Mars Ice Cubesat Expedition (MICE)

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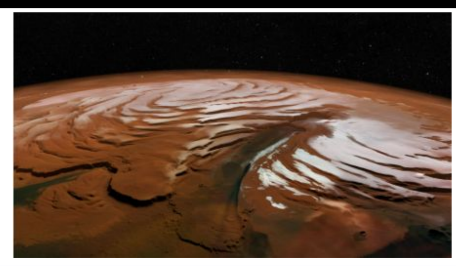
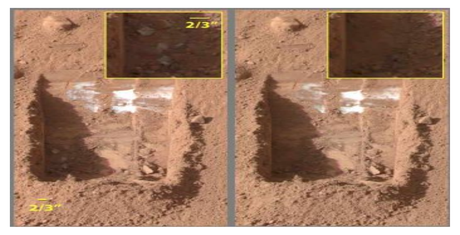
Mission Objectives

Focus on **Ice mapping** near-surface ice deposits in mid-latitude regions of Mars

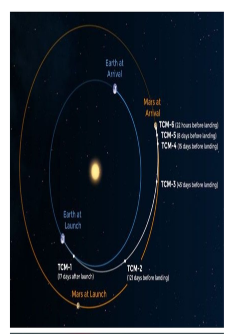


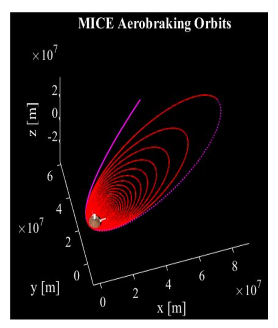


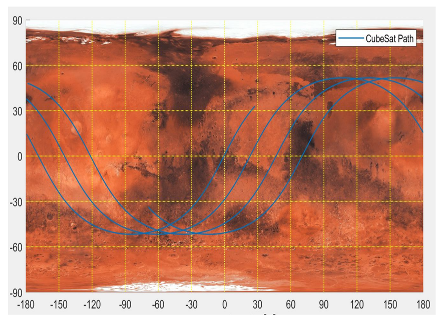
Develop a scalable approach to planetary mapping using **SmallSat technology** to obtain high-resolution data **without needing large expensive hardware**

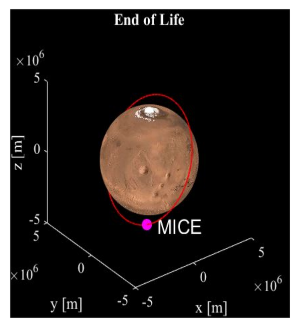
Timeline of Project

Launch (Rideshare VIA Falcon X)	Heliocentric Cruise (9 Months)	Aerobraking (10 Months)	Scientific Orbit (26.5 Days)	End of Life (1 Hour)





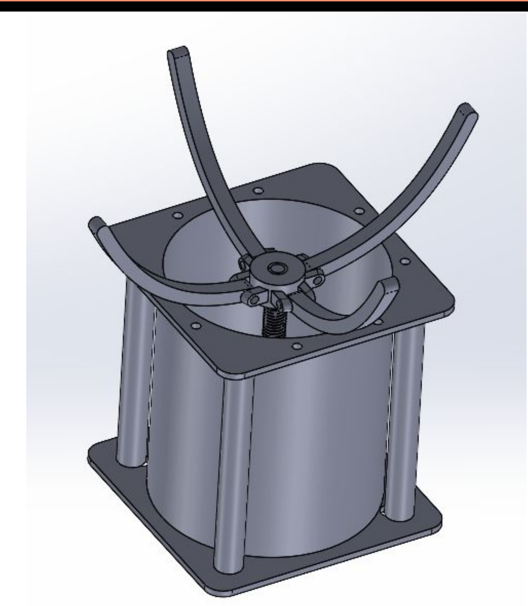


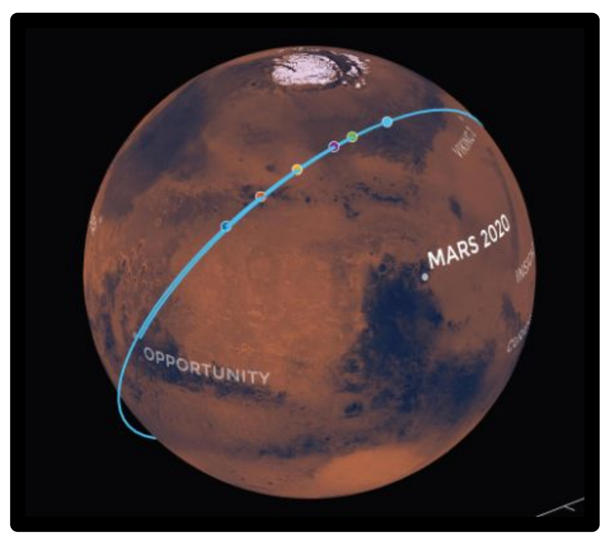


Payload

Mission Details

- 6 Cubesats around Mars
- Circular Orbit, 300 km Altitude
- 60 degree Inclination
- Antenna takes up 1.5 U in CubeSat
- Martian Regolith, Water Ice, and Dry Dust
- swath width of 26.18 meters
- Mars will be fully scanned in 26.5 days





Antenna Details

- L-Band radar, 930 MHz
- Resolution of 10 - 20 m
- Penetration 0 - 10 m
- 7.1 Gigameters Coverage per day
- Total Coverage of 86.6% of Mars
- Data rate of 12.5 kbps for 1.03 Gb per day

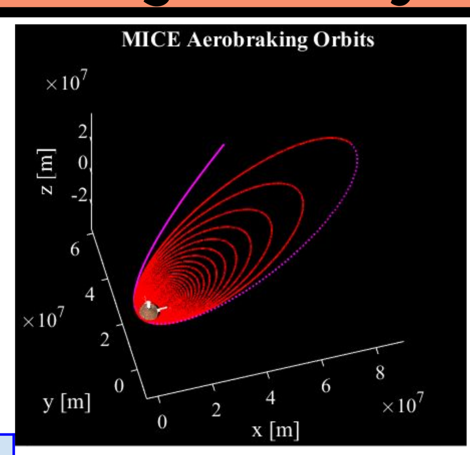
Trajectory

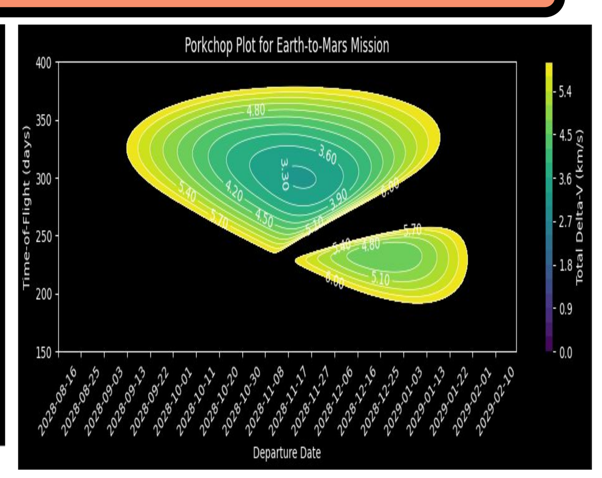
Transfer Requirements

- ΔV < 5 km/s
- Get from GEO to Mars insertion

Solution

- **Transfer Date:** November 27, 2028
- **Change of Velocity:** ΔV = 3.22
- **Time of Flight:** 280 Days





Insertion Requirements

- Minimize ΔV to save fuel and weight
- Insert into a Mars orbit
- Establish the science orbit at an alt. of 300km

Solution

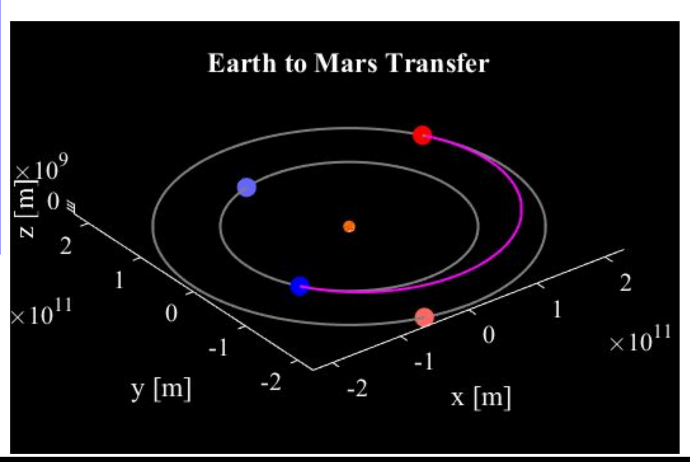
- Insert into a highly elliptical orbit ranging from 98,000 km to 270 km
- Lower periapsis to 200km and aerobrake to slow down
- Reduce apoapsis to 1,050 km then circularize
- **Change of Velocity:** ΔV = 1728 m/s

End of Life Requirements

- Minimize ΔV to save fuel
- Avoid collision with Mars
- Finish the mission in a safe orbit

Solution

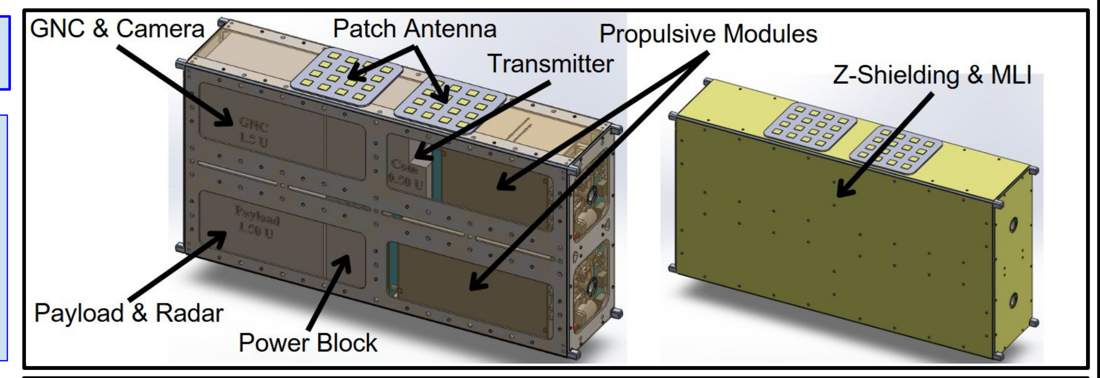
- Orbit at altitude of 660km
- **Change of Velocity:** ΔV = 155 m/s



CAT and MICE

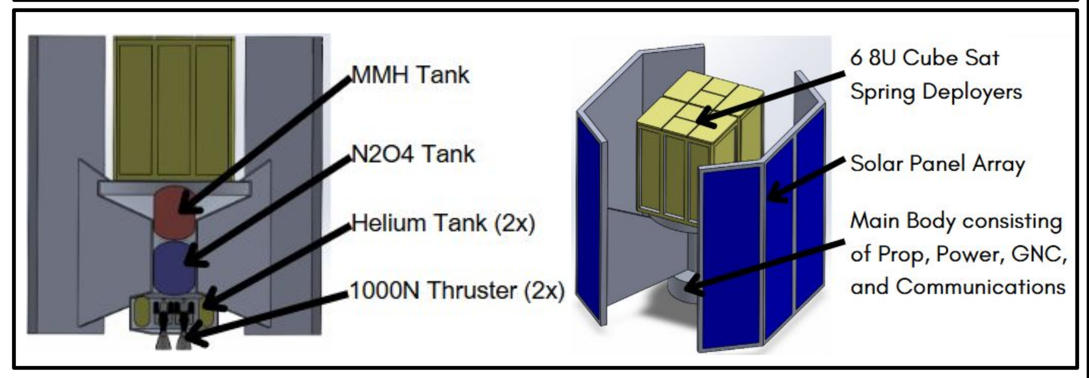
MOUSE: CubeSat

The MOUSE is an 8U CubeSat structure utilizing an anodized T6-6061 Aluminum and Titanium frame. The anodized frame, exterior z-shielding panels, and a layer of MLI protect against radiation and thermal loads. Total weight amounts to **14.135 kg**.



CAT: Carrier Vehicle

The CAT vehicle is able to hold 6 MOUSE CubeSats on its journey to mars. The CAT's propulsive capabilities take the form of two 20N thrusters fueled by MMH and N2O4. The CAT also features 2 large solar panels to power the vessel on its journey.

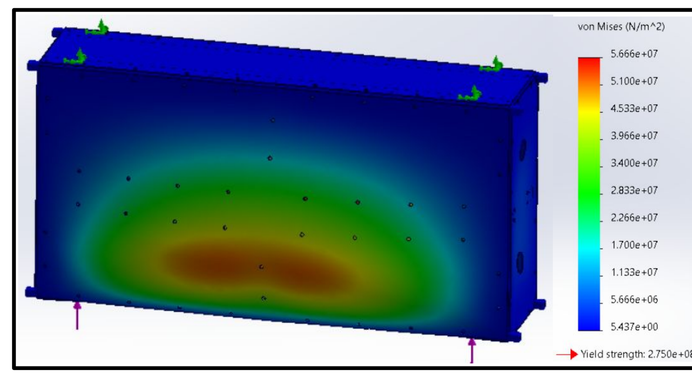


Structural Simulations

Overall Factor of Safety: **1.5**

Statically Simulated to mimic launch loads

- Axially Loaded: **832 N**
- Laterally Loaded: **278 N**
- Avoid natural frequency range **25-100 Hz** to avoid resonance with carrier



All above 100 Hz

Natural Frequencies

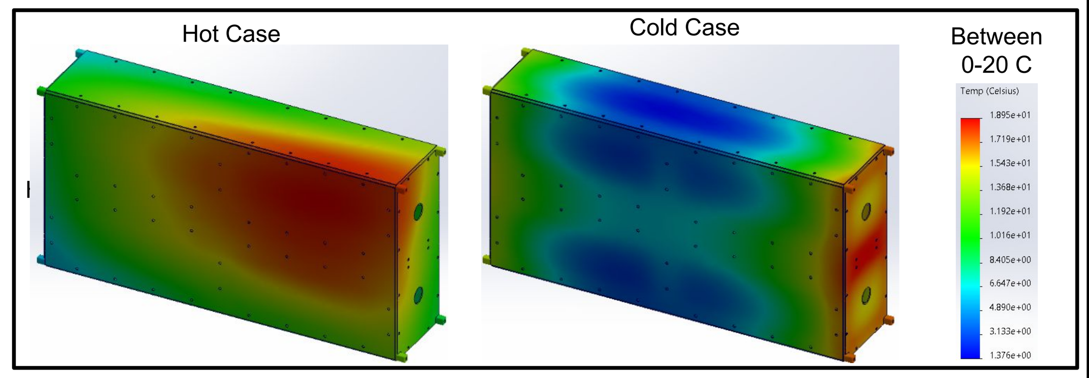
Mode	Frequency Axial Load	Frequency Lateral Load
#	(Hz)	(Hz)
1	188.47	173.71
2	243.16	237.23
3	312.26	307.16
4	349.24	337.74
5	476.78	432.08

Thermal Simulations

Hot Case: Exposed directly to the Sun within Mars' Atmosphere

Cold Case: Eclipsed from the Sun in Mars' Atmosphere

Must be within **0-20 C** to ensure good operating conditions



Guidance, Navigation, and Control

MOUSE Requirements

- Achieve pointing accuracy of sub 25 arcescs during SAR imaging
- Perform semi autonomous orbit and attitude corrections
- Maintain precise relative positions and orientations between other MOUSE units with sub-meter accuracy

CAT Requirements

- Execute precise and controlled aerobraking maneuvers
- Deploy MOUSE units with precise velocities and orientations
- Maintain attitude and orbit post MOUSE deployment to serve as communications relay

MOUSE GNC

- Compact system based on XACT-50 unit (1.23 kg)
- Pointing accuracy of ±10.8 arcsec and ±25.2 arcsec
- Thrusters for large corrections

CAT GNC

- State of the art sensor and control suite: Honeywell MIMU, 3x RWs, star and sun trackers, 8x control thrusters
- Optical navigation and deployment verification cameras

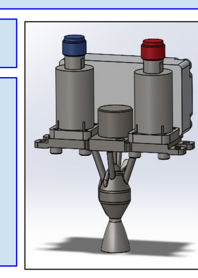
Attitude Simulations

- Simulation visualizes hybrid attitude control system in Mars orbit
- Visualizes cubesat trajectory around mars with fixed-body axis, control system performance, and efficient control actuator usage
- Reaction wheels provide continuous pointing within ±6 mNm
- Thrusters only remain active throughout initial stabilization achieving precise attitude maintenance with minimum propellant usage
- Initial conditions - roll:45˚, pitch:45˚, yaw:180˚, 0.01 rad/s rotation along X and Y axis

MOUSE Thrusters

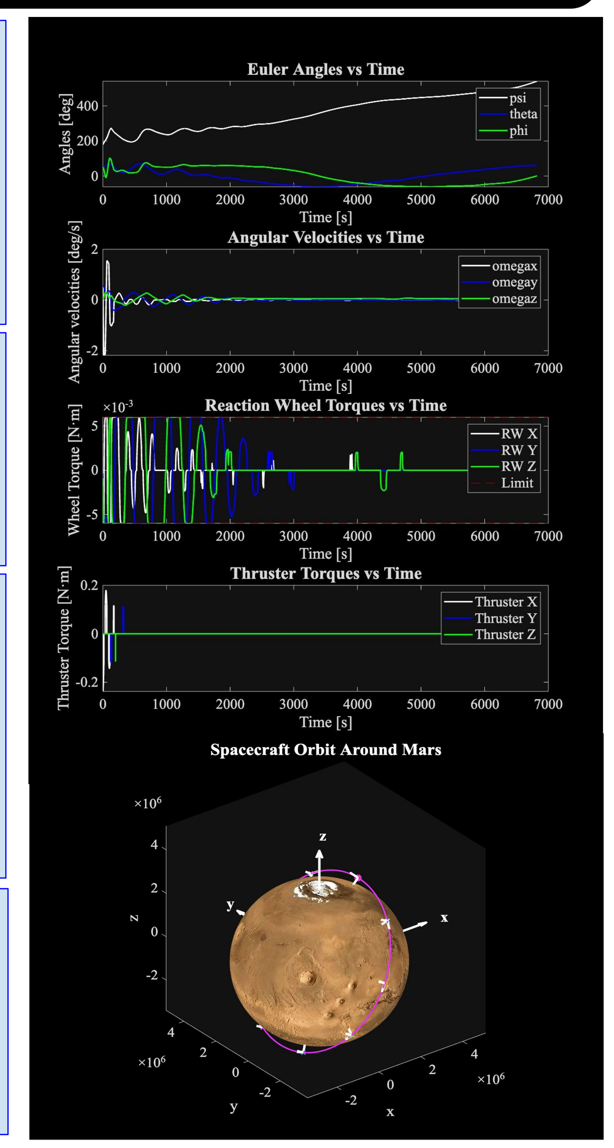
Requirements:

- Volume envelope ≤ 3.5 U
- ΔV ≥ 246 m/s (160 m/s EOL + 40% margin)
- Total impulse ≥ **3 586 N·s**



Solution:

- **CubeDrive Modules:** 1.5 U + 2 U → **~3700 N·s** impulse
- **Compact Fit:** 3.5 U envelope
- **Thrusters:** Dawn Aerospace CubeDrive bipropellant thrusters



Acknowledgements

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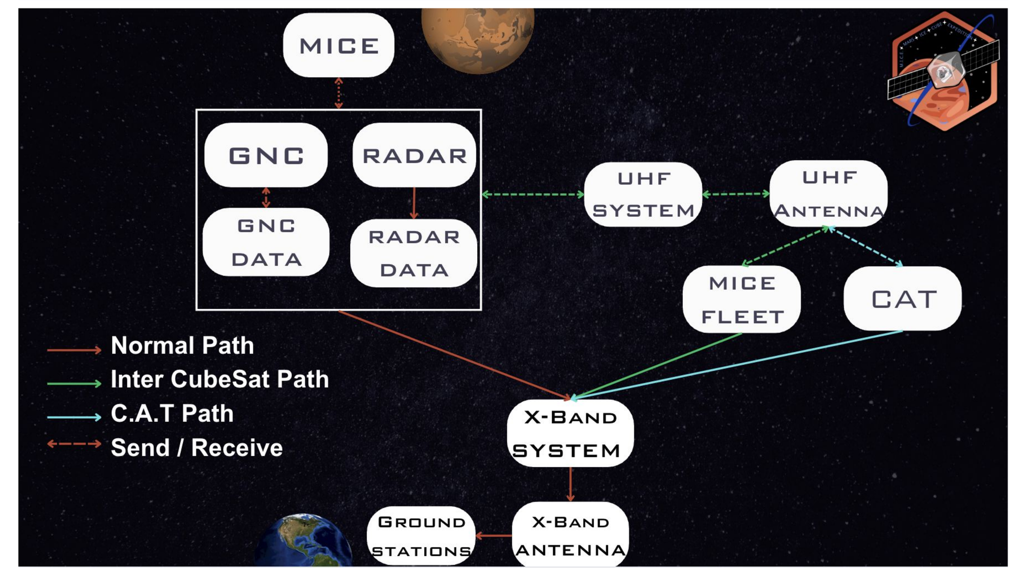
Communications

Mission Dataflow



Requirements

- Minimum data rate speed of 1500 kbps to send .4 GB (8hrs)
- Linked for at least 8 hours a day.
- The required signal strength also has to be over 20 dB for a mars orbiter.

Antenna

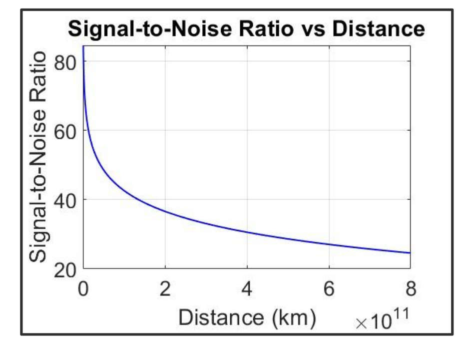
Ground Station Communications:

- 2 X-Band Patch Array Antennas
- X-Band Transmitter

MICE & CAT Communications

- 2 UHF Patch Array Antennas
- UHF Transmitter

Link Budget



Minimum SNR:

24.1 dB

Maximum SNR:

82.3 dB

Ground Stations

Nasa Deep Space Network 70m Antennas:

- Goldstone, CA
- Madrid, Spain
- Canberra, AU

PCMS

Power: 5-7 W
Cost: $25 million
Mass: 442 grams
Size: .5U

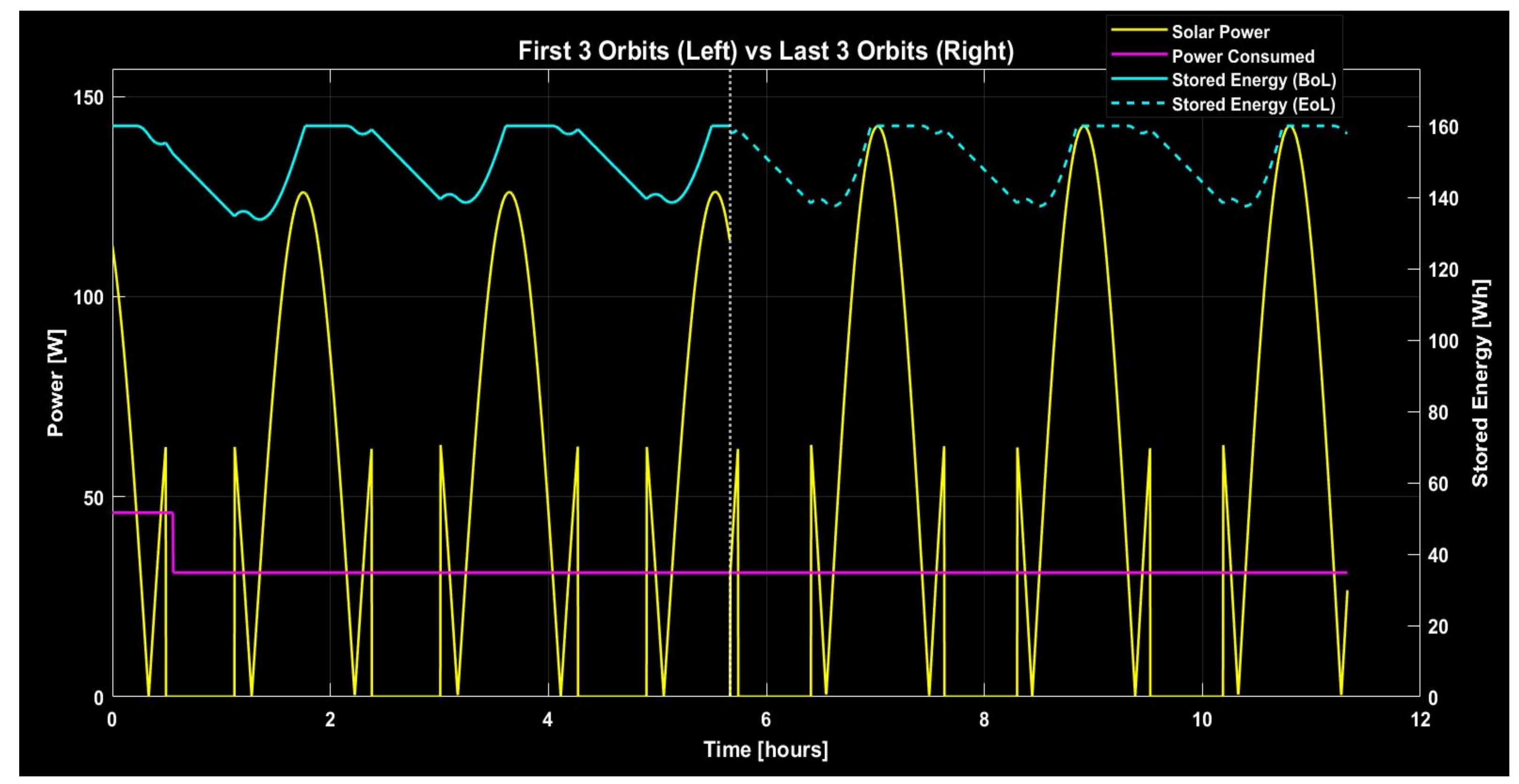
Power

Requirements

- Produce an average of at least 46 watts of solar power per orbit to have energy stored for eclipses
- Store enough energy to survive multiple eclipses
- 40Wh backup battery for communications

Solution

- 0.8 m^2 double-sided panels (160 W peak) to capture
- 160Wh total battery capacity
- Power consumption: 46 W (attitude control, first 2000 seconds), then 31 W thereafter



Mission Summary

MOUSE Summary

Power	Cost	Mass	Size
31-46W	$920k-$3.4M per cube	14.95kg - 15.5kg	8 U

MARCO	MICE Mission	IMIM Projection
Cost	Cost	Cost
$17M for 2 CubeSat	$82M-$190M	$185M

Spring 2025