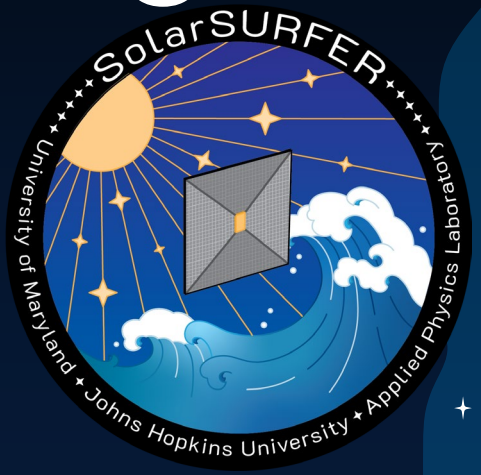
SolarSURFER: Solar Surfing Revisited

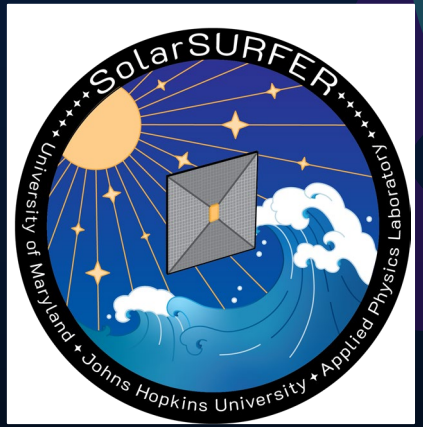


Arya Kazemnia & Mateo Otero-Diaz
CubeSat Developers Workshop 2025

Who are we?


JOHNS HOPKINS
UNIVERSITY


Olin College
of Engineering


SolarSURFER
University of Maryland
Johns Hopkins University
Applied Physics Laboratory


THE UNIVERSITY OF CALIFORNIA BERKELEY
1868
Berkeley
UNIVERSITY OF CALIFORNIA


UNIVERSITY OF
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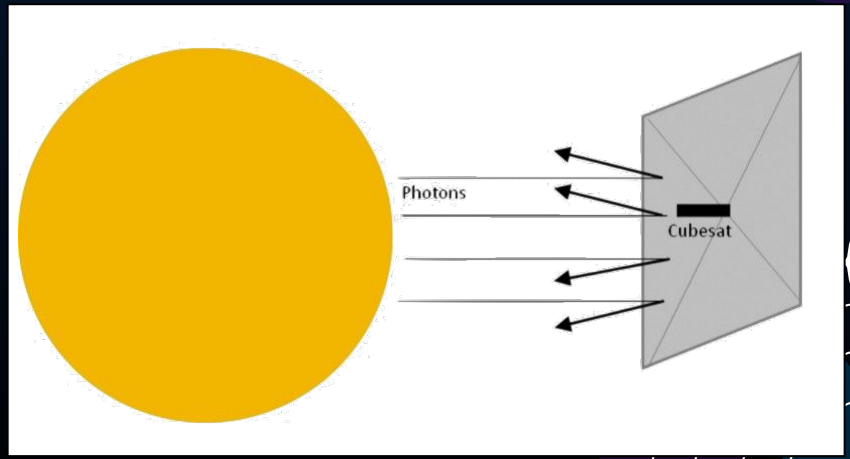
What is Solar Sailing?

- 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

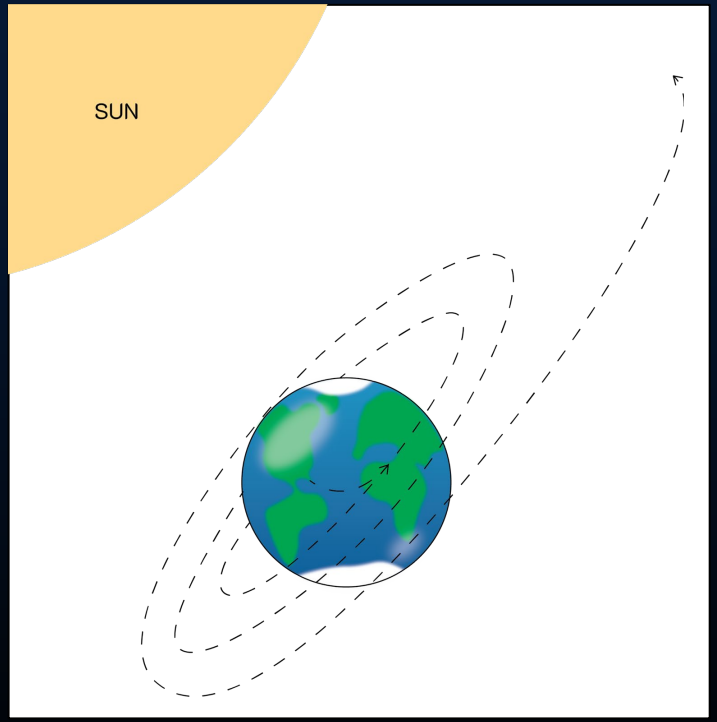
- Apply and demonstrate the feasibility of solar sail propulsion.
- Innovate deployment procedure for the sails.
- Demonstrate the feasibility of High Gain Antenna (HGA) sail.

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



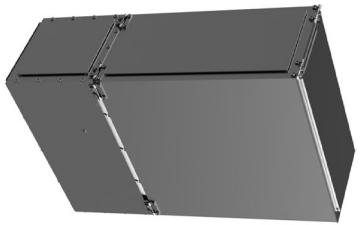
Phase 4: High Gain Antenna Testing
Satellite begins operating its HGA

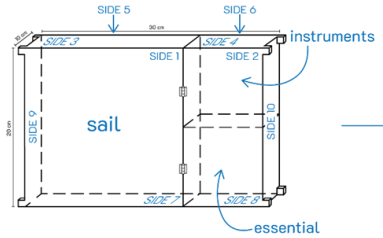
Phase 4: High Gain Antenna Testing
Satellite begins operating its HGA

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

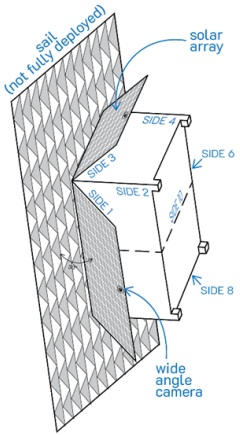
Deployment

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

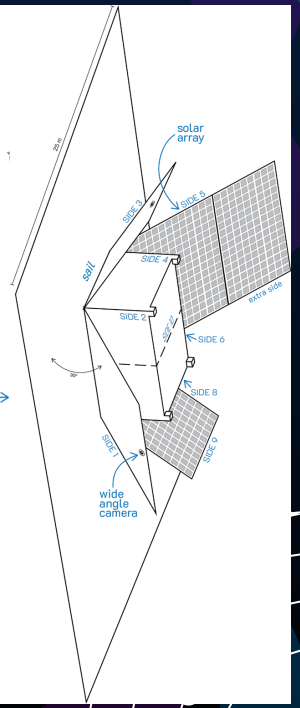




closed

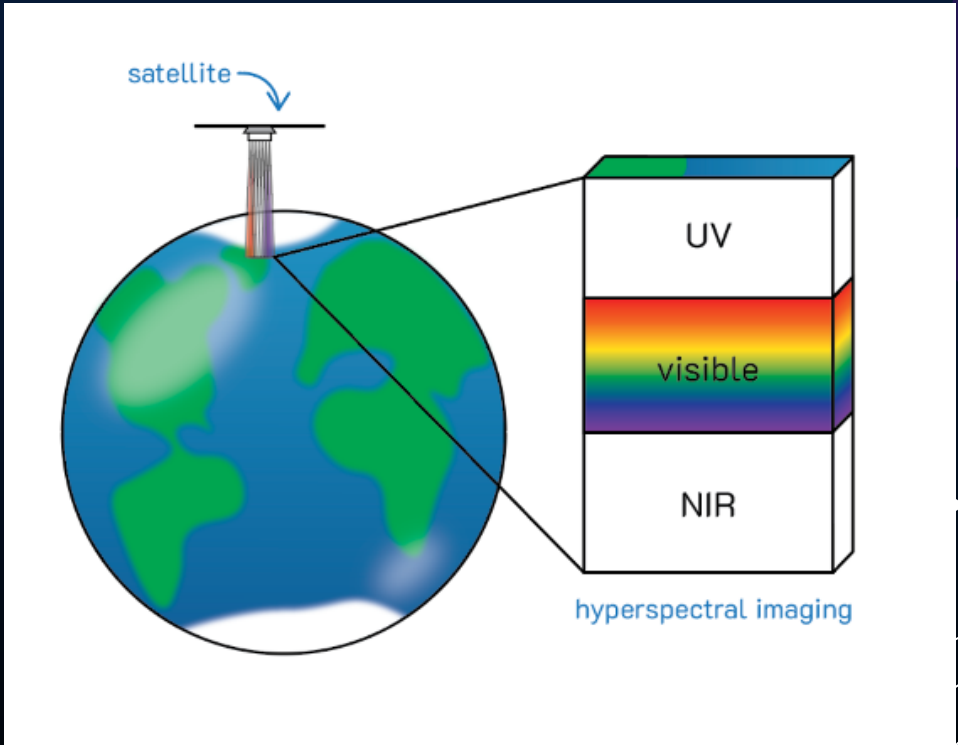


half open



Average Operations

- SolarSURFER uses the ADCS system to orient towards the observation target
- Hyperspectral Imaging takes pictures of the surface
- SolarSURFER reorients 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

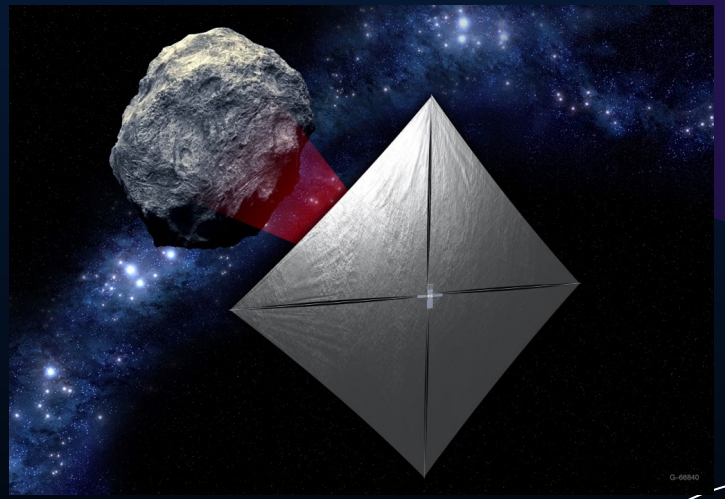
- What is the reflectivity and emissivity of our material?
- What's the best layer configuration?

Communications

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

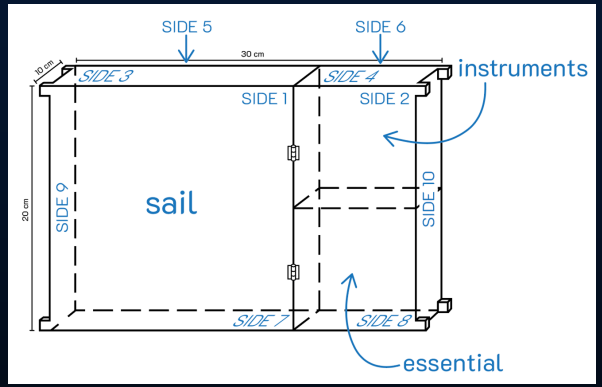
Deployment

- How do we extend the sail?



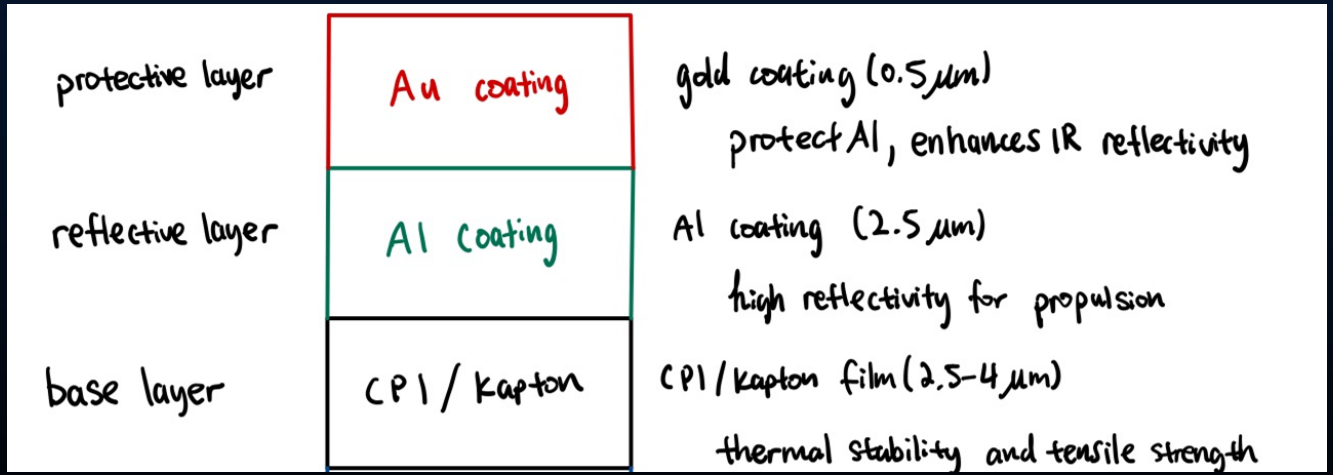
SolarSURFER Module Design

- 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



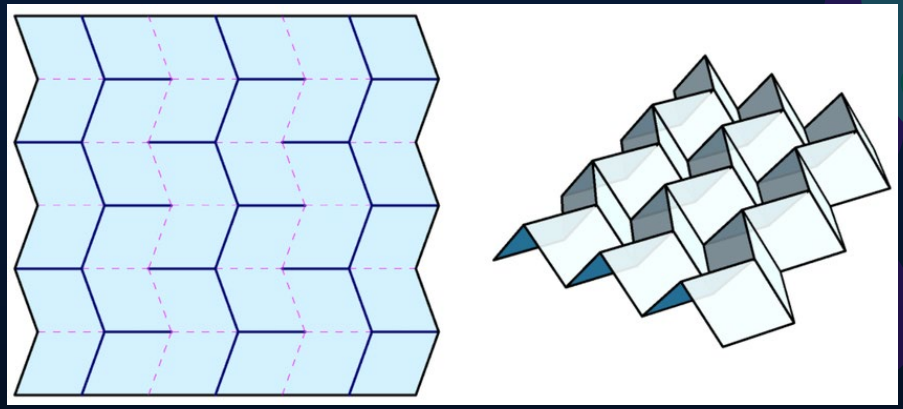
Material Selection

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

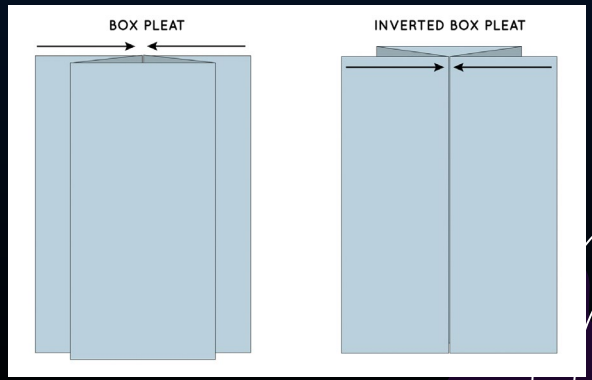


Folding Techniques Overview

- **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)

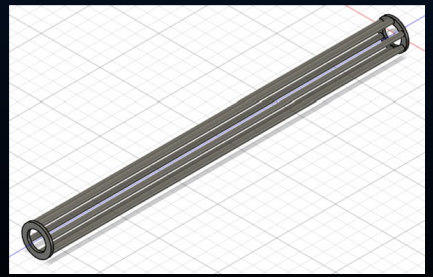


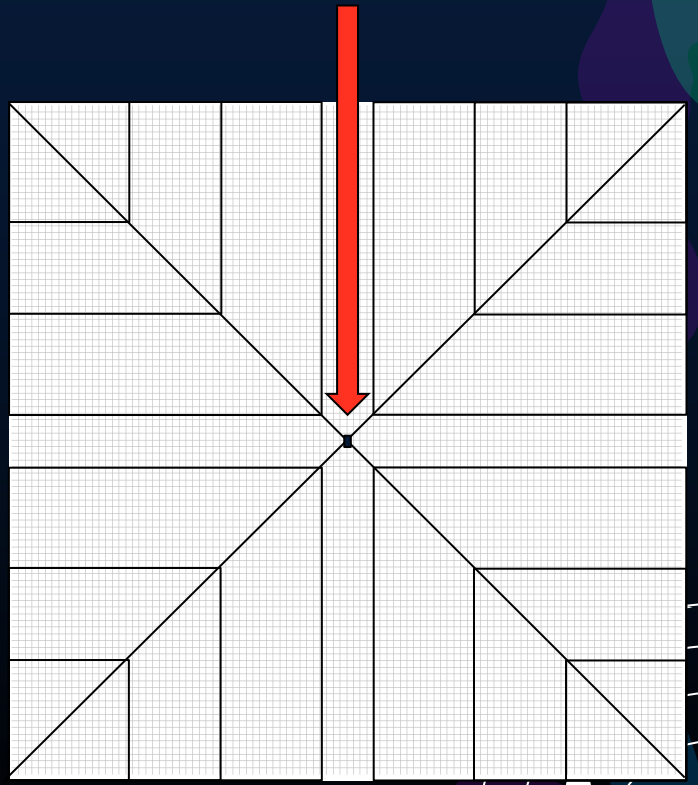
(below)

Box Pleated

Deployment

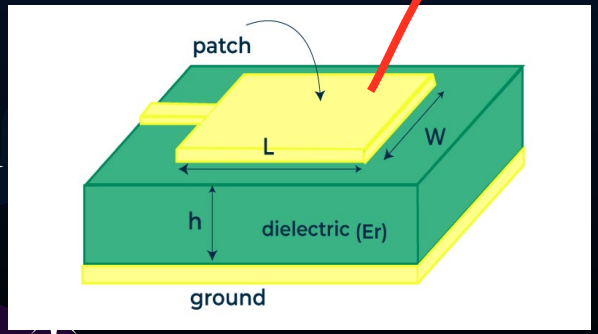
- 20m x 20m Sail needs to be unfurled from the 4U compartment
- Deployment will be carried out through a backbone of SMA
- Booms will be initially deployed through Induction Heating through a PWM circuit
- Passive heating from Sun prevents booms from losing their

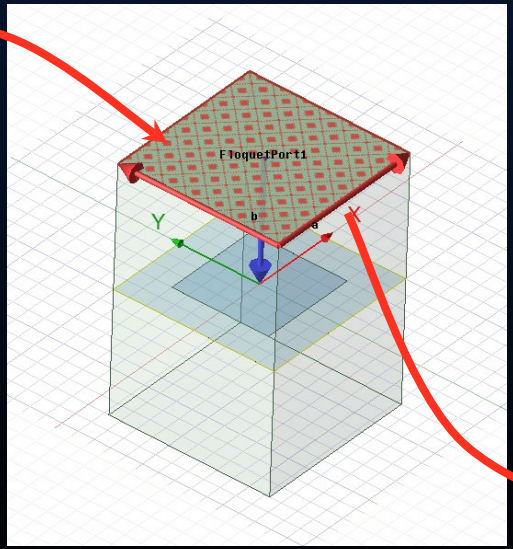


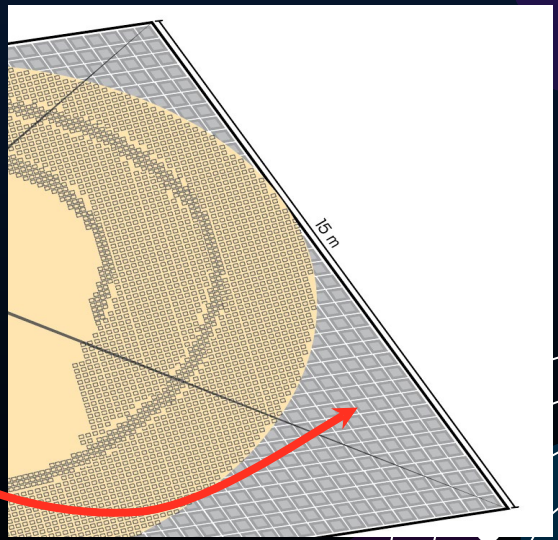


Sail High Gain Antenna

- 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