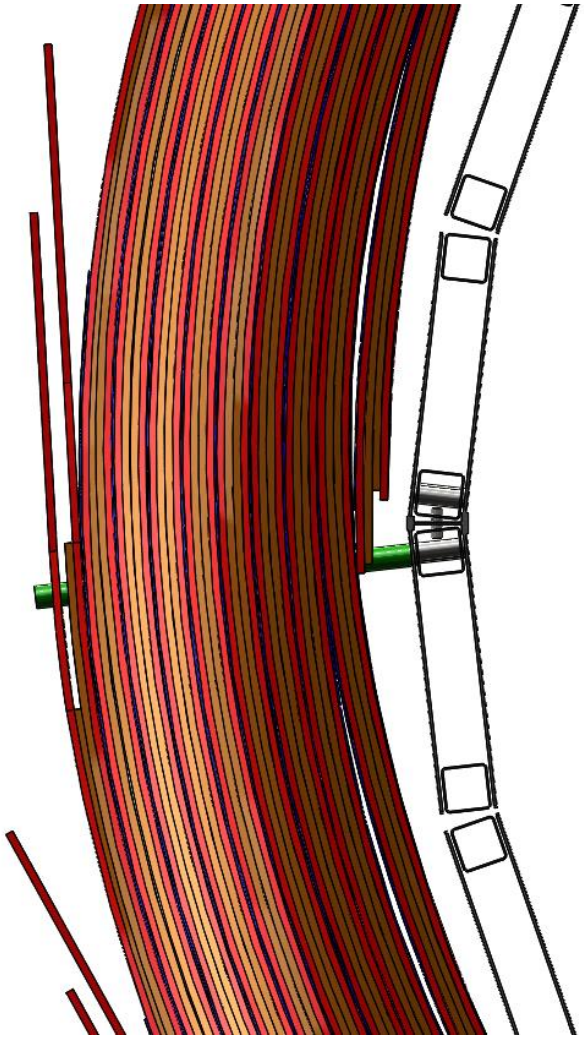
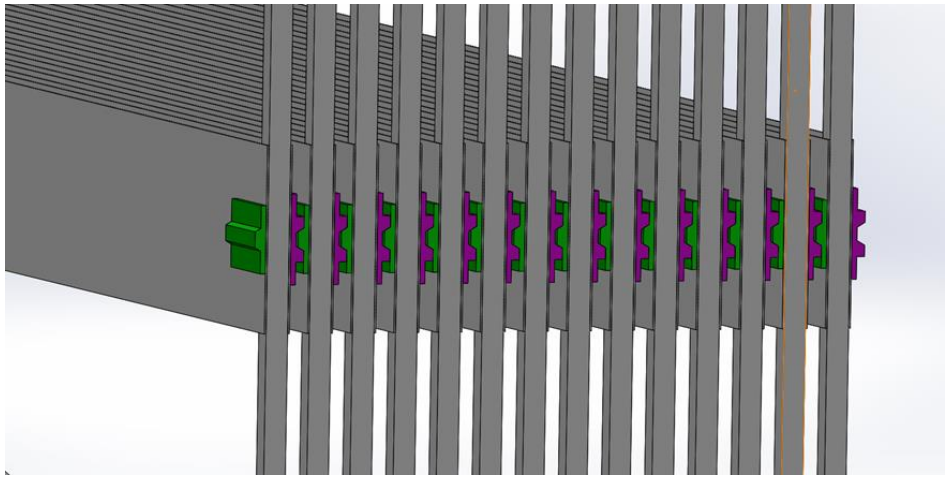


# Snubber and Mechanism Mockup & Testing

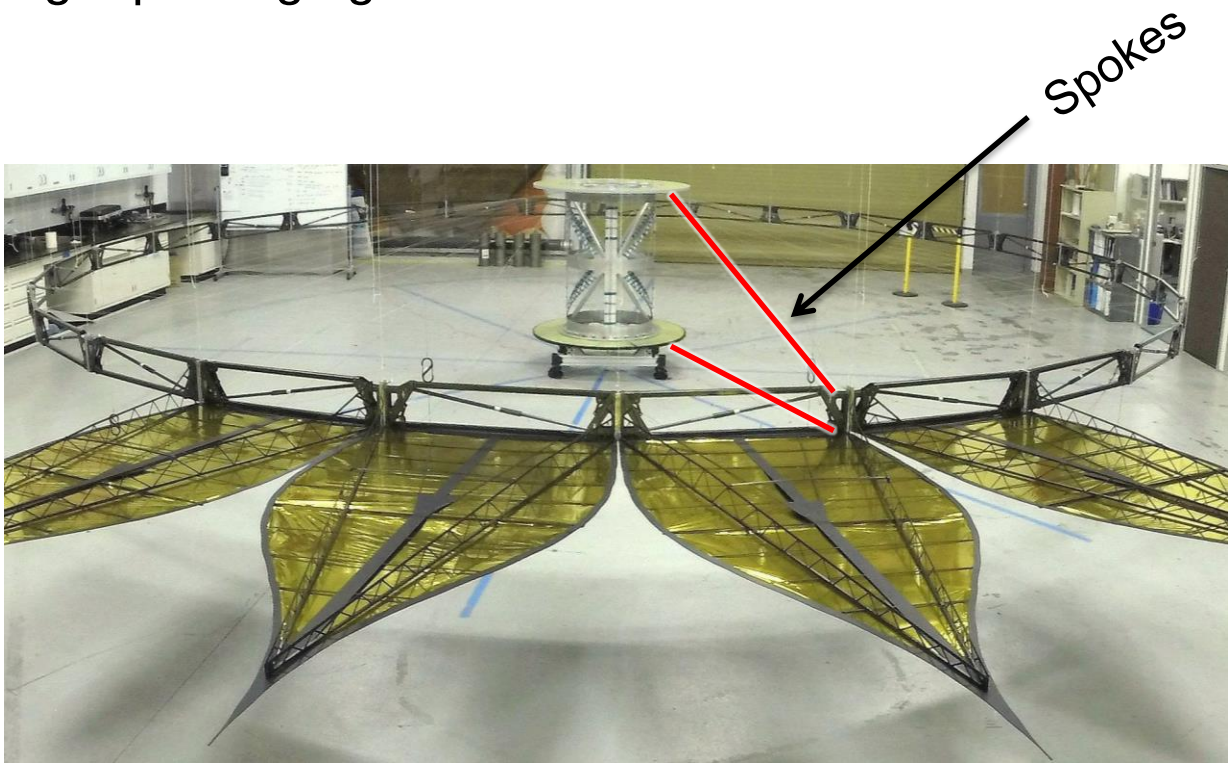




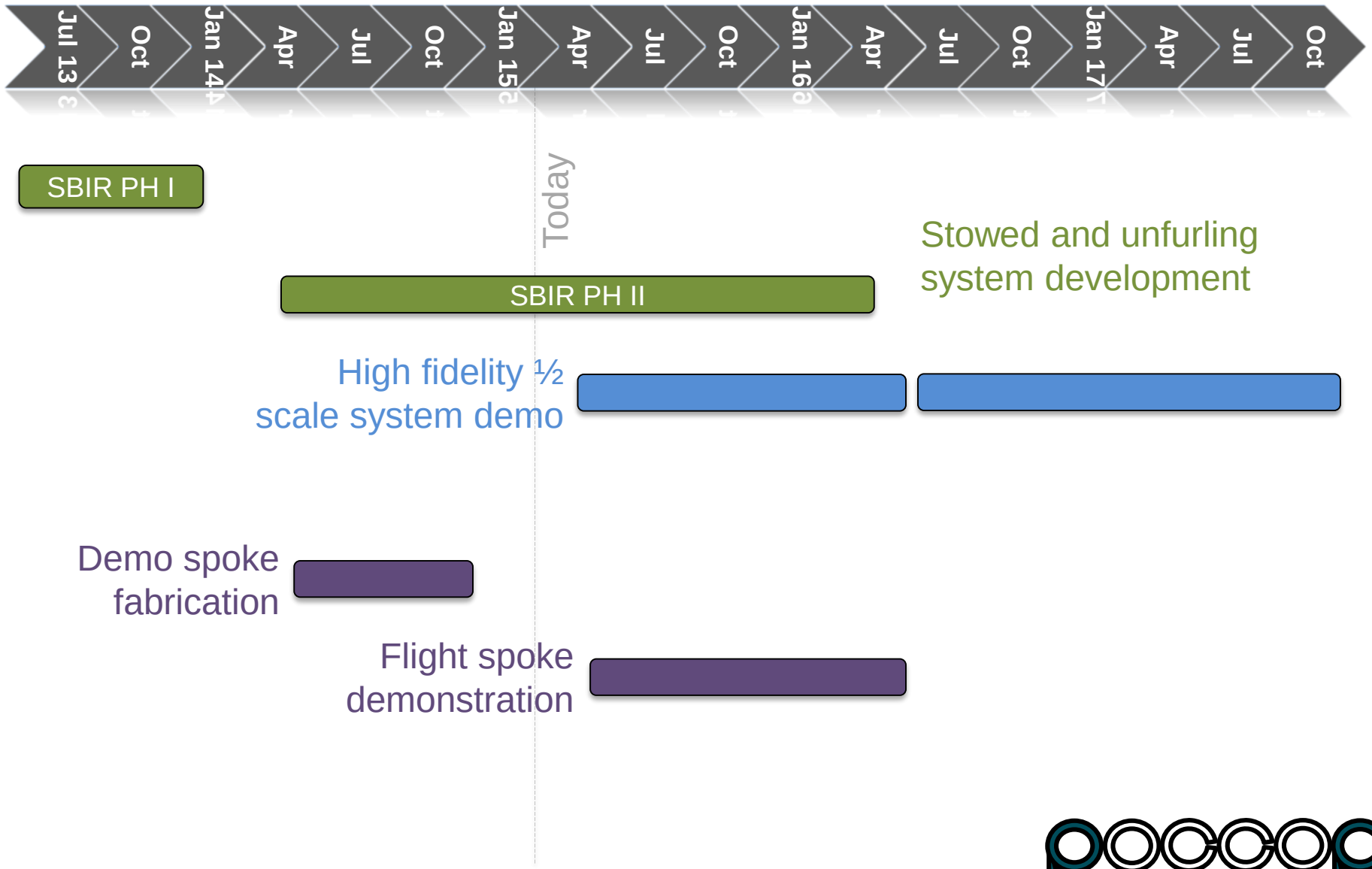
# Starshade Spoke Design & Fabrication

- Development of Dimensionally Stable Structural Space Cable
  - Linear structural behavior at low-tension levels
  - Near-zero coefficient of thermal expansion
  - Ability to withstand a tight packaging radius

- Demo spokes fabricated for JLP ½ scale ring truss deployment test (Aug ‘14)



# Technical Roadmap



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