PowerCube: Design And Development Of A 100 W Origami-Inspired Deployable Solar Array For Nanosatellites

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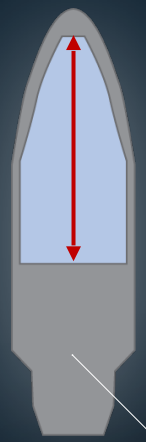
2022 Small Satellites Conference
August 6-11, 2022
Utah State University
Logan, UT

SMALL SATELLITES
OUT OF THIS WORLD!

DCUBED



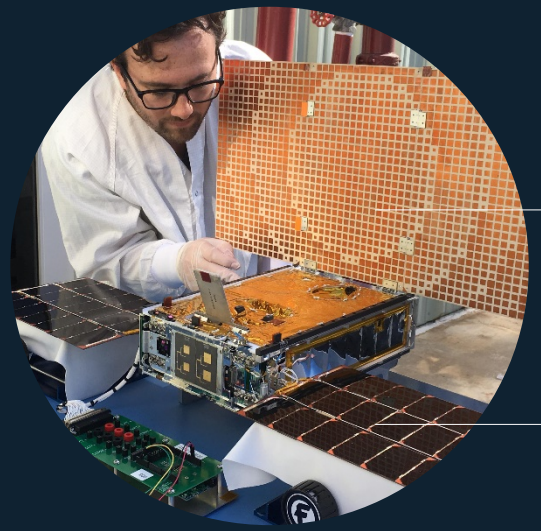
Two big factors: size & weight

Launch is expensive: ~ $30,000 / kg

~ 5% of Mass are Payloads

Payload space is limited

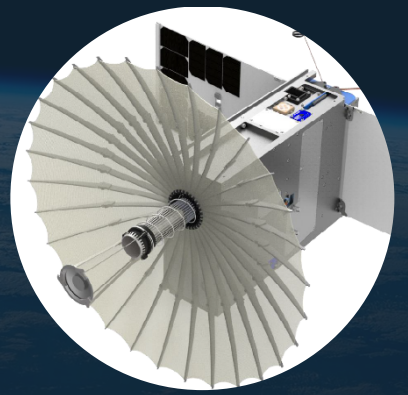
Deployable Structures



Communication Antennas

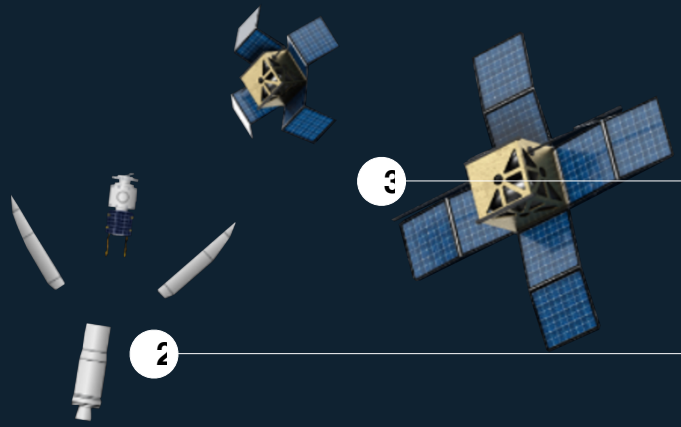
Solar Arrays

Drag / Solar Sails



Earth Observation Antennas

OUR SOLUTION

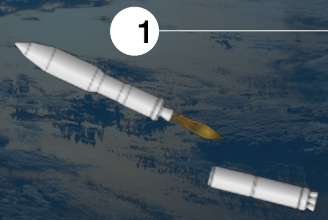


SmallSat Deployables

Deployable structures (like solar arrays, radiators, baffles, antennas, -) that are small on Earth and big in Space.

Satellite Deployment

Release the satellite from the rocket/ satellite deployer



Hold-Down and Release

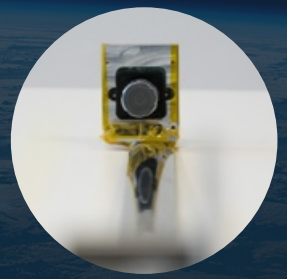
Release mechanisms for satellites, space stations, landers and rovers

RELEASE ACTUATORS

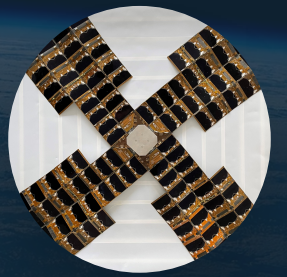
nD3PP Pin Puller

nD3RN Release Nut

DEPLOYABLES



D3S3 Space Selfie Stick



Solar Array Development

Overview of PowerCube Development

Technology Development:

power cube

100W NanoSat Solar Array

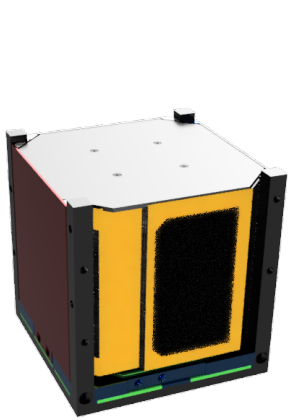
esa DCUBED GERMAN ORBITAL SYSTEMS AZURSPACE TECHNISCHE HOCHSCHULE DEGGENDORF THD

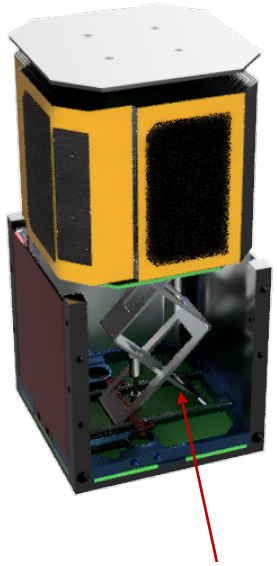
System Verification and In-Orbit Demonstration:

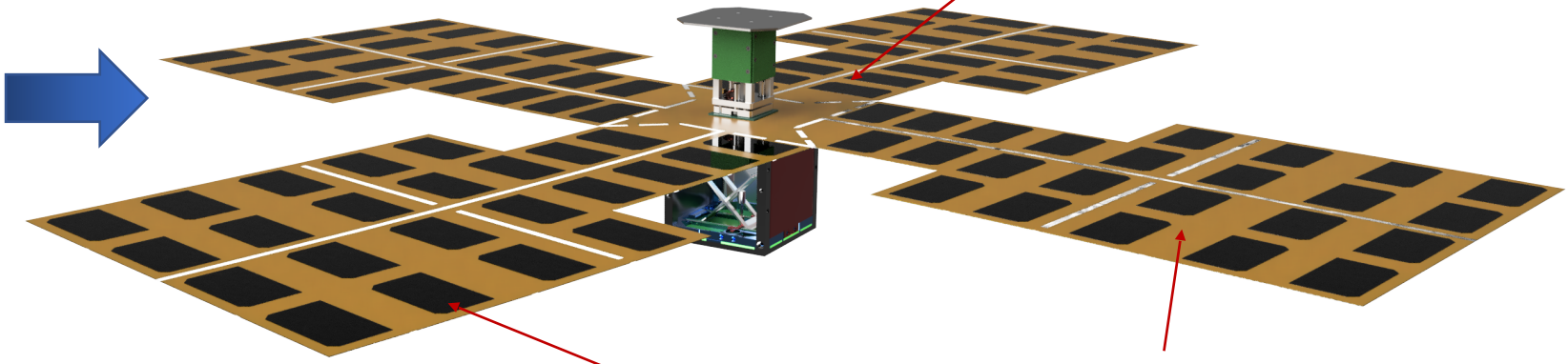
POWERSAT
Space Solar Power:
a Pathway to a Sustainable Future
for Earth and Space Applications

NASA CAL POLY DCUBED

System Overview







Stowed volume:
1000 cm^3 (1U)

Extraction mechanism:
Spring-loaded scissor lift

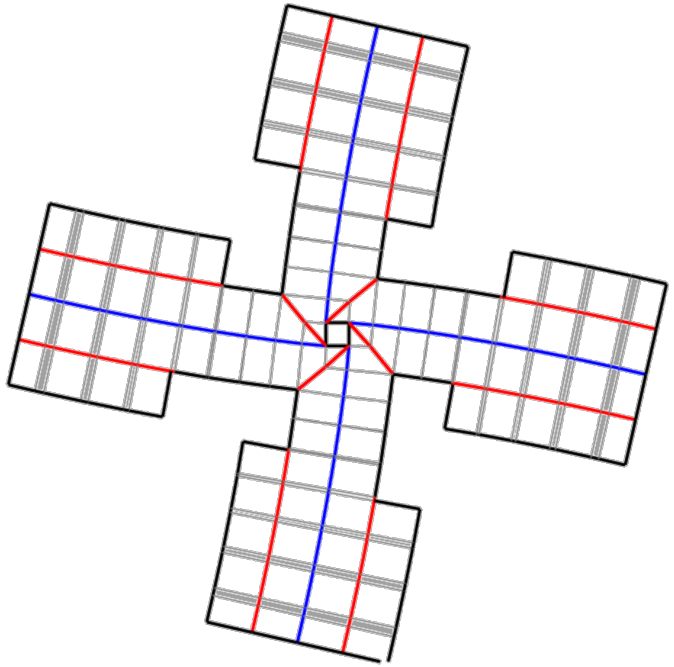
Release actuator: nD3RN release nut

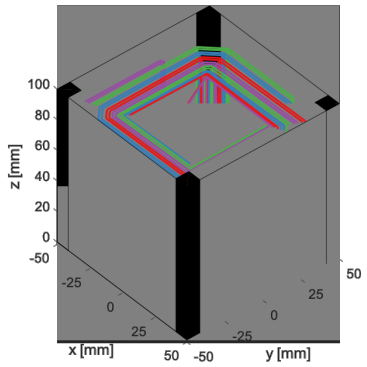
96x triple-junction III-V solar cells $\Longrightarrow$ peak power
up to 100 W @14.7 V

Key Design Features

Origami-Inspired Folding Pattern

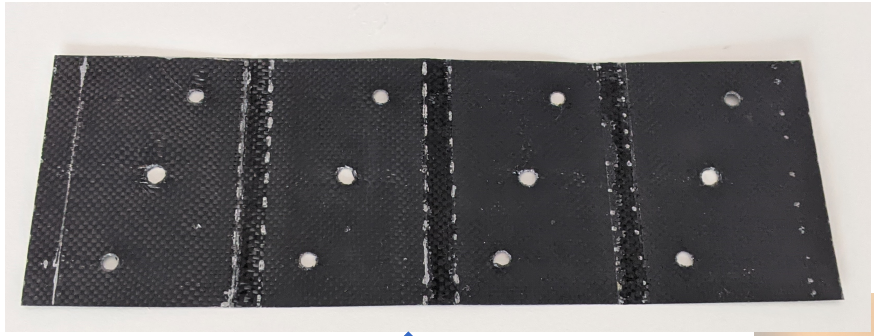
- High packaging efficiency
- No deformation of solar cells $\Longrightarrow$ Can use III-V 30% efficient COTS solar cells

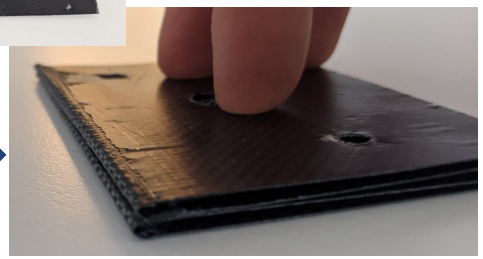




Dual-Matrix Composite Substrate

- Rigid-flexible structure
- Less than 300 µm thick
- Folding radius of 350 µm
- Self-deployable

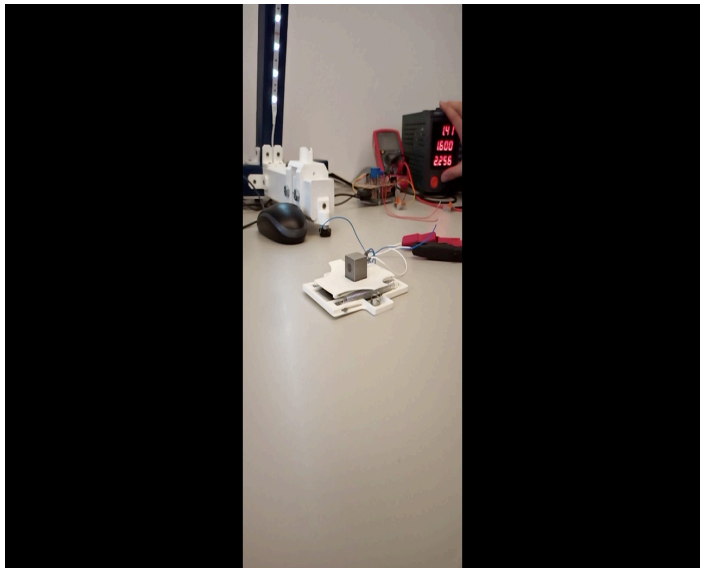




Key Design Features

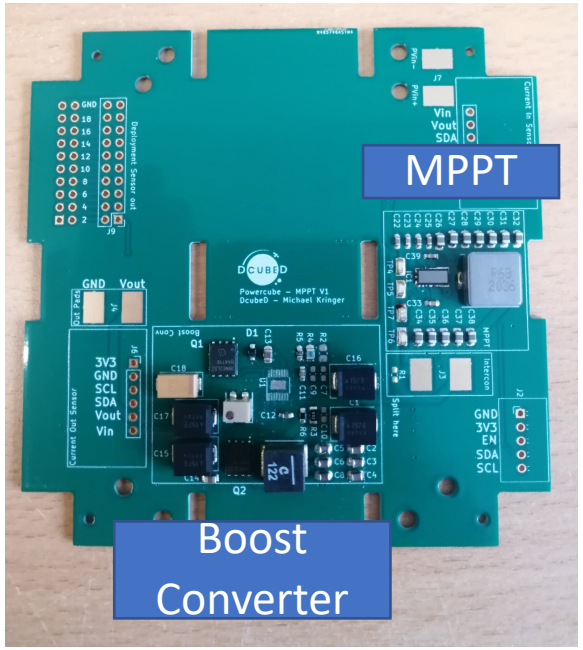
Extraction Mechanism & HDRM

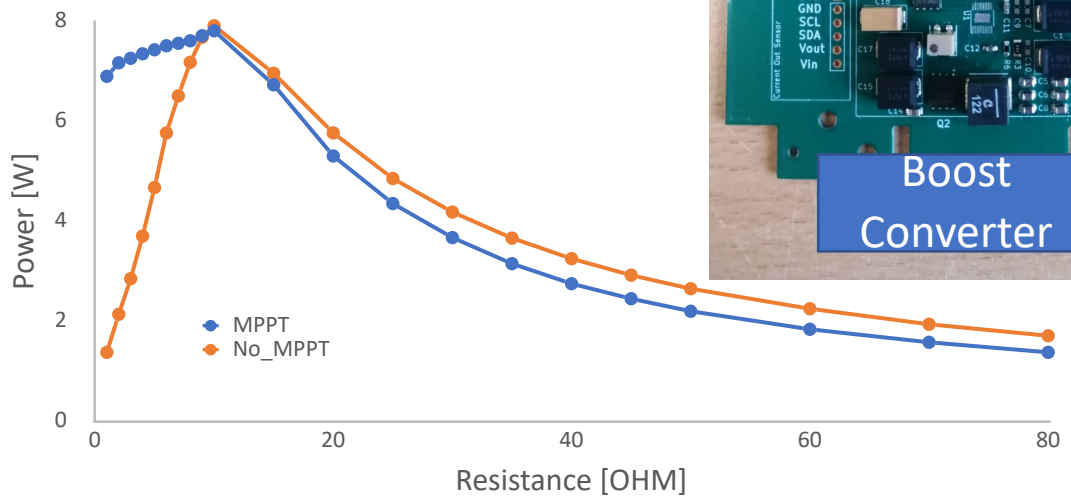
- Flight-proven, SMA-based nD3RN Release Nut
- Spring-loaded scissor mechanism
- Only 8 mm high when stowed



MPPT (Optional)

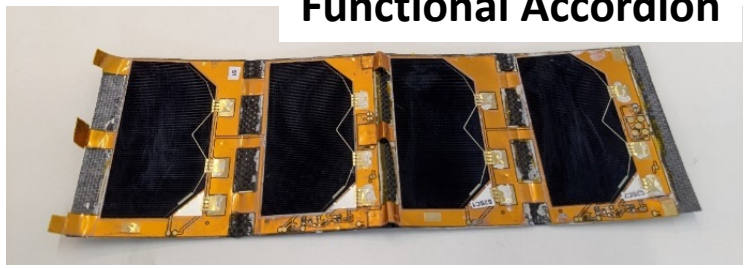
- MPPT circuit for maximum power under most operating conditions
- Boost converter for constant voltage output

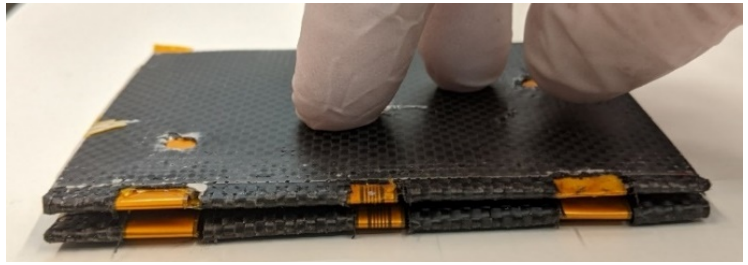




Breadboarding Campaign

Functional Accordion



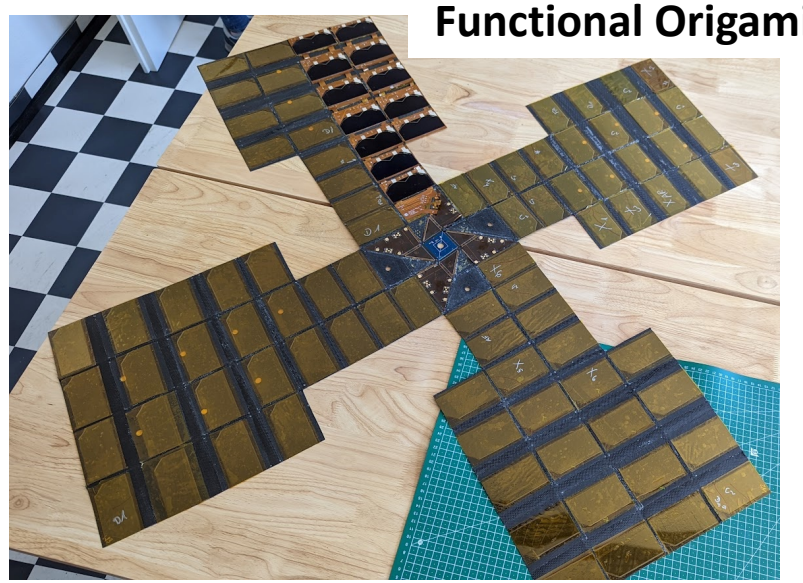


- 300 mm x 90 mm structure
- 2 strings of 2 SCAs each
- Assembly procedures
- Functional tests
- Packaging and deployment

Structural Origami

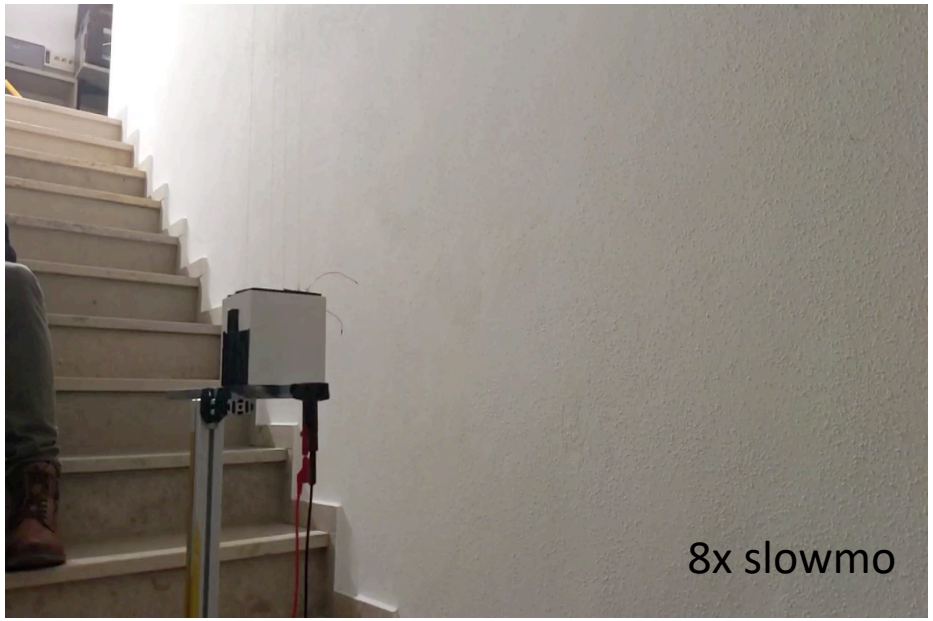
- 1.2 m x 1.2 m, full-scale CFRP structure
- Manufacturing procedures
- Packaging and deployment
- Mechanism demonstration

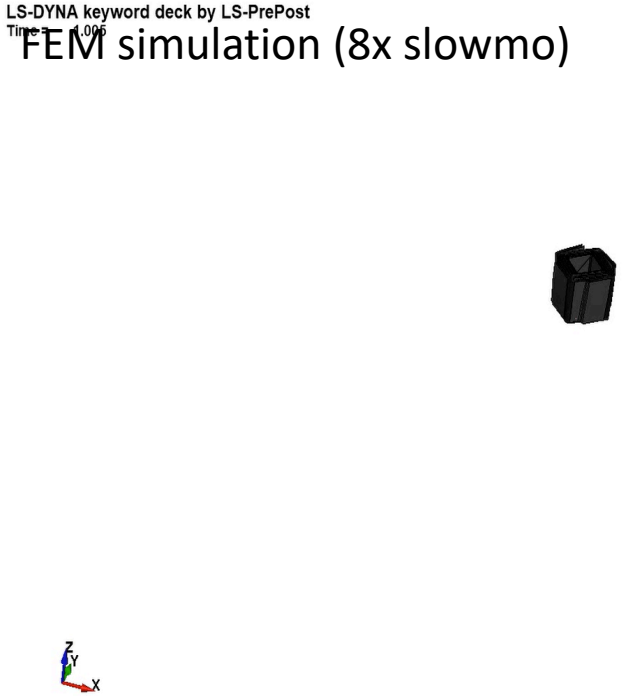
Functional Origami



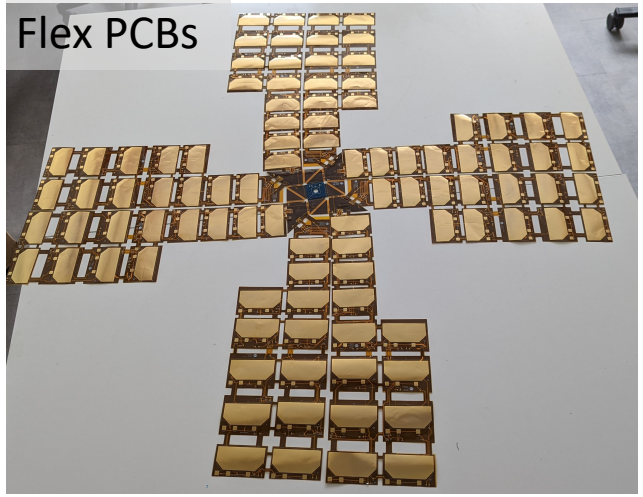
- Full-scale CFRP structure
- 1/8 real SCAs, 7/8 glass dummies
- Packaging and deployment with full thickness
- Functional tests

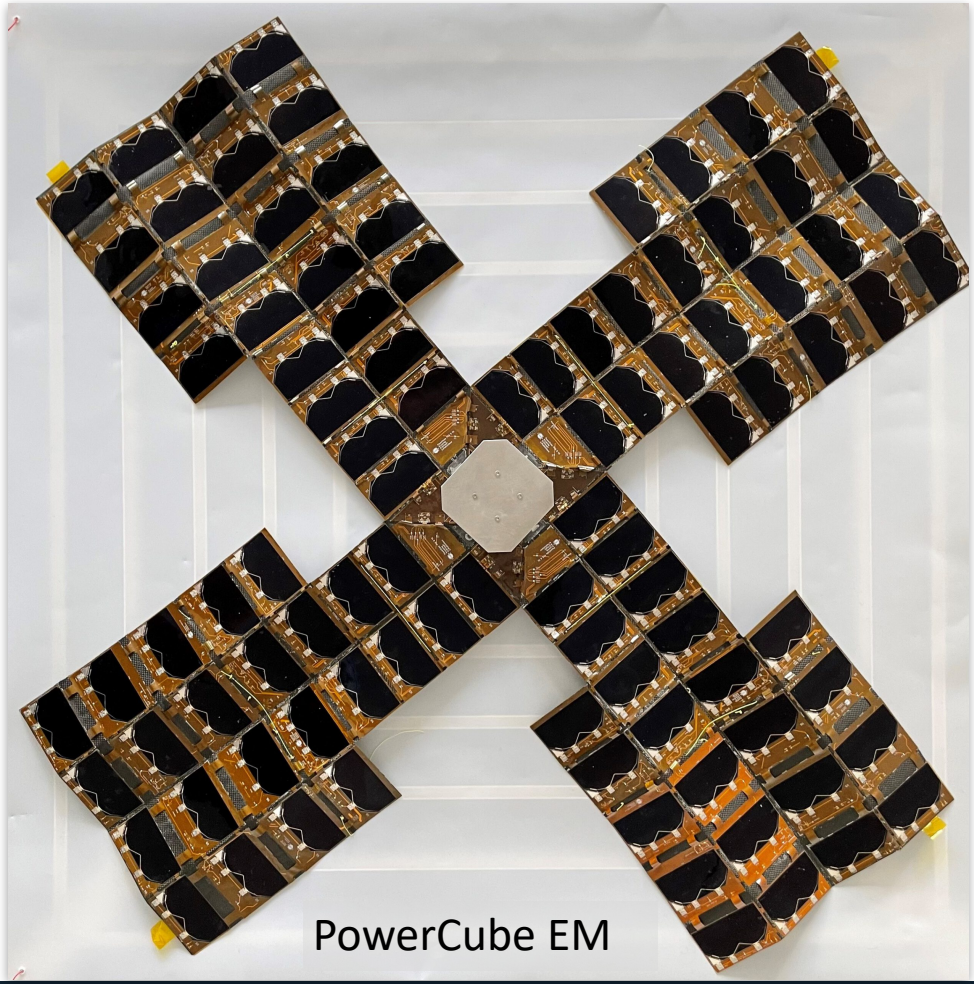
Deployment Tests

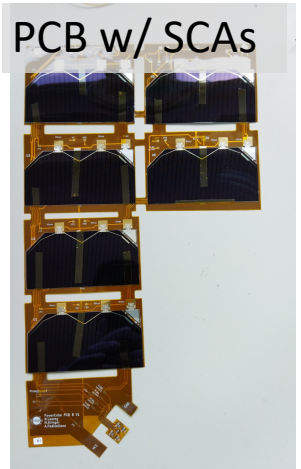


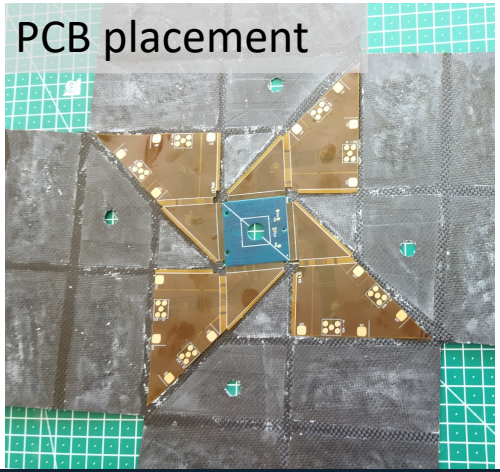


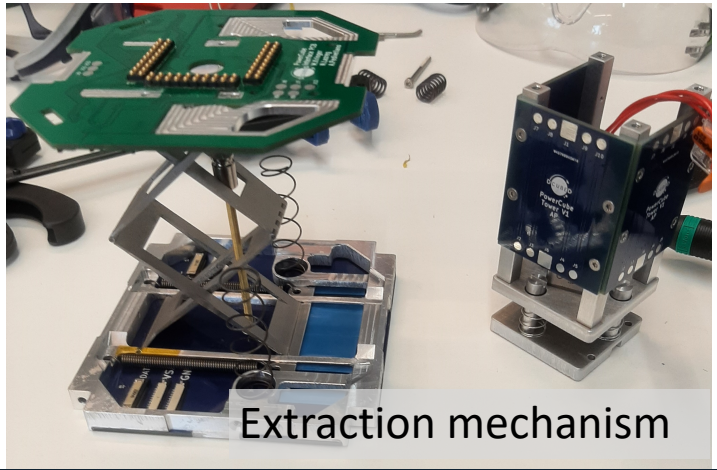
Engineering Model Development





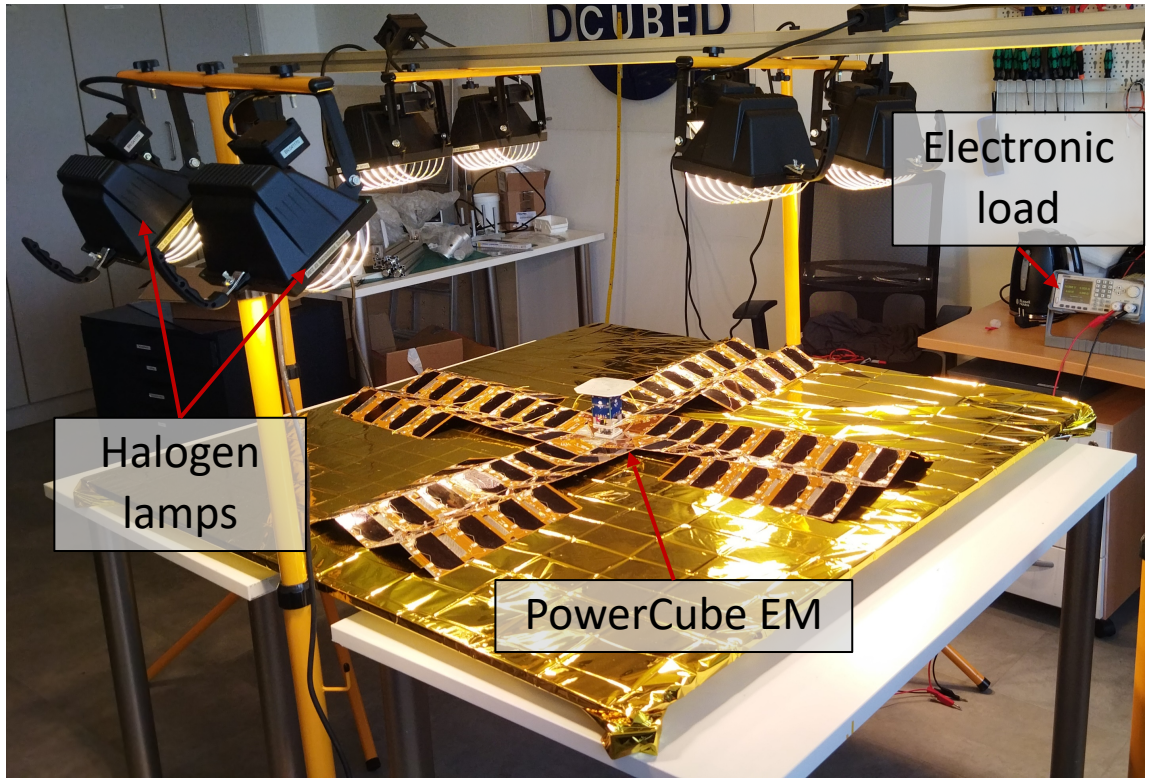


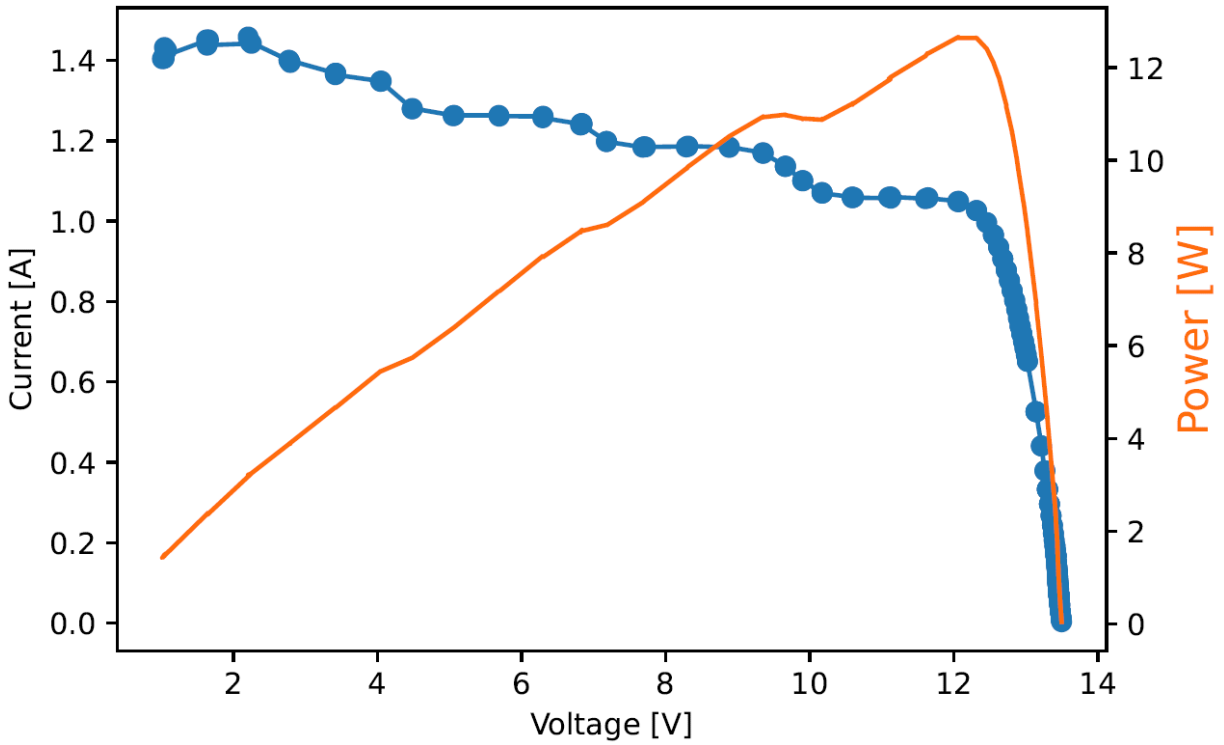




Functional Tests

- Currently generating about 12% of expected power under AM0 conditions with in-house test setup
- Functional test with Sun simulator at ESA facilities planned in the coming months



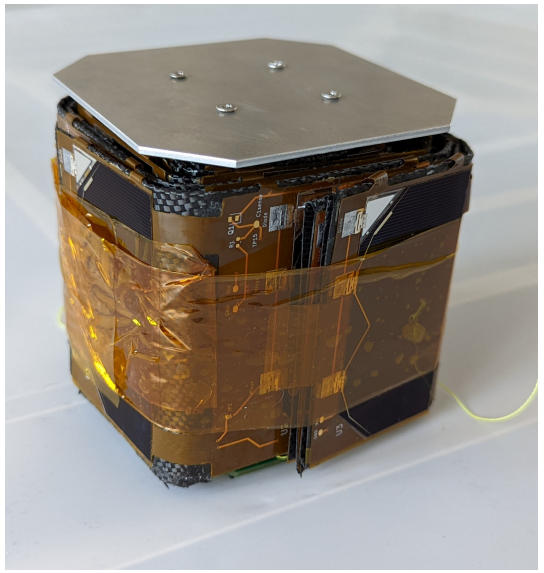


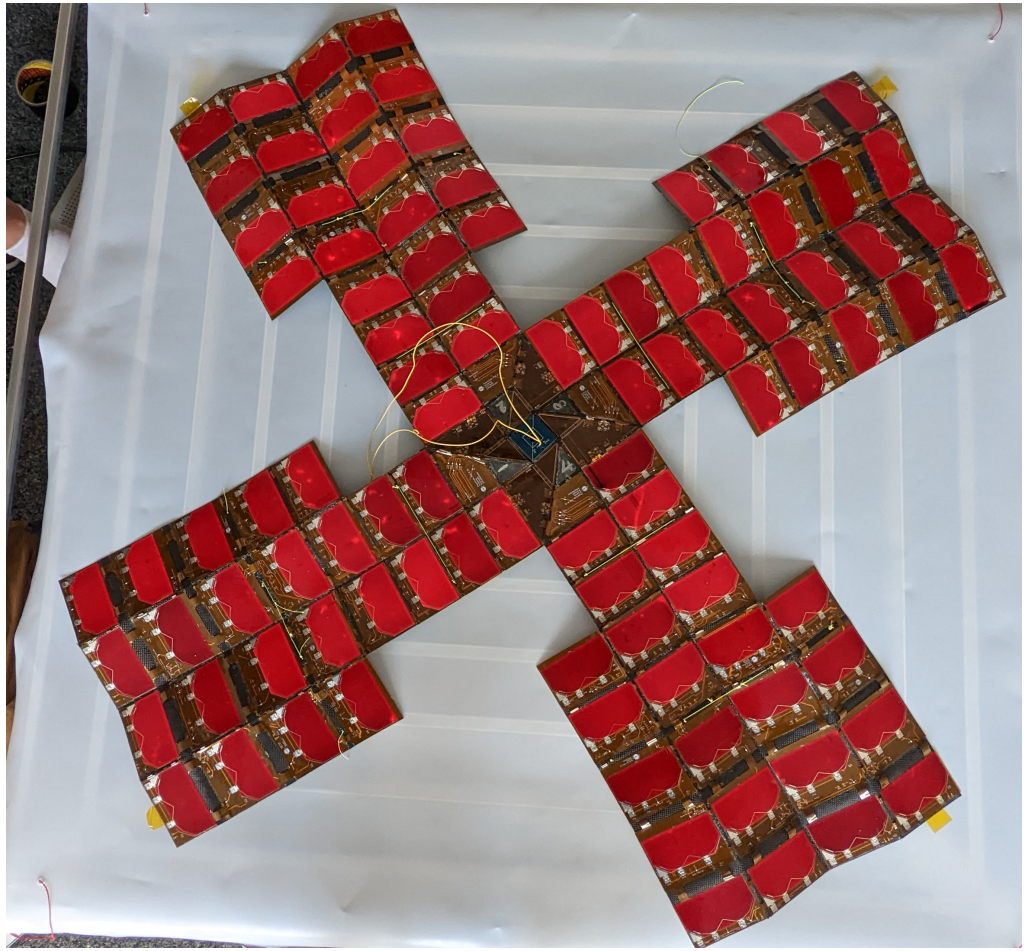
Packaging Tests

- Successful packaging in expected configuration
- Demonstrated functionality of flexible hinges
- Performed electro-luminescence (EL) tests to verify structural integrity of solar cells
  - No cracks appeared after 4 packaging/deployment cycles

Ongoing work

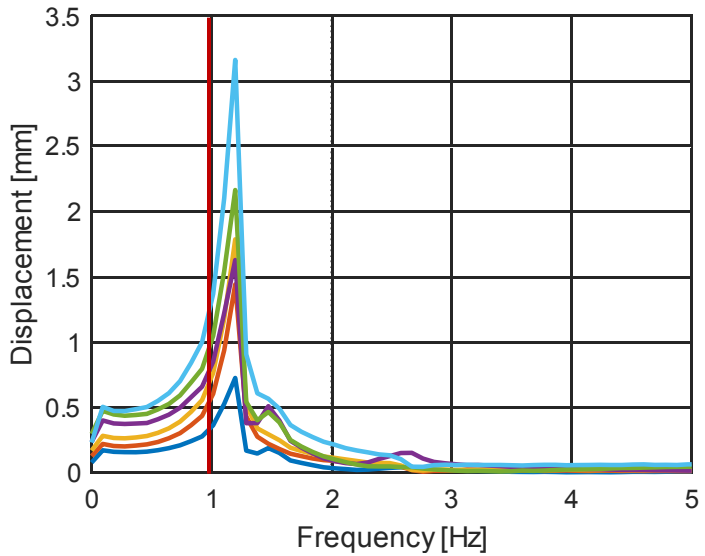
- Integration with CubeSat structure
- Deployment tests with gravity compensation system

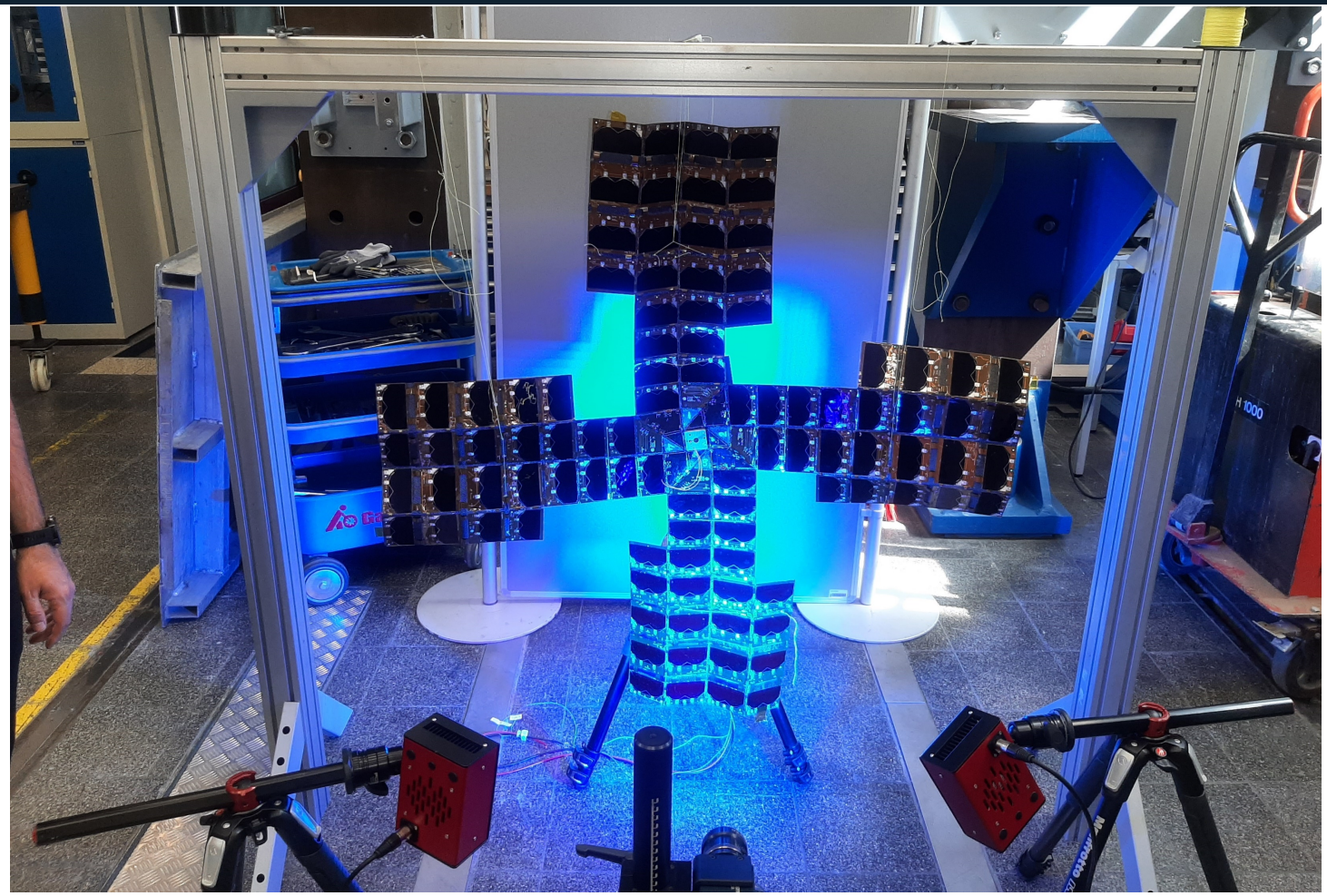




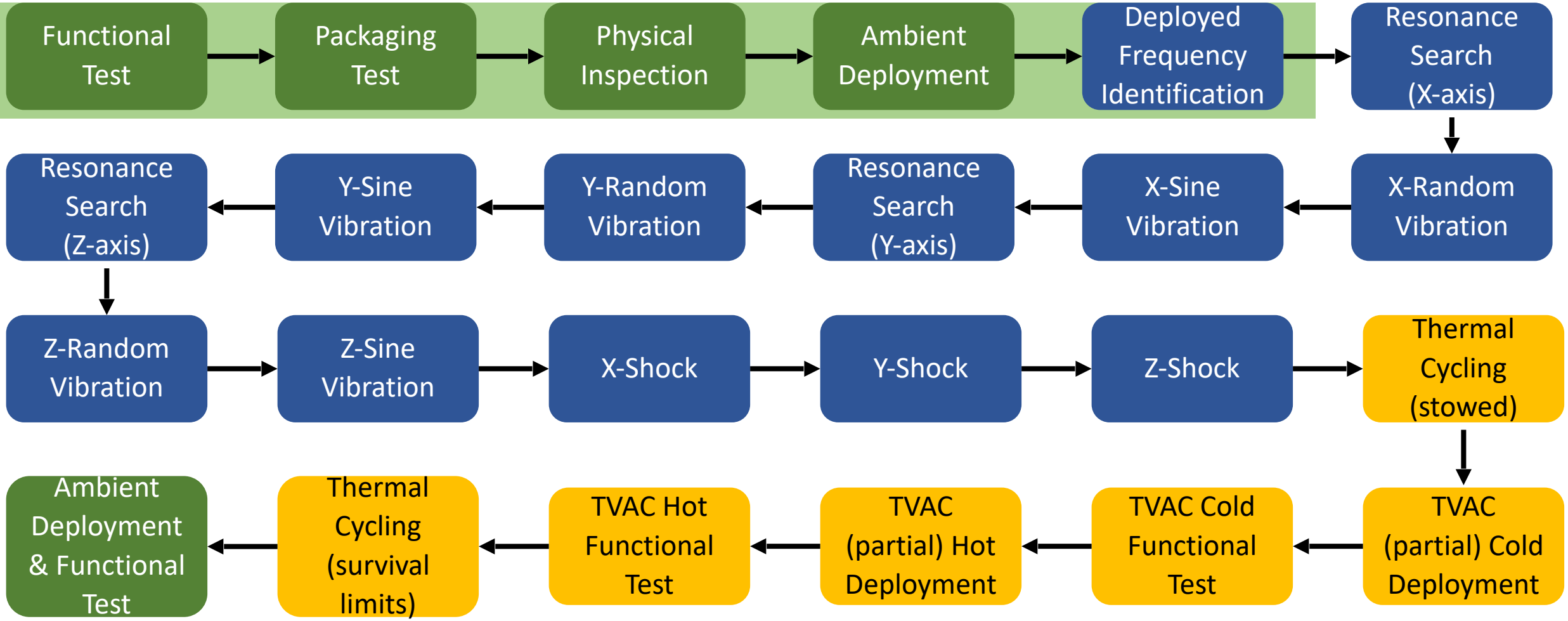
Deployed Frequency Measurement

- Deployed frequency measured with photogrammetry
  - Structure excited by impulse hammer
  - Targets on the structure tracked at 60 fps
- **Passed 1 Hz requirement**





Test Sequence Overview

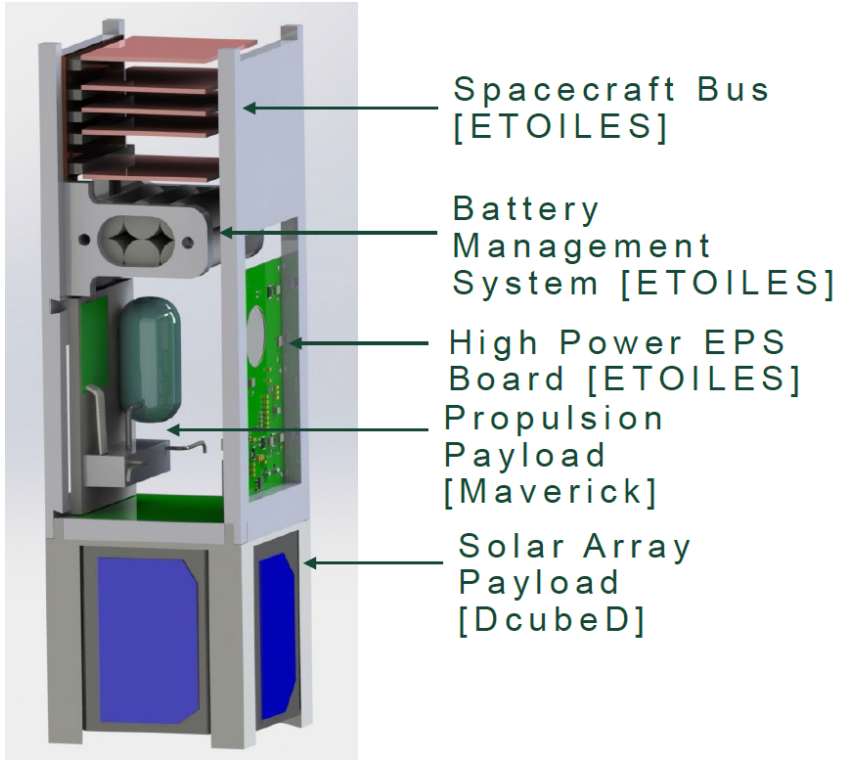


Towards the PowerSat IOD Mission

- Technology demonstration mission to demonstrate the use of a high-power system on a CubeSat
- Selected for the NASA ELaNa program for a launch in 2023

Key technologies:

- CPCL: EPS from TRL 3 to TRL 9
- CPCL: X-band comms from TRL 3 to TRL 9
- CPCL: Optical beacon
- DcubeD: 100W solar array from TRL 5 to TRL 9
- Maverick: water propulsion system



Delivering more Power for your Cube

DCUBED

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