National Aeronautics and Space Administration

FY23 Strategic University Research Partnership (SURP)

High Precision Thermally Stable Flexures for Large Deployable Antennas in SmallSats

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Objectives: Replacing the traditional spring-loaded mechanical hinges in a deployable space structure with high strain composite (HSC) flexures. Improving the thermal stability of the space structure while reducing the parasitic weight and the part count of hinges. Deployment of flat panels for Reflectarray antennas used in previous and proposed JPL missions were used as a representative design problem. The research goals developing a design framework that considers both the stowed and deployed configurations, building and testing of realistic prototypes for different requirements, and assessing the performance of the selected architecture as a candidate for future missions.

Background: HSC for deployable structures has been a topic of interest in the recent years as they reduce the weight while making the deployment mechanisms simpler. The thin-walled composites are made into different geometries such as Tubular, TRAC or DLR and can bend with large deformations and strains. Previous work using HSC mainly focus on relatively large structures (500mm-2000mm).

Approach and Results: Scale down the flexure dimensions to CubeSat level (100mm – 300mm) while achieving precise deployments. Demonstration replacement of the mechanical hinges with a suitable HSC hinge was accomplish for a 1 m Reflectarray Antenna (OMERA) technology case study. This benefit the reflectarray with a higher thermal stability that minimize the difference in thermal coefficients. Developed a novel hinge architecture, assessed suitable materials, and performed static/dynamic tests to evaluate the hinge performance. Investigated the application of similar flexures for other missions with different panel size and mass.

Significance/Benefits to JPL and NASA: Unique designs to reduce stress concentrations and improve thermal/mechanical stability, and reduced part count when compared to the torsion spring powered hinges used on the current MarCO and OMERA antennas. Enable antennas like LADeR to self-deploy, eliminating the need for a deployment mechanism, reducing stowed volume and design complexity. This research development will not only be useful technology for future JPL SmallSat missions, but contributed to the advancement of research in failure, creep, and viscoelasticity.

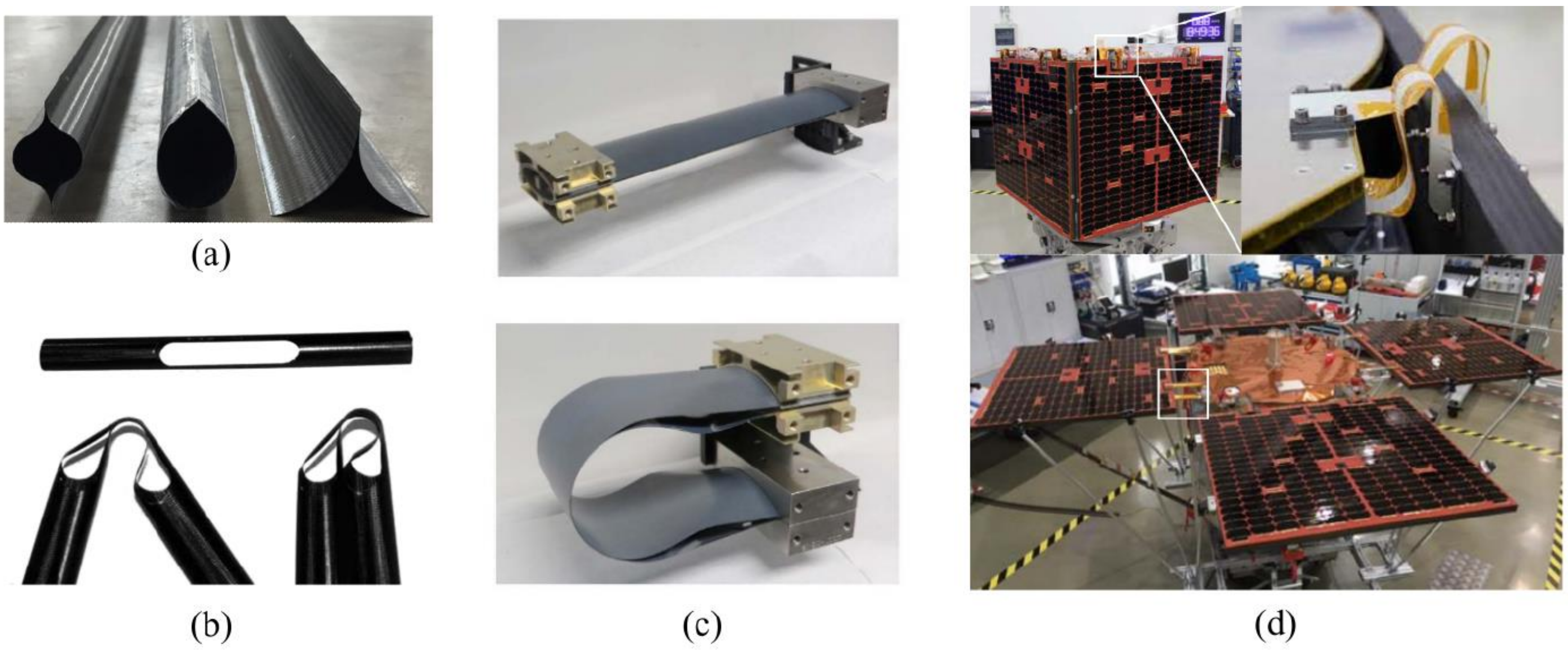

Fig 1: Flexible Deployable Booms: a)CTM, SHEARLESS, TRAC; b) Tape-spring; c) Flexure hinge designed for high precision deployments; and d) Eu:CROPIS satellite using tape-spring hinges.

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Publications:

[1] Dharmadasa, B. Y., Mejia-Ariza, J. M., Arya, M., Sauder, J. F., Focardi, P., Bradford, S. C., & Lopez Jimenez, F. "Free Vibration of a Panel Supported by a Shear Compliant Two-Flexure Hinge" Submitted to *AIAA Journal*

[2] Dharmadasa, B. Y., Mejia-Ariza, J. M., Arya, M., Sauder, J. F., Focardi, P., Bradford, S. C., & Lopez Jimenez, F., "A Closed-Form Formulation to Estimate the Natural Frequency of Tape Spring Hinges", AIAA SCITECH 2024.

[3] Dharmadasa, B. Y., Mejia-Ariza, J. M., Arya, M., Sauder, J. F., Focardi, P., Bradford, S. C., & Lopez Jimenez, F., "Design and Fabrication of a High Strain Composite Flexure for CubeSat Reflectarrays" In *AIAA SCITECH 2023*.

[4] Dharmadasa, B. Y., Mejia-Ariza, J. M., Arya, M., Sauder, J. F., Focardi, P., Bradford, S. C., & Lopez Jimenez, F., "Design of Flexures for Deployable Reflectarrays using High Strain Composites" In *AIAA SCITECH 2022.*