

# Origami-inspired antenna technology for use in small satellites

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**New Satellite Antenna Design Based on Origami Theory**

Small satellites like CubeSats are used in low earth orbit (LEO) for high-quality communications

The antenna is a crucial component of this system, but modern antennas are often too bulky or costly

Researchers used ideas from space-mapping origami theory and the mechanical dynamics of a planar spring to design a shape- and polarization-reconfigurable lightweight antenna for LEO satellites and CubeSats

**4-planar dipole prototype antenna**

- Lamina Emergent Torsion (LET) joint
- Rigid FR4 board (0.5 mm thick)

**Active Modes**

- No-Link: Launching
- Vertical Link: Folded Mode
- Horizontal Link: Planar Mode

3 operational modes (inactive – during launch/storage, planar – omnidirectional linearly polarized wave for inter-satellite communications, folded – directional circularly polarized wave for earth-to-satellite communications)

- 4-way Gysel power divider circuit (antenna-feeding network)
- Delay lines

Size = 100 × 100 mm<sup>2</sup>

Reconfigurable volume, radiation patterns, and polarization

Lightweight (5 g)

Fits into a 1U CubeSat

C-band frequency (high data transmission rate)

**This small, lightweight reconfigurable antenna can improve LEO nanosatellite technology – a first stepping stone to a fully connected world for 6G communication and beyond**

Origami-Inspired Radiation Pattern and Shape Reconfigurable Dipole Array Antenna at C-band for CubeSat Applications  
Hwang et al. (2020) | IEEE Transactions on Antennas and Propagation | DOI: 10.1109/TAP.2020.3030908



A multidisciplinary team engineered a small, light, and low-cost deployable antenna for nano- and micro-satellite communications Credit: Pusan National University

Modern telecommunication systems rely on satellites to relay signals across the globe quickly and reliably, enabling users to send messages across the world in an instant, watch live television, or—more

recently—hold conference calls with global partners right from the kitchen table!

Communications satellites use high-frequency radio waves to transmit data, with antennas acting as a two-way interface, converting electric current provided by the transmitter into radio waves, and vice versa when paired with a receiver. Antennas are therefore vital pieces of equipment, without which satellites and ground receivers would be practically useless. However, despite advances in modern [satellite](#) design and performance, [antenna technology](#) remains a limiting factor for next-generation telecommunications such as 6G.

Engineers struggle to miniaturize antennas for nanosatellites without compromising on their cost or performance. For instance, nanosatellites like CubeSats can be as small as a  $10\text{ cm}^3$  cube, but manufacturing a [communication antenna](#) small enough to be stored inside it during launch and flight is expensive and technologically challenging. "Many high-performance antennas reported for CubeSat systems are deployable, foldable, or inflatable." explains Dr. Sangkil Kim from Pusan National University in South Korea.

Recently, Dr. Kim and his colleagues at Pusan National University and the University of Alabama, U.S., developed a new deployable antenna for CubeSats used in [low-earth orbit](#) (LEO). Interestingly, their design was inspired by the mathematics of "origami," the Japanese art of paper folding—specifically a field called spatial mapping—which enabled them to decide on the best geometry for a foldable, deployable antenna. With the design on paper, they set out to manufacture the antenna and test it.

With remarkable dimensions of  $32.5\text{ mm}^3$  when folded and weighing merely 5 grams, the prototype antenna fits snugly within a CubeSat. The researchers used an inexpensive material to make the bulk of the

antenna, using special joints to fold the square boards into a cube, which can easily be stored during launch and flight. Once in orbit, the antenna can be deployed outside of the CubeSat, ready to receive and transmit data.

Prof. Kim and his team went one step further and set up different deployment modes, depending on whether satellites needed to communicate with each other or with Earth. "The volume, radiation patterns, and polarizations of the antenna are reconfigurable according to the required operation mode," Dr. Kim explains. This configuration enabled the researchers to optimize the antenna's performance for each type of communication.

With such promising results, the scientists hope their design will inspire future deployable designs for nanosatellite antenna technology and pave the way for next-generation communication systems, such as 6G. Not only will their prototype reduce the cost of future nanosatellites and improve their overall performance, but it can also be scaled up to larger satellites in geostationary orbit and other communication platforms on Earth.

**More information:** Myeongha Hwang et al, Origami-Inspired Radiation Pattern and Shape Reconfigurable Dipole Array Antenna at C-band for CubeSat Applications, *IEEE Transactions on Antennas and Propagation* (2020). [DOI: 10.1109/TAP.2020.3030908](https://doi.org/10.1109/TAP.2020.3030908)

Provided by Pusan National University

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