FY24 R&TD Innovative Spontaneous Concepts (ISC)

Utilizing Modern Fabrication Techniques to Build Large Precision Composite Structures

Principal Investigator: Juan Mejia-Ariza (353)**; Co-Investigators:** Jonathan Sauder (355), Christine Gebara (355), Shana Worel (355), Sergio Pellegrino (Caltech)

Strategic Focus Area: Innovative Spontaneous Concepts

Objectives:

- Demonstrate the feasibility of coiling large precision composite structures for space applications.
- Develop a lightweight, deployable structure using modern fabrication techniques.
- Integrate a tensioned Kapton membrane with a composite structure for high performance under extreme conditions.
- Optimize the design for compact stowage and reliable deployment in space.
- Create scalable, high strain composite structures for applications such as telescopes, antennas, and solar arrays.

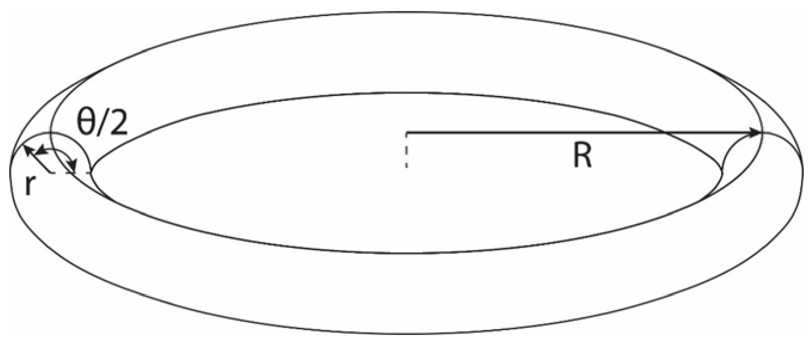

Figure 1: Torus geometry, composite shell. For the prototype, R, r and θ were 10", 0.5", and 140°.

Significance/Benefits to JPL and NASA:

- Enables the creation of lightweight, stowable structures essential for large-scale space missions.
- Supports NASA's Strategic Focus on in-space manufacturing and deployment capabilities.
- Improves mission efficiency with compact, reliable deployable systems for space telescopes, antennas, and solar arrays.
- Facilitates future missions like Artemis and interplanetary exploration by providing scalable and durable structures.
- Reduces spacecraft payload constraints, allowing for more ambitious mission designs and infrastructure deployment.
- Advances technology for deep space exploration, Earth observation, and communication networks.

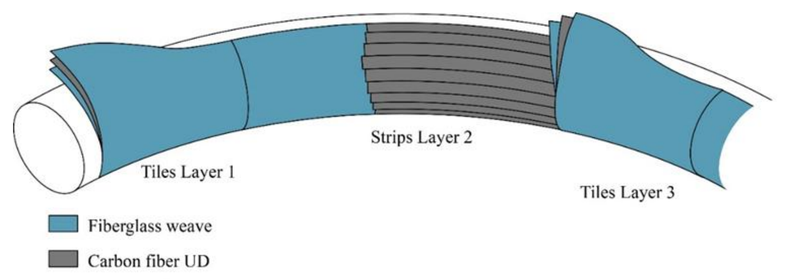

Figure 2: [±45FG, 0CF, ±45FG, 0CF, ±45FG, 0CF, ±45FG] layup, with one layer of unidirectional fibers sandwiched between two layers of tiles.

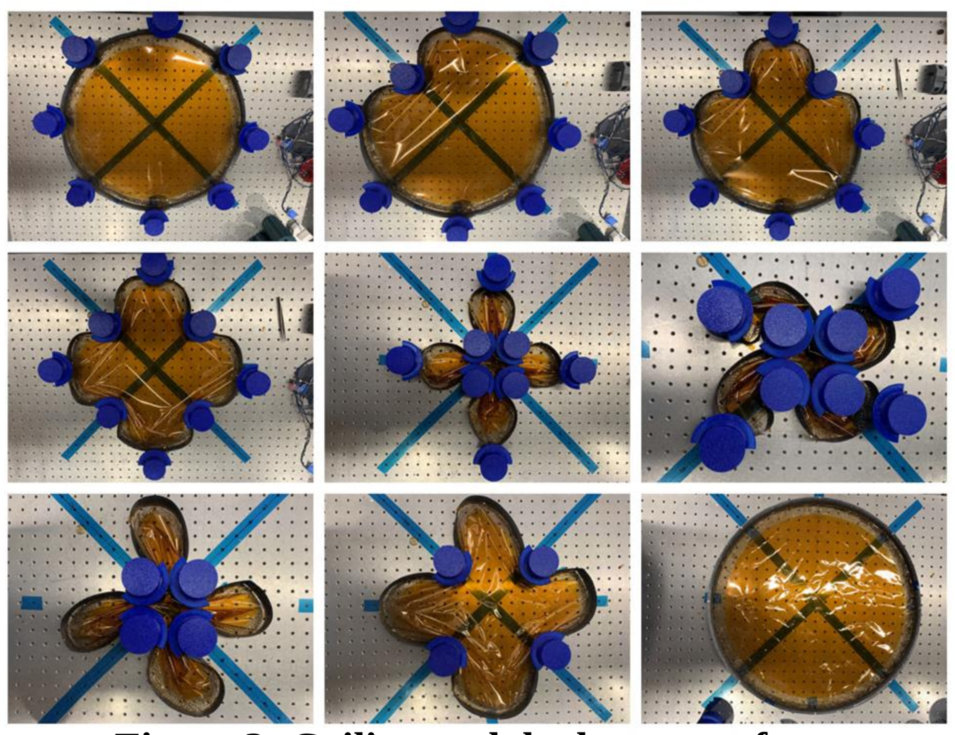

Figure 3: Coiling and deployment of torus. Membrane creases were intentionally implemented during the coiling process.

Background:

- Advancements in space exploration require lightweight, large-scale deployable structures.
- Traditional fabrication methods struggle to meet space requirements for strength, weight, and deployability.
- This research focuses on coiling and deploying tensioned composite structures for space missions.
- High-performance materials like carbon fiber and Kapton membranes are used to withstand extreme space conditions.
- Applications include space telescopes, solar sails, and large antennas for future NASA missions.

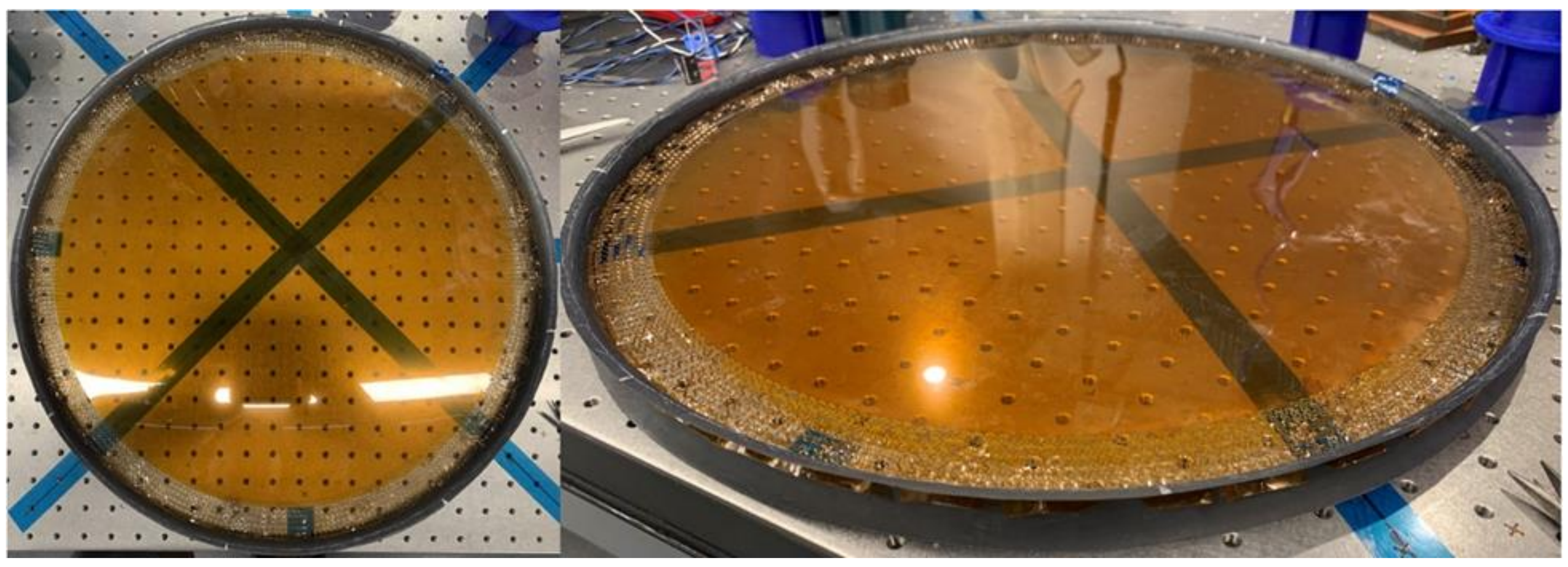

Figure 4: Uniformly pretensioned Kapton membrane and buckled attachment.

Approach and Results:

- Developed a lightweight composite structure using carbon fiber and glass fiber layups, integrated with a tensioned Kapton membrane for uniform load distribution.
- Employed vacuum bagging and autoclave processes for consolidation, followed by testing the coiling and deployment using an 8-cylinder system to minimize stress.
- Successfully fabricated and tested a 1-meter deployable structure with consistent tension and rapid deployment.
- Conducted surface accuracy tests with laser scanning and used finite element analysis to optimize coiling and scaling for larger structures.
- Exploring thermoplastic-carbon fiber prepregs for lighter, more durable composites.

Publications:

- Mejia-Ariza, J., Worel, S., Sauder, J., & Gebara, C. (2024). Utilizing Modern Fabrication Techniques to Build Large Precision Composite Structures. JPL Technical Report.
- Pellegrino, S., Benazzo, F., Popov, G. A., & Mejia-Ariza, J. (2024). Coiling and Deploying Tensioned Composite Structures for Space Applications. Caltech Journal of Aerospace Engineering.

PI/Task Mgr. Contact Information:

626-524-3990 and Juan.M.Mejia-Ariza@jpl.nasa.gov

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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