# Origami Solar Arrays for Small Space Systems

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Space system miniaturization has gained traction in recent years. Large-scale space flight is costly as launch costs are expensive for high mass and volume. CubeSats and small-scale rovers are far less costly to develop and launch but must operate off small-scale components. An efficient means to supply power for these small-scale missions is needed, both in orbit and extraterrestrial environments. Recent research utilizes flexible solar arrays for small systems as conventional Silicon panels are too heavy. Rapidly expanding and contracting polymer-based solar panels have been developed using straightforward mechanical systems, but they are easily wrinkled over time or torn through by dust particles. New small-scale missions based upon these super thin technologies must be simultaneously rigid yet compact.

Origami allows for a small, storable system to expand in space while maintaining rigidity. There are two mainstream methods of creating a compact solar array utilizing origami. The Hannaflex design uses a Hoberman ring to expand from a compressed cylinder to a disk-like shape. As the ring expands radially outward, a sheet of silicon-based panels is exposed, allowing for much of the surface area to be contained in the folds. However, it requires a heavy metal skeleton that uses a complex system of motors to expand the design. The Ultraflex design has a lightweight mechanical structure that creates an umbrella from a compressed wedge shape. The wedge uses tension to rotate, expanding the system. Unfortunately, the system is never fully compressed, leaving room for debris to cover the surface. Small-scale missions require a solution that minimizes both volume and mass.

We propose a doughnut origami design using lightweight perovskite solar arrays for small-scale rovers and satellites. Inspired by the Yoshimura pattern, it uses isosceles triangles to create a cylindrical surface that rapidly expands upward. When a force is applied to the center of the cylinder, the triangles temporarily compress to absorb the force while maintaining structural stability. The interior of this surface is hollow, allowing for the placement of perovskite cells across the exterior and interior of the design. The array minimizes both packaged mass and volume, suitable for small lunar or interplanetary rovers and small satellites. The rigidity of the cylindrical structure can withstand strong winds and ragged dust particles characteristic of Mars. The design exposes the exterior and interior space to generate the largest amount of power for small-scale missions

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