TWIST | Imperial College London

High performance thin film small satellite subsystems with a twist

Overview

In this project, carried out within the Department of Aeronautics, Imperial College London, we demonstrate a thin-film drop-in replacement for a traditional small satellite solar array using a 1U CubeSat as a proof of concept. A multifunctional hybrid printed electronics thin-film substrate is deployed by an adaptive material hoop 'bustle', stowed to fit on one side of a 1U CubeSat through the use of one or more figure-of-eight twist folds resulting in a subsystem that can combine one or more of the following as per mission requirements:

- **High power solar array** — generating up to 128 W from up to 32x the available area of a 1U CubeSat array;
- **Large aperture communications antenna** — S-band conformal reflectarray up to 64 cm diameter;
- **Aerodynamic drag deorbit device** — increases spacecraft cross sectional area by an order of magnitude.

The developed concept — named TWIST — is a modular thin-film subsystem proof of concept for 1U CubeSats based on the Pumpkin 1U skeletonized CubeSat structure. The subsystem consists of a Pumpkin Solar Panel Clip Kit compatible Printed Circuit Board Frame (PCBF), between one and four Thin Film Deployable Subsystems (TFDSs), depending on the application plus electrical and mechanical connections.

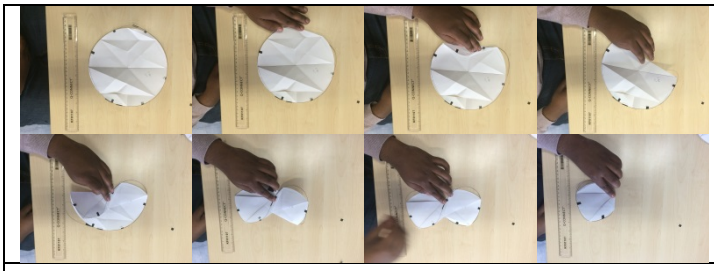
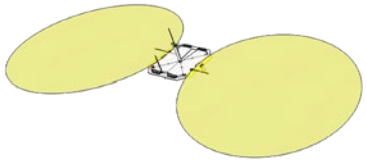
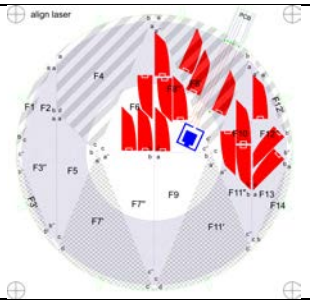
Key innovations include the development of the carbon fibre/superelastic alloy adaptive bustle to allow extremely compact stowage and controlled deployment of shaped thin film printed hybrid electronics substrate with multiple functions simultaneously incorporated with minimal or no additional mass or volume; compatibility with existing standard spacecraft interfaces with no encroachment of the internal volume of the spacecraft; and providing the ability to steer the array in a single axis.

Achievements

Over the duration of the project, the following goals were achieved:

- **Membrane origami fold patterns** compatible with the bustle structure have been developed and demonstrated. Modifications have been developed to allow for similar stowage mechanisms to be used with rigid plates such as conventional solar cells. Fold patterns for up to three levels of twist have been quantified.
- **CubeSat compatible interfaces** have been designed for up to 3 TWIST systems to be deployed from the surface of a 1U satellite.
- **FlexPCB cuttings patterns** have been produced for the inclusion of de-orbit, magnetorquer, patch antenna, and solar cell on a single membrane.
- **Deployment verification** driven by release of stored strain energy in the bustle component has been demonstrated in a 1-g environment. High speed footage indicates that the deployment is robust, repeatable and controlled.

- **Deployment initiation** has been successfully demonstrated using a designed monofilament burnwire mechanism.
- **The electrical interface** connecting the membrane to the bus has been designed.

	Fold sequence for a single twist membrane
	Example configuration: two TWIST systems integrated with a Pumpkin Solar Panel Clip Kit compatible Printed Circuit Board Frame
	O8 multifunctional membrane fold and cutting pattern incorporating de-orbit, magetorquer, patch antenna, and solar cell integration

In summary, the project has been successfully completed. The TWIST concept has been proved and offers substantial potential advantages over existing deployable solar array concepts, particularly with respect to the addition of multifunctionality and the improvement in stowage efficiency.