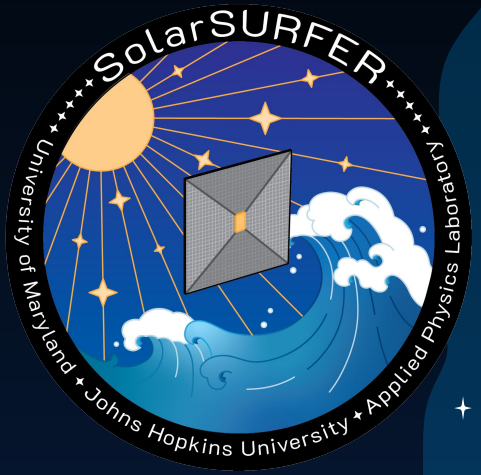
SolarSURFER: Solar Surfing Revisited



Arya Kazemnia & Mateo Otero-Diaz
CubeSat Developers Workshop 2025

Who are we?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Olin College
of Engineering


SolarSURFER
University of Maryland
Johns Hopkins University
Applied Physics Laboratory


THE UNIVERSITY OF CALIFORNIA BERKELEY
1868
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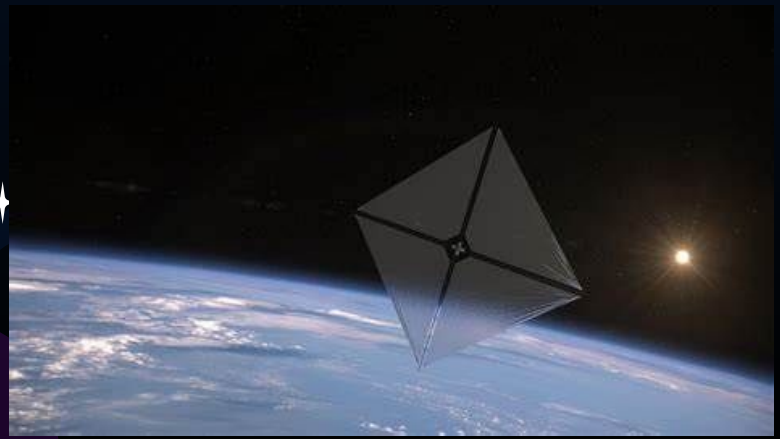
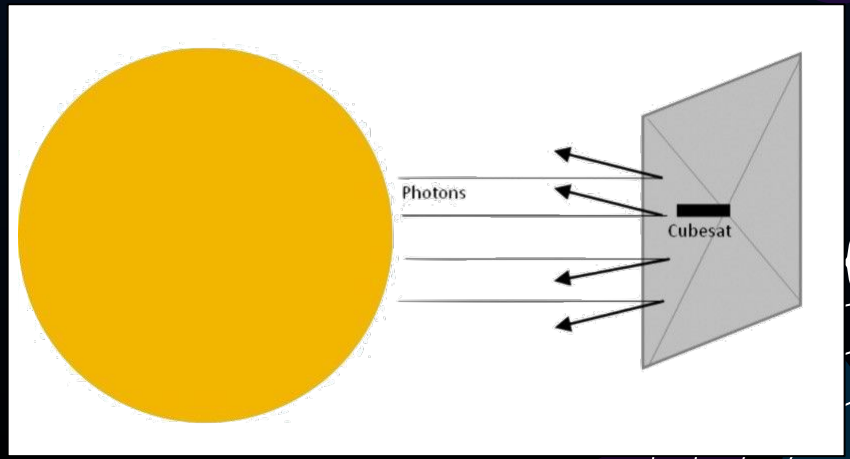
UNIVERSITY OF CALIFORNIA


UNIVERSITY OF
MARYLAND

What is Solar Sailing?

- Uses photons' momentum by reflecting them off a surface
  - Like a sailboat but with light instead of wind
- Sail size is directly proportional to the thrust generated
  - Bigger is better!





Overview Of Mission

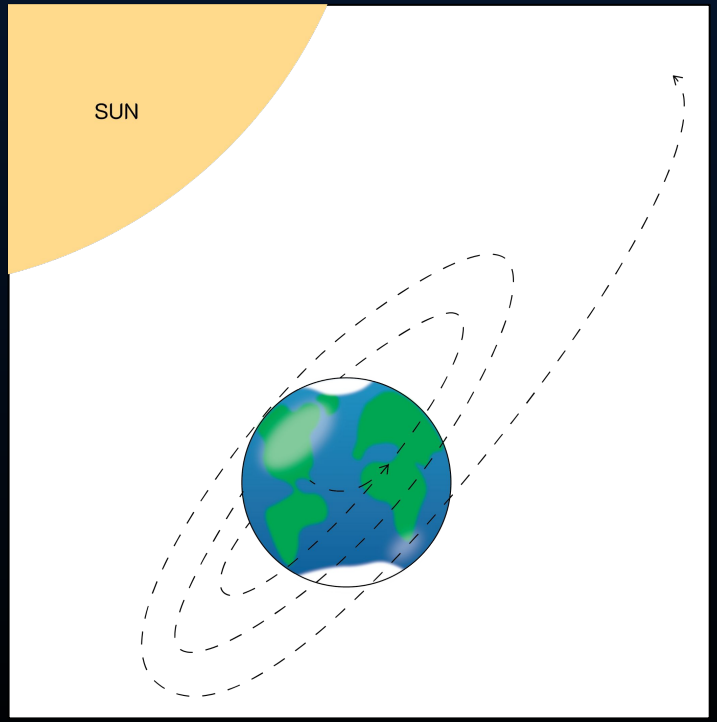
- Apply and demonstrate the feasibility of solar sail propulsion.
- Innovate deployment procedure for the sails.
- Demonstrate the feasibility of High Gain Antenna (HGA) sail.

Concept of Operations

Phase 1: **Launch**
Satellite is launched into Low Earth Orbit

Phase 2: **Deployment**
Satellite detumbles and deploys its sail

Phase 3: **Orbit Raising**
Satellite begins to raise its orbit and collects imagery of the surface of the Earth

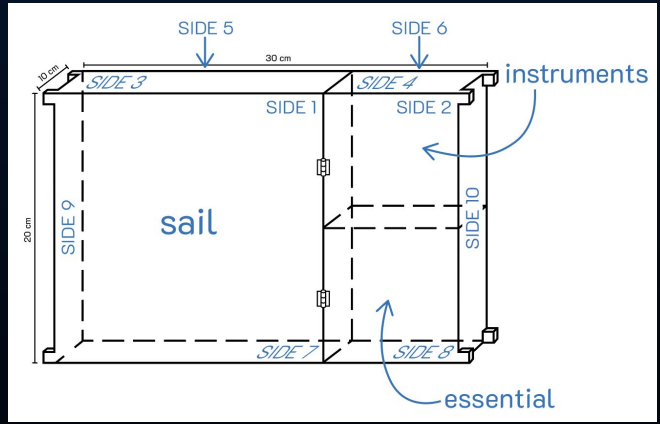


Phase 4: **High Gain Antenna Testing**
Satellite begins operating its HGA

Phase 5: **End of Life**
Satellite will either turn sail to fall into Earth's atmosphere or drift away until it cannot communicate

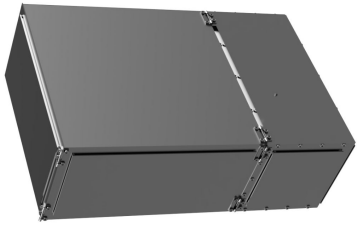
SolarSURFER Module Design

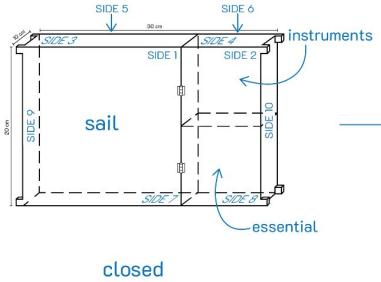
- Dedicated 4U volume for solar sail.
  - Actual volume will be approximately 200cm^3 less due to deployment systems, electrical wiring, fasteners, and detonators.
- 1U of the remaining 2U will be utilized for “life essentials”.
  - Battery pack, OBC, ADCS kit, transceivers
- Last 1U will house scientific instrumentation.
  - Hyperspectral imaging sensors, fiber-optic cabling,
- Tuna-can pod volume 1 will be utilized for horn extension mechanism (3 nitinol wires)
- Tuna-can pod volume 2 will be utilized for a 9cm lens for hyperspectral imaging



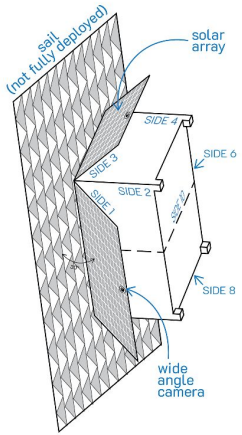
Deployment

Separate from Launcher **Detumble** **Open Panels** **Open Solar Sail**

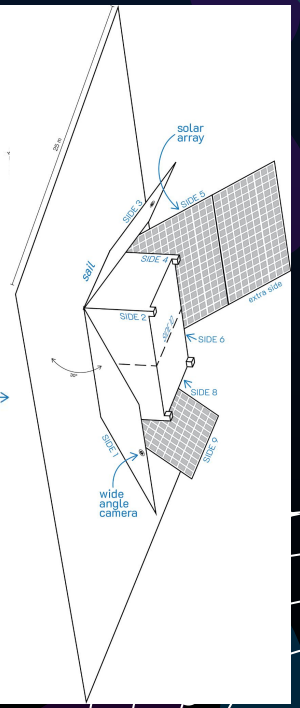




closed

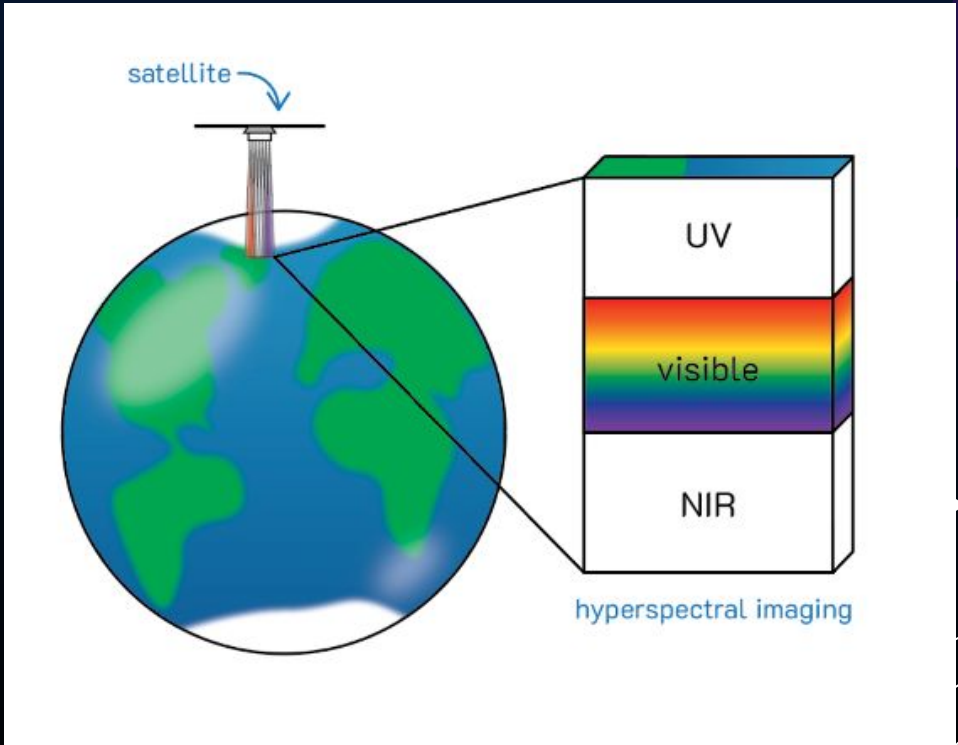


half open



Average Operations

- SolarSURFER uses the ADCS system to orient the cubesat towards the observation target
- Hyperspectral Imaging takes pictures of the surface
- SolarSURFER reorients itself towards the sun to continue propulsion
- Over JHU we downlink our collected data
  - Battery Health and Charge
  - Photos
  - IMU Data
  - Orientation Data
- We uplink commands and analyse data
- Repeat!



Sail Experiments

Sail Composition

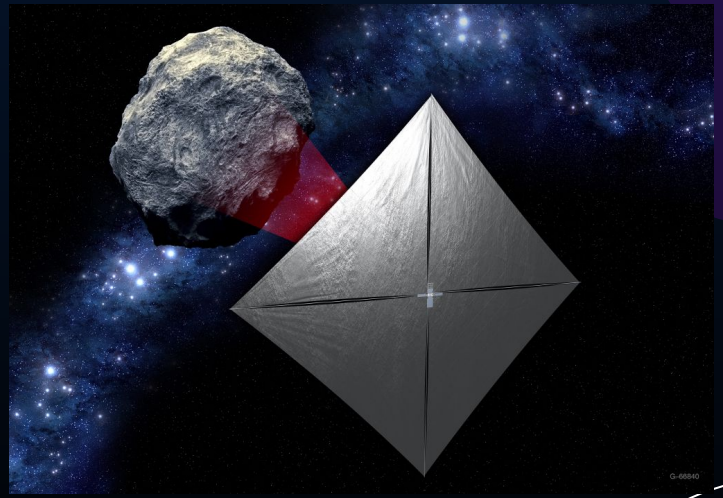
- What is the reflectivity and emissivity of our material?
- What's the best layer configuration?

Communications

- How does folding the sail affect signal strength?
- Test different reflectarray shapes and sizes

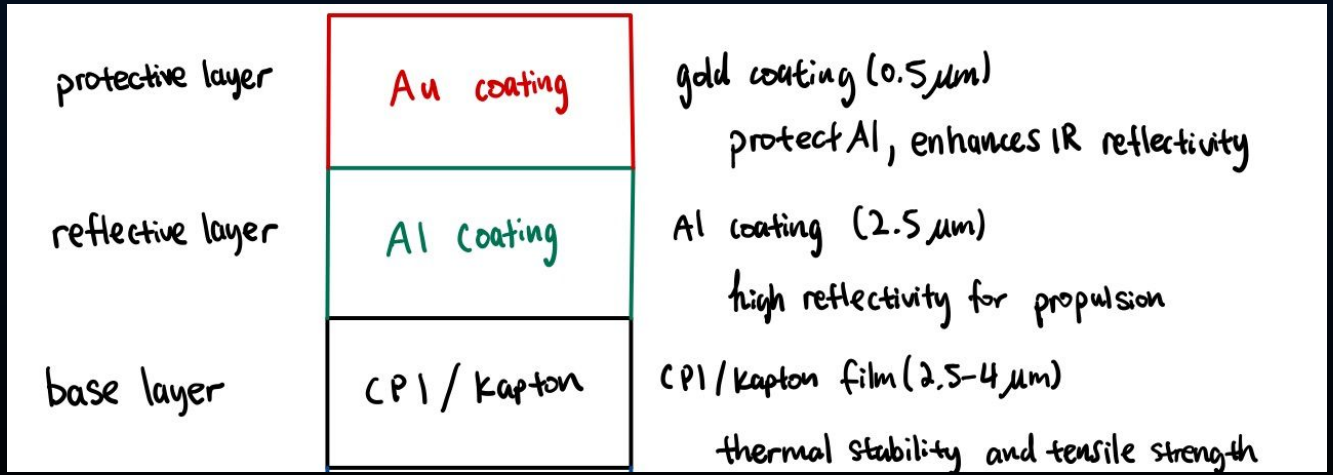
Deployment

- How do we extend the sail?



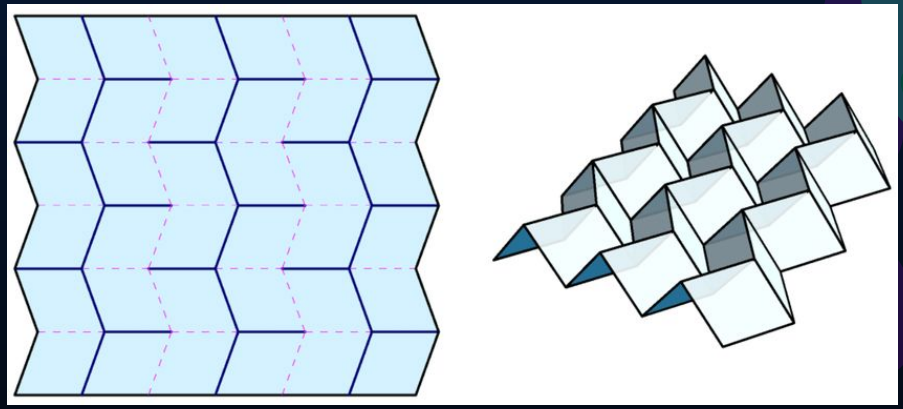
Material Selection

- **Backbone**: CP1 or Kapton films
  - Optimal thermal stability, tensile strength, and resistance to UV radiation and atomic oxygen



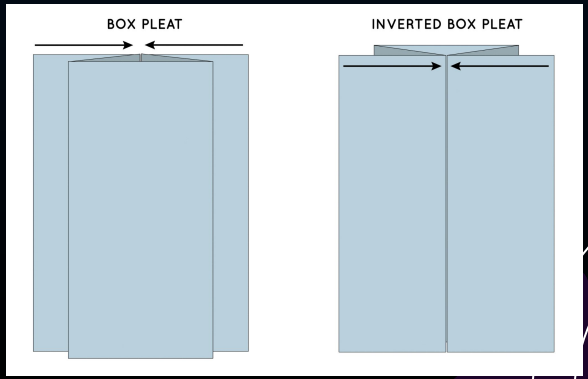
Folding Techniques Overview

- **Miura-Ori Fold**: A single-degree-of-freedom pattern, allowing rapid and reliable deployment with high packing efficiency.
- **Box Pleated Fold**: A rigid and structured fold, distributing stress evenly and providing better material control during deployment.



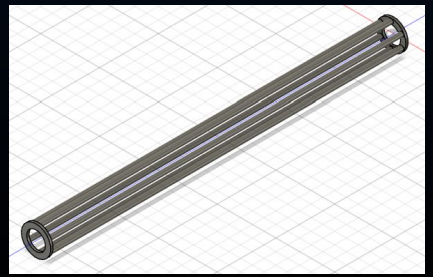
Miura-Ori Fold (top)

Box Pleated (below)

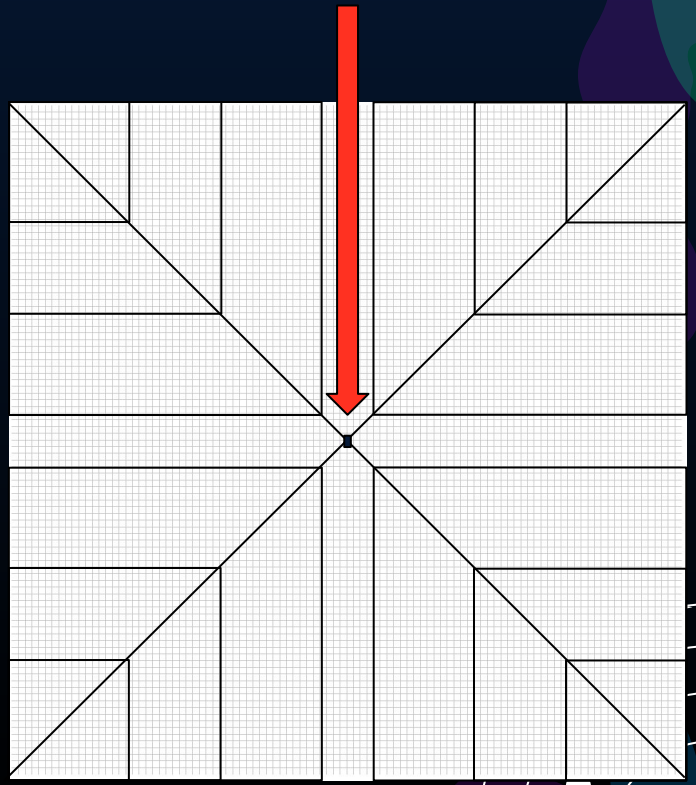


Deployment

- 20m x 20m Sail needs to be unfurled from the 4U compartment
- Deployment will be carried out through a backbone of SMA
- Booms will be initially deployed through Induction Heating through a PWM circuit
- Passive heating from Sun prevents booms from losing their shape

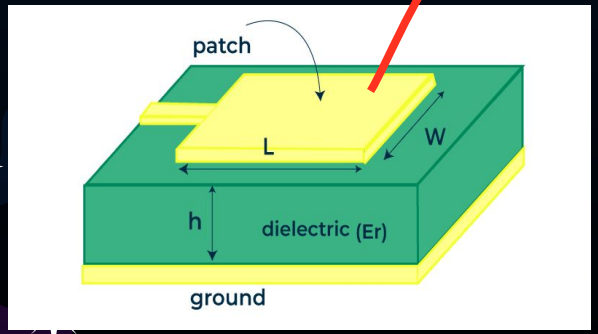


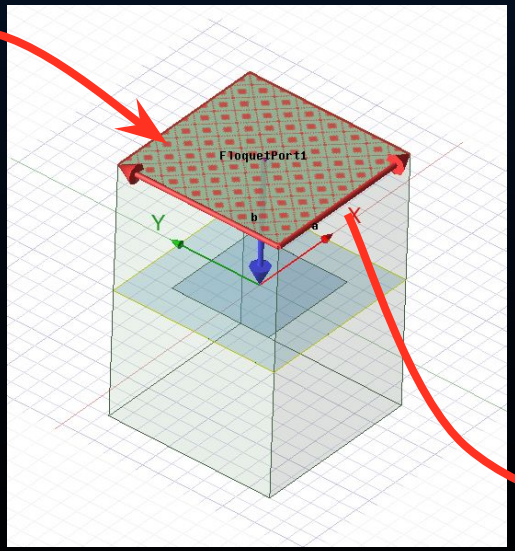
This is the Cubesat

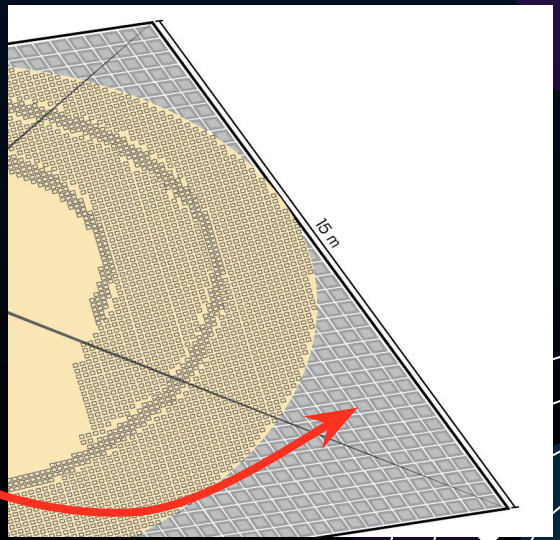


Sail High Gain Antenna

- Sail will be fitted with an array of patches to create a reflectarray
- Building on previous reflectarray designs, we seek to build a flexible one
- Array simulation on HFSS dictates a concentric pattern







Sail High Gain Antenna

- Normal horn design requires too much heating and deployment
- Reflector design allows for everything to fit in the 6U form factor
- Horn can be minimized saving space
- Reflector is deployed and adjusted by a nitinol network